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GEO105

INTRODUCTION TO ENVIRONMENTAL SCIENCES

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Course code: GEO 105
Course title: Introduction to Environmental Sciences
Course credit load: 2 Units

Series 1: Foundations of Environmental Science

1.1 Definition and Scope of Environmental Science

- **1.1.1 Meaning of Environmental Science**
- **1.1.2 Scope and Relevance of Environmental Science**
- **1.1.3 Importance of Environmental Science in Contemporary Society**

1.2 Historical Development and Evolution of Environmental Science

- **1.2.1 Early Concepts of Environment**
- **1.2.2 Emergence of Environmental Science as a Discipline**
- **1.2.3 Key Milestones in Environmental Studies**

1.3 Core Concepts of the Environment

- **1.3.1 Components of the Environment (Atmosphere, Biosphere, Hydrosphere, Lithosphere)**
- **1.3.2 Environment as a System**
- **1.3.3 Interactions within Environmental Systems**

1.4 Principles of Environmental Sustainability

- **1.4.1 Meaning of Sustainability**
- **1.4.2 Strategies for Sustainable Environmental Management**
- **1.4.3 Role of Individuals and Institutions in Sustainability**

Introduction

Environmental challenges such as climate change, pollution, and resource depletion are increasingly shaping the way societies live and develop. To address these issues effectively, it is essential to first grasp the foundations of environmental science, which provide the basic definitions, concepts, and principles that underpin the discipline. This Series sets the stage for your journey into environmental studies by equipping you with the essential knowledge needed to interpret how the environment operates and why its sustainable management is crucial.

The aim of this Series is to introduce you to the fundamental principles of environmental science and to enable you to define its scope, trace its historical development, explain its core concepts, and evaluate strategies for sustainability.

We shall commence this Series by examining the definition and scope of environmental science, highlighting its meaning, relevance, and importance. Then, we will move on to explore the historical development of the discipline, considering how early ideas evolved into modern environmental science. Following that, our attention will turn to the core concepts of the environment, including its components and systemic interactions. Finally, we will wrap up by discussing the principles of environmental sustainability, focusing on strategies for managing the environment responsibly and the role of individuals and institutions in promoting sustainable practices.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define environmental science clearly and explain its scope and relevance in contemporary society,
- **SLO 1.2** describe the historical development of environmental science and identify key milestones in its evolution,
- **SLO 1.3** explain the major components of the environment and analyse how they interact as a system,
- **SLO 1.4** evaluate the principles of environmental sustainability and assess strategies for sustainable environmental management.

1.1 Definition And Scope Of Environmental Science

1.1.1 Meaning of environmental science

Environmental science is the study of the interactions between humans and the natural environment. It combines knowledge from several disciplines such as biology, chemistry, physics, geography, and social sciences to explain how the environment functions and how human activities influence it. The discipline seeks to provide solutions to environmental problems by applying scientific principles.

To put it simply, environmental science helps us to answer questions such as: *How does the atmosphere regulate climate? What happens when pollutants enter rivers? How do human activities affect biodiversity?*

Fill in the blank: Environmental science is the study of the interactions between _____ and the natural environment.

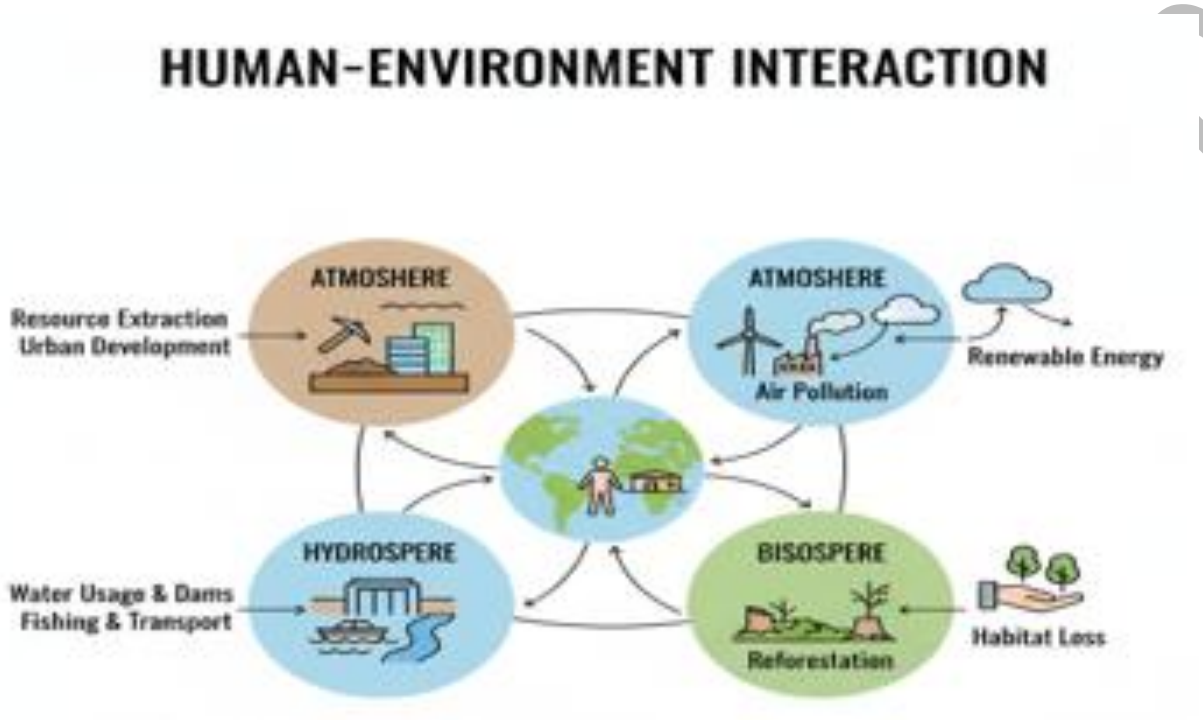


Figure 1.1: Human–environment interaction

1.1.2 Scope and relevance of environmental science

The **scope of environmental science** refers to the range of topics and issues it covers. This includes the study of natural processes, environmental systems, and the impact of human activities. It also involves examining environmental hazards such as pollution, erosion, drought, and climate change.

The **relevance of environmental science** lies in its ability to guide societies towards sustainable living. By studying environmental science, learners gain the knowledge needed to evaluate environmental problems and propose practical solutions. For example, understanding how deforestation affects the atmosphere can help in designing policies for forest conservation.

Fill in the blank: The scope of environmental science includes the study of natural processes, environmental systems, and the impact of _____ activities.

Environmental science is an interdisciplinary field that investigates the complex interactions between humans and the Earth's natural systems. Its primary goal is to

identify, analyze, and solve environmental problems using a combination of biological, physical, and social sciences.

The Scope of Environmental Science

Focus Area	Core Topics & Study Objectives
Pollution	**Types:** Air, water, soil, noise, and radioactive pollution. **Scope:** Studying the sources (industrial, agricultural, urban) and chemical fate of pollutants, and developing mitigation strategies like waste management and circular economy models.
Climate Change	**Drivers:** Greenhouse gas emissions, deforestation, and fossil fuel combustion. **Scope:** Monitoring global warming, sea-level rise, and ocean acidification; creating climate adaptation and mitigation frameworks (e.g., renewable energy transitions).
Biodiversity	**Conservation:** Protecting endangered species, habitats, and ecosystems (forests, wetlands, oceans). **Scope:** Analyzing threats like habitat fragmentation and invasive species; implementing in-situ (nature reserves) and ex-situ (seed banks) conservation.
Sustainability	**Resource Management:** Sustainable use of water, minerals, and land. **Scope:** Balancing the "Triple Bottom Line" (Social, Economic, Environmental) to ensure that current human needs are met without compromising the ability of future generations to meet theirs.

Box 1.1: Selected areas covered by environmental science

1.1.3 Importance of environmental science in contemporary society

The **importance of environmental science** today cannot be overstated. It equips individuals and institutions with the tools to manage environmental challenges responsibly. For instance, knowledge of environmental science helps in designing strategies to reduce air pollution, mitigate climate change, and prepare for natural hazards such as floods and earthquakes.

Environmental science also promotes awareness of the role humans play in shaping the environment. By recognising this role, societies can adopt sustainable practices that ensure resources are available for future generations.

Fill in the blank: Environmental science equips individuals and institutions with the tools to manage environmental _____ responsibly.

Plate 1.1: Promoting sustainability through education and action

Pilot questions 1.1

1. Which disciplines contribute to the study of environmental science?
2. What is meant by the scope of environmental science?
3. Why is environmental science relevant to modern society?

4. Identify one example of how environmental science helps in solving environmental problems.
5. What role does environmental science play in promoting sustainability?

1.2 Historical Development And Evolution Of Environmental Science

1.2.1 Early concepts of environment

In ancient times, people viewed the **environment** mainly as a source of resources such as water, soil, and forests. The term environment refers to the surroundings in which organisms live and interact. Early societies often believed that natural events such as floods or droughts were controlled by supernatural forces. As human knowledge grew, these events began to be explained through observation and reasoning.

For example, farmers in early civilisations recognised the importance of fertile soil and seasonal rainfall for crop production. This awareness marked the beginning of human attempts to understand and manage the environment.

Fill in the blank: Early societies often believed that natural events such as floods or droughts were controlled by _____ forces.

Figure 1.2: Early human interaction with the environment

1.2.2 Emergence of environmental science as a discipline

The formal study of environmental science began much later, particularly during the industrial revolution. The **industrial revolution** refers to the period of rapid industrial growth in the eighteenth and nineteenth centuries. It brought about new technologies but

also created serious environmental problems such as air pollution, water contamination, and deforestation.

Scientists and policymakers started to recognise the need for systematic study of the environment to address these challenges. This gave rise to environmental science as a distinct discipline, combining natural and social sciences to provide solutions.

Fill in the blank: The industrial revolution created serious environmental problems such as air pollution, water contamination, and _____.

- Industrial revolution and pollution
- Rapid urbanisation
- Population growth
- Resource depletion
  AI prompt suggestion: “Generate a text box listing industrial revolution, urbanisation, population growth, and resource depletion as drivers.”
  Search string: “history of environmental science industrial revolution OER”

1.2.3 Key milestones in environmental studies

Several milestones have shaped the growth of environmental science. For example, the publication of Rachel Carson’s book *Silent Spring* in 1962 drew attention to the dangers of pesticides. International conferences such as the 1972 United Nations Conference on the Human Environment in Stockholm highlighted global environmental concerns. More recently, agreements like the Paris Climate Accord have emphasised the need for collective action against climate change.

These milestones demonstrate how environmental science has evolved from local observations to a global discipline concerned with sustainability and human survival.

Fill in the blank: Rachel Carson’s book _____ drew attention to the dangers of pesticides.

Pilot questions 1.2

1. How did early societies view the environment?
2. What major historical event contributed to the emergence of environmental science as a discipline?
3. Identify two environmental problems caused by the industrial revolution.
4. Name one milestone that drew global attention to environmental issues.
5. Why are international agreements important in the evolution of environmental science?

1.3 Core Concepts Of The Environment

1.3.1 Components of the environment (atmosphere, biosphere, hydrosphere, lithosphere)

The **environment** is made up of several interconnected components. The **atmosphere** is the layer of gases surrounding the Earth, responsible for regulating climate and supporting life through oxygen and carbon dioxide exchange. The **biosphere** refers to all living organisms, including plants, animals, and microorganisms, interacting with each other and with their surroundings. The **hydrosphere** includes all water bodies such as oceans, rivers, lakes, and groundwater, which are vital for sustaining life. The **lithosphere** is the solid outer part of the Earth, consisting of rocks, soils, and landforms that provide habitats and resources.

These components do not exist in isolation, but rather interact continuously. For example, plants in the biosphere depend on water from the hydrosphere and gases from the atmosphere, while their roots anchor in the lithosphere.

Fill in the blank: The lithosphere is the solid outer part of the Earth, consisting of _____, soils, and landforms.

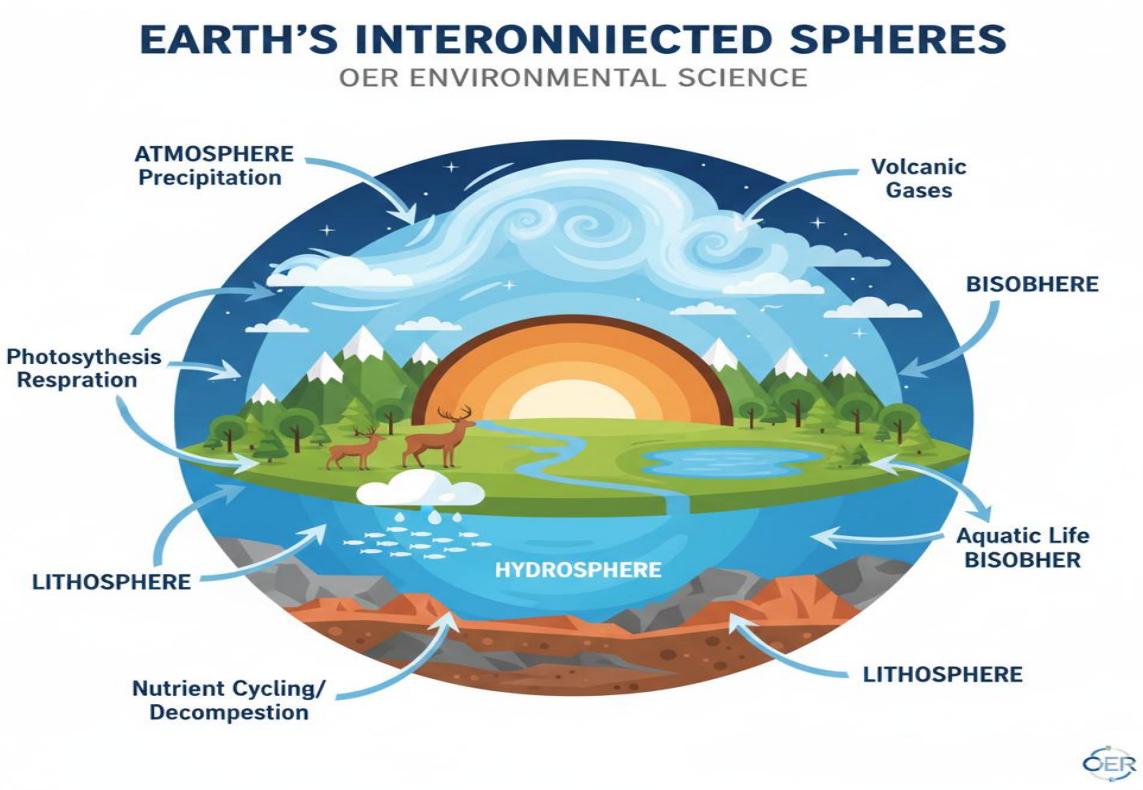


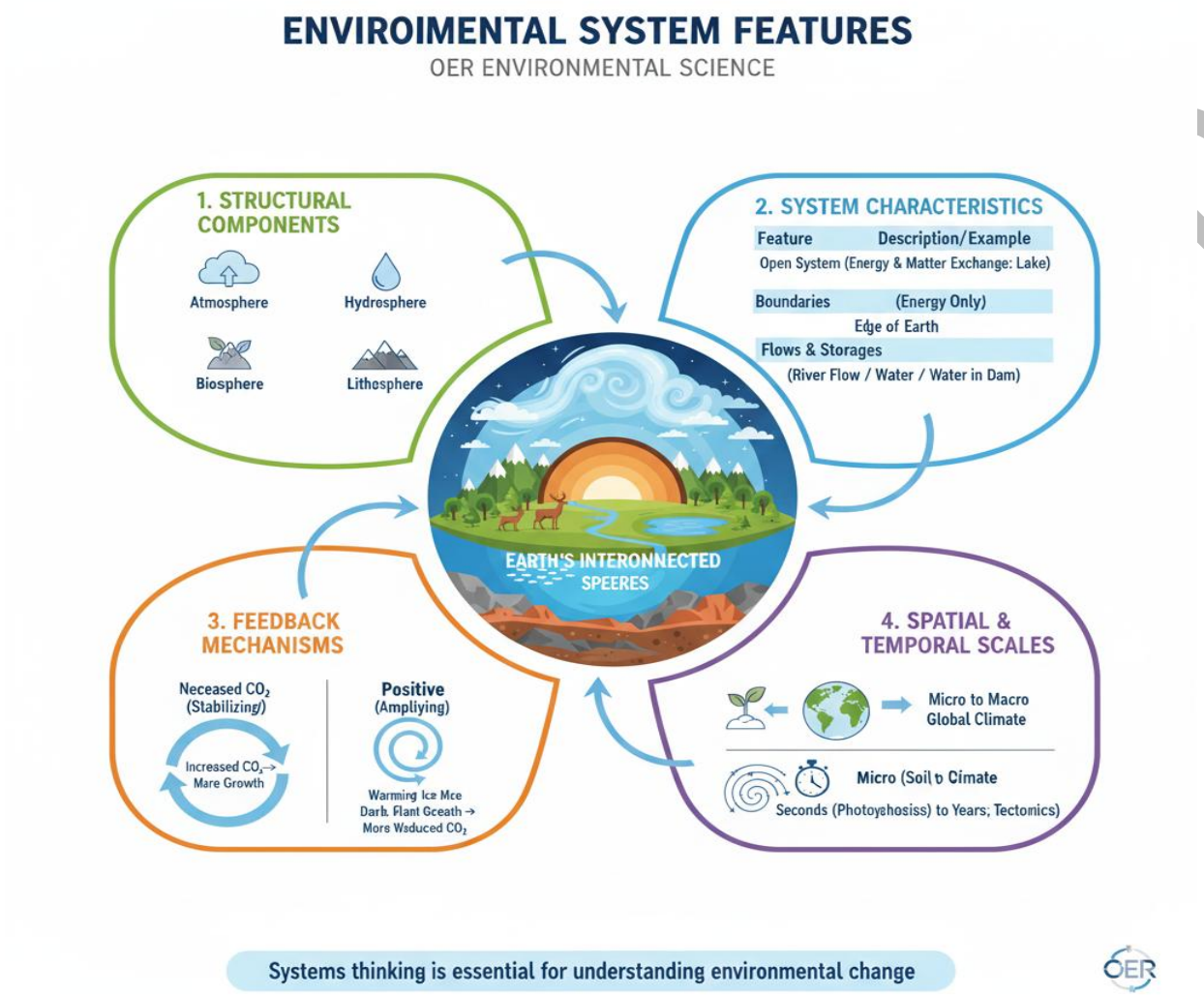
Figure 1.3: Components of the environment

1.3.2 Environment as a system

The environment functions as a **system**, meaning it is a collection of components that interact to form a whole. A system has inputs, processes, and outputs. For instance, solar energy enters the atmosphere, drives processes such as photosynthesis in the biosphere, and influences water cycles in the hydrosphere.

Viewing the environment as a system helps us to understand how changes in one part affect the others. For example, pollution in rivers (hydrosphere) can harm fish populations (biosphere), which in turn affects food supply for humans.

Fill in the blank: Viewing the environment as a _____ helps us to understand how changes in one part affect the others.



Box 1.3: Features of an environmental system

- Inputs: energy, matter
- Processes: interactions among components
- Outputs: products, waste, impacts

AI prompt suggestion: “Generate a text box listing inputs, processes, and outputs of an environmental system.”

Search string: “environment as a system inputs processes outputs OER”

1.3.3 Interactions within environmental systems

Interactions within environmental systems are complex and dynamic. For example, the **carbon cycle** illustrates how carbon moves between the atmosphere, biosphere, hydrosphere, and lithosphere. Human activities such as burning fossil fuels alter these natural cycles, leading to challenges like climate change.

Another example is the **water cycle**, where water evaporates from oceans, condenses into clouds, and falls as precipitation. This cycle links the hydrosphere with the atmosphere and biosphere.

Fill in the blank: Human activities such as burning _____ alter natural cycles like the carbon cycle.

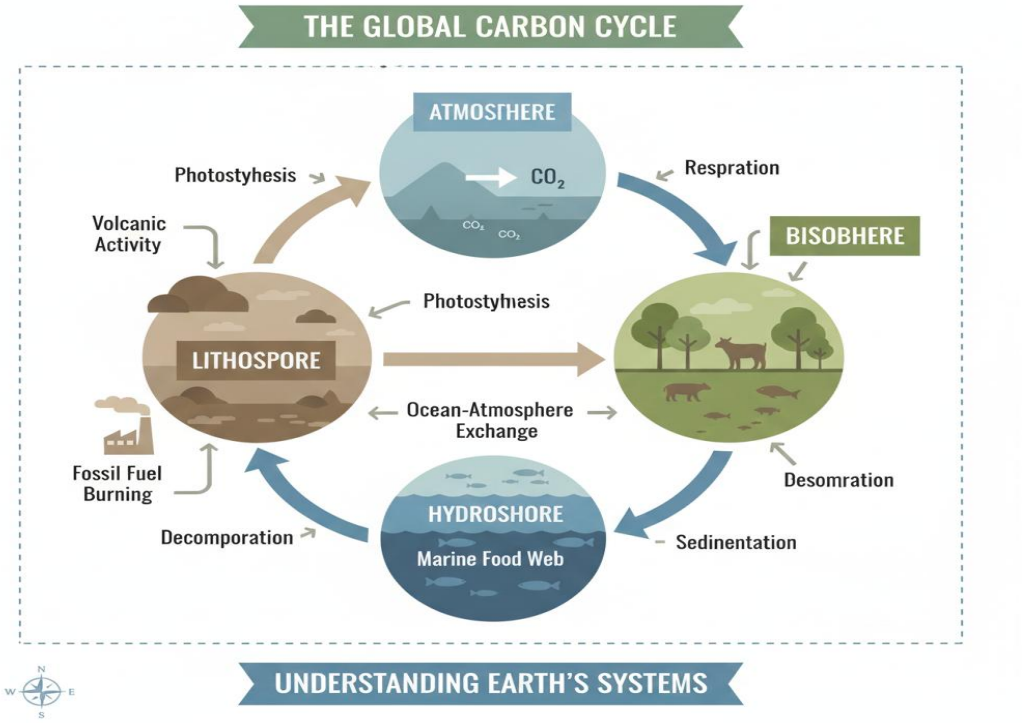


Figure 1.4: The carbon cycle as an environmental interaction

Pilot questions 1.3

1. List the four main components of the environment.
2. What does it mean to view the environment as a system?
3. Give one example of how pollution in the hydrosphere can affect the biosphere.
4. What cycle demonstrates the movement of carbon among environmental components?
5. Why are human activities significant in altering environmental systems?

1.4 Principles Of Environmental Sustainability

1.4.1 Meaning of sustainability

Sustainability refers to the ability to meet present needs without compromising the ability of future generations to meet their own needs. In environmental science, sustainability means using resources wisely, maintaining ecological balance, and ensuring that human activities do not cause long-term harm to the environment.

For example, sustainable farming practices involve crop rotation and soil conservation, which allow land to remain productive over time. Similarly, renewable energy sources such as solar and wind power are sustainable because they do not deplete finite resources.

Fill in the blank: Sustainability means meeting present needs without compromising the ability of _____ generations to meet their own needs.

1.4.2 Strategies for sustainable environmental management

Environmental management refers to the planning and implementation of practices that protect and improve the environment. Strategies for sustainability include reducing waste, conserving energy, protecting biodiversity, and promoting renewable resources.

For instance, recycling materials reduces the demand for raw resources, while energy-efficient technologies lower greenhouse gas emissions. Conservation of forests and wetlands helps maintain biodiversity and regulate climate.

Fill in the blank: Recycling materials reduces the demand for _____ resources.

- Recycling and waste reduction
- Renewable energy adoption
- Biodiversity conservation
- Energy efficiency measures
  AI prompt suggestion: “Generate a text box listing strategies such as recycling, renewable energy, biodiversity conservation, and energy efficiency.”
  Search string: “sustainable environmental management strategies OER”

1.4.3 Role of individuals and institutions in sustainability

Both individuals and institutions play vital roles in promoting sustainability. Individuals contribute by adopting eco-friendly habits such as reducing plastic use, conserving water, and supporting green initiatives. Institutions, including governments, universities, and businesses, influence sustainability through policies, education, and investment in sustainable technologies.

For example, governments can enforce environmental regulations, while universities can integrate sustainability into curricula. Businesses can adopt corporate social responsibility practices that reduce environmental impact.

Fill in the blank: Institutions such as governments, universities, and businesses influence sustainability through policies, education, and _____.

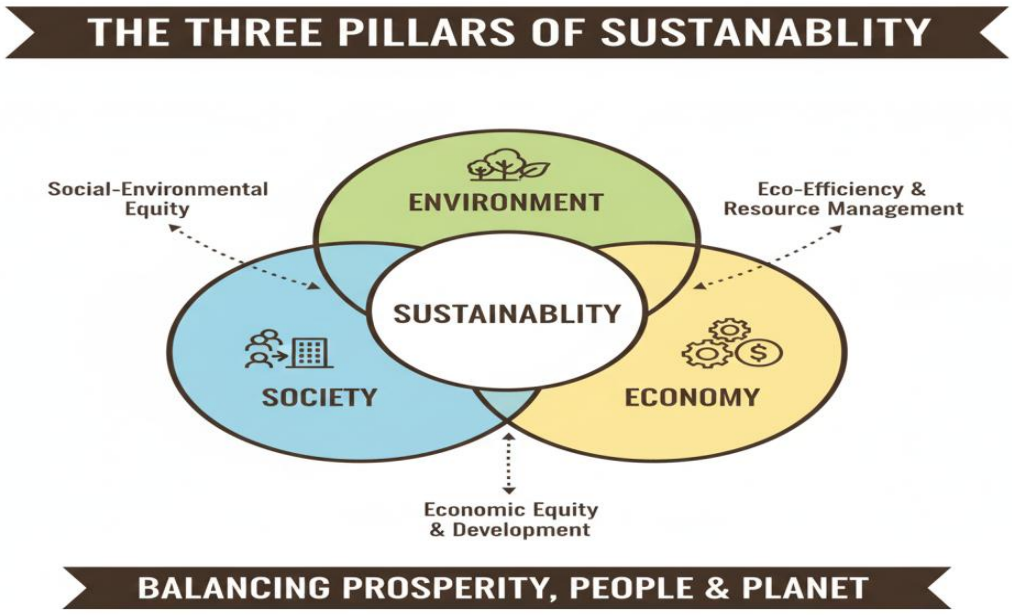


Plate 1.3: Institutional role in promoting sustainability

Pilot questions 1.4

1. What does sustainability mean in environmental science?
2. Identify two strategies for sustainable environmental management.
3. How does recycling contribute to sustainability?
4. Give one example of how individuals can promote sustainability.
5. What role do institutions play in advancing sustainability?

Summary

In this Series, we have laid the foundation for your study of environmental science. We began by defining environmental science and explaining its scope and relevance, highlighting how it draws from multiple disciplines to address pressing environmental challenges. We then traced the historical development of the discipline, from early human

interactions with nature through the industrial revolution to key milestones such as *Silent Spring* and international environmental agreements.

Following that, we explored the core concepts of the environment, examining its components—the atmosphere, biosphere, hydrosphere, and lithosphere—and considering how they function together as a system. We also discussed the interactions within these systems, such as the carbon and water cycles, and how human activities can disrupt them. Finally, we examined the principles of environmental sustainability, focusing on its meaning, strategies for sustainable management, and the roles of individuals and institutions in promoting responsible practices.

Altogether, this Series has provided you with the essential definitions, historical context, systemic concepts, and sustainability principles that form the bedrock of environmental science. These foundations will support your learning in subsequent Series, where you will delve deeper into the multidisciplinary nature of the environment, its energy dynamics, and the role of humans in contemporary environmental issues.

Glossary of Terms

- **Environmental science**: The multidisciplinary study of the interactions between humans and the natural environment, aimed at understanding processes and solving environmental problems.
- **Environment**: The surroundings in which organisms live and interact, including physical, chemical, and biological components.
- **Atmosphere**: The layer of gases surrounding the Earth, which regulates climate and supports life through oxygen and carbon dioxide exchange.
- **Biosphere**: The part of the Earth that contains all living organisms, including plants, animals, and microorganisms.
- **Hydrosphere**: All water bodies on Earth, such as oceans, rivers, lakes, and groundwater, which are essential for sustaining life.
- **Lithosphere**: The solid outer part of the Earth, consisting of rocks, soils, and landforms that provide habitats and resources.
- **System**: A collection of components that interact to form a whole, with inputs, processes, and outputs.
- **Carbon cycle**: The natural process by which carbon moves between the atmosphere, biosphere, hydrosphere, and lithosphere.
- **Water cycle**: The continuous movement of water through evaporation, condensation, precipitation, and infiltration, linking different components of the environment.
- **Sustainability**: The ability to meet present needs without compromising the ability of future generations to meet their own needs.

- **Environmental management**: The planning and implementation of practices that protect and improve the environment.
- **Industrial revolution**: The period of rapid industrial growth in the eighteenth and nineteenth centuries, which created both technological advances and environmental challenges.
- **Silent Spring**: A book published by Rachel Carson in 1962 that highlighted the dangers of pesticides and marked a milestone in environmental awareness.
- **Renewable energy**: Energy derived from sources that are naturally replenished, such as solar, wind, and hydropower.
- **Biodiversity**: The variety of living organisms within a given ecosystem, region, or the entire planet.

Concept Check Questions

Objective questions

1. (Linked to SLO 2.1) Which of the following best defines environmental science?

a. The study of only plants and animals
b. The study of human interactions with the natural environment
c. The study of economic growth and development
d. The study of weather forecasting

2. (Linked to SLO 2.2) Which historical event contributed significantly to the emergence of environmental science as a discipline?

a. The discovery of electricity
b. The industrial revolution
c. The invention of the printing press
d. The space age

3. (Linked to SLO 2.3) Which of the following is NOT a component of the environment?

a. Atmosphere
b. Biosphere
c. Lithosphere
d. Technosphere

Short-answer questions

4. (Linked to SLO 2.1) Briefly explain why environmental science is relevant to contemporary society.

5. (Linked to SLO 2.3) Describe how the hydrosphere interacts with the biosphere in the water cycle.

Long-answer questions

6. Linked to SLO 2.2) Discuss the importance of Rachel Carson's *Silent Spring* and the 1972 United Nations Conference on the Human Environment in shaping environmental awareness.
7. (Linked to SLO 2.4) Evaluate three strategies for sustainable environmental management and explain how individuals and institutions can contribute to their success.

Answers to Pilot Questions

Pilot questions 1.1

1. Disciplines such as biology, chemistry, physics, geography, and social sciences contribute to environmental science.
2. The scope of environmental science refers to the range of topics it covers, including natural processes, environmental systems, and human impacts.
3. Environmental science is relevant because it helps societies address challenges like pollution, climate change, and resource depletion.
4. An example is using environmental science to design policies for forest conservation to reduce deforestation.
5. It promotes sustainability by equipping individuals and institutions with knowledge to manage resources responsibly.

Pilot questions 1.2

1. Early societies viewed the environment mainly as a source of resources and often explained natural events through supernatural beliefs.
2. The industrial revolution contributed significantly to the emergence of environmental science as a discipline.
3. Air pollution and deforestation are two major environmental problems caused by the industrial revolution.
4. Rachel Carson's *Silent Spring* and the 1972 United Nations Conference on the Human Environment are examples of milestones.
5. International agreements are important because they encourage collective global action to address environmental challenges.

Pilot questions 1.3

1. The four main components of the environment are the atmosphere, biosphere, hydrosphere, and lithosphere.
2. Viewing the environment as a system means recognising it as a collection of interacting components with inputs, processes, and outputs.
3. Pollution in rivers (hydrosphere) can harm fish populations (biosphere), which affects food supply for humans.
4. The carbon cycle demonstrates the movement of carbon among environmental components.
5. Human activities are significant because they alter natural cycles and disrupt environmental systems.

Pilot questions 1.4

1. Sustainability means meeting present needs without compromising the ability of future generations to meet their own needs.
2. Recycling and biodiversity conservation are examples of strategies for sustainable environmental management.
3. Recycling contributes to sustainability by reducing the demand for raw resources.
4. Individuals can promote sustainability by conserving water, reducing plastic use, and supporting green initiatives.
5. Institutions play a role by enforcing policies, providing education, and investing in sustainable technologies.

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Series 2 The Multidisciplinary Nature of the Environment

Outline for Series 2: The Multidisciplinary Nature of the Environment

2.1 Environmental science as a multidisciplinary field

- 2.1.1 Meaning of multidisciplinary approach
- 2.1.2 Disciplines contributing to environmental science
- 2.1.3 Benefits of multidisciplinary perspectives

2.2 Natural science contributions to environmental studies

- 2.2.1 Biology and ecology
- 2.2.2 Chemistry and physics
- 2.2.3 Geology and geography

2.3 Social science contributions to environmental studies

- 2.3.1 Economics and resource management
- 2.3.2 Sociology and human behaviour
- 2.3.3 Political science and policy development

2.4 Integrating disciplines for environmental problem-solving

- 2.4.1 Case studies of multidisciplinary solutions
- 2.4.2 Challenges in integration
- 2.4.3 Future directions for multidisciplinary approaches

Introduction

The environment is complex, and no single discipline can fully explain its processes or solve its challenges. For example, tackling climate change requires insights from physics to understand energy transfer, chemistry to analyse greenhouse gases, biology to assess impacts on ecosystems, and economics to evaluate costs and benefits of solutions. This interconnectedness makes environmental science inherently multidisciplinary, drawing strength from diverse fields to provide holistic understanding and practical solutions.

The aim of this Series is to highlight the multidisciplinary nature of environmental science by examining contributions from both natural and social sciences, and by showing how these perspectives can be integrated to address environmental problems effectively.

We shall commence this Series by exploring what it means for environmental science to be multidisciplinary, identifying the disciplines that contribute and the benefits of such perspectives. Next, we will examine the contributions of natural sciences such as biology, chemistry, physics, geology, and geography. Following that, we will turn to the social sciences, considering how economics, sociology, and political science enrich environmental studies. Finally, we will conclude by discussing how these disciplines can be integrated for problem-solving, illustrated with case studies, challenges, and future directions.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** define the meaning of a multidisciplinary approach in environmental science and explain its benefits,
- **SLO 3.2** describe the contributions of natural sciences such as biology, chemistry, physics, geology, and geography to environmental studies,
- **SLO 3.3** explain the role of social sciences including economics, sociology, and political science in environmental problem-solving,
- **SLO 3.4** evaluate how different disciplines can be integrated to address environmental challenges effectively, using case studies and examples

2.1 Environmental Science As A Multidisciplinary Field

2.1.1 Meaning of multidisciplinary approach

A **multidisciplinary approach** refers to the integration of knowledge, methods, and perspectives from different academic disciplines to address complex issues. In environmental science, this means combining insights from natural sciences such as biology and chemistry with social sciences like economics and sociology. By doing so, environmental science provides a holistic understanding of environmental problems and their solutions.

For example, studying air pollution requires chemistry to analyse pollutants, biology to assess impacts on health, and economics to evaluate the costs of control measures.

Fill in the blank: A multidisciplinary approach refers to the integration of knowledge, methods, and perspectives from different _____.

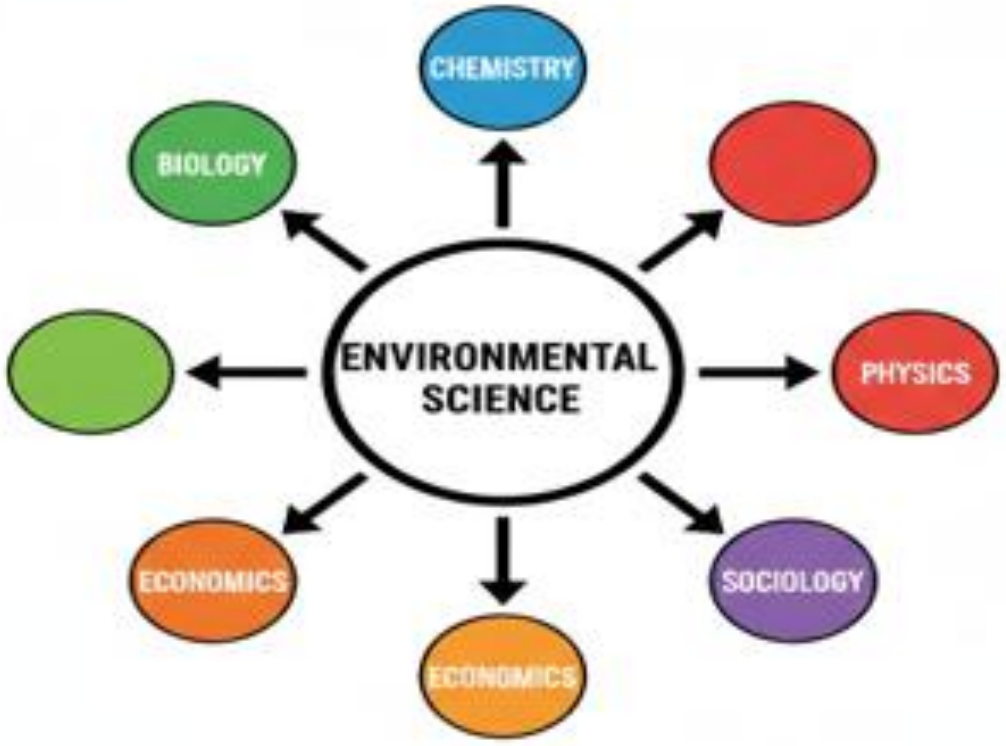


Figure 2.1: Environmental science as a multidisciplinary field

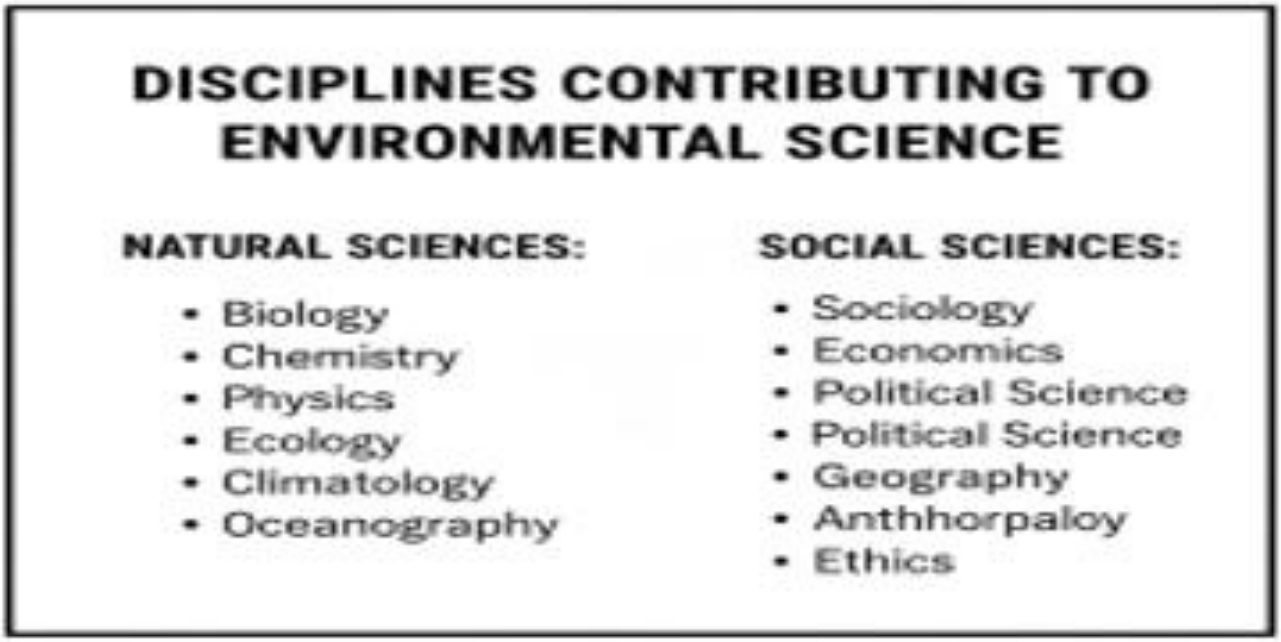
2.1.2 Disciplines contributing to environmental science

Several disciplines contribute to environmental science. **Biology** provides knowledge about ecosystems and biodiversity. **Chemistry** explains the composition of pollutants and their reactions. **Physics** helps in understanding energy transfer and climate dynamics.

Geology studies Earth's structure and resources, while **geography** examines spatial patterns of human–environment interactions.

On the social science side, **economics** evaluates resource use and costs, **sociology** studies human behaviour and social impacts, and **political science** focuses on policies and governance. Together, these disciplines enrich environmental science with diverse perspectives.

Fill in the blank: Biology contributes to environmental science by providing knowledge about ecosystems and _____.



Box 2.1: Disciplines contributing to environmental science

- Biology: ecosystems and biodiversity
- Chemistry: pollutants and reactions
- Physics: energy and climate
- Geology: Earth's structure and resources
- Geography: spatial patterns
- Economics: resource use and costs
- Sociology: human behaviour
- Political science: policies and governance

2.1.3 Benefits of multidisciplinary perspectives

The benefits of a multidisciplinary perspective in environmental science are significant. It allows for comprehensive problem-solving, as environmental issues are rarely confined to

one discipline. For instance, climate change involves physical processes, chemical reactions, biological impacts, economic costs, and political decisions.

A multidisciplinary approach also encourages collaboration among experts, leading to innovative solutions. It helps policymakers design strategies that are scientifically sound, socially acceptable, and economically feasible.

Fill in the blank: A multidisciplinary perspective in environmental science encourages _____ among experts, leading to innovative solutions.

Pilot questions 2.1

1. What does a multidisciplinary approach mean in environmental science?
2. Identify three disciplines that contribute to environmental science.
3. How does chemistry contribute to environmental science?
4. What is one benefit of adopting a multidisciplinary perspective?
5. Why is collaboration important in solving environmental problems?

2.2 Natural Science Contributions To Environmental Studies

2.2.1 Biology and ecology

Biology is the study of living organisms, while **ecology** focuses on how these organisms interact with each other and with their environment. In environmental science, biology and ecology help us understand biodiversity, food chains, and ecosystem dynamics. For example, ecologists study how deforestation affects species distribution and how pollution impacts aquatic life.

Fill in the blank: Ecology focuses on how organisms interact with each other and with their _____.

2.2.2 Chemistry and physics

Chemistry contributes to environmental science by explaining the composition of pollutants, chemical reactions in the atmosphere, and processes such as acid rain formation. **Physics** helps us understand energy transfer, radiation balance, and climate dynamics. Together, they explain phenomena like the greenhouse effect, ozone depletion, and renewable energy technologies.

Fill in the blank: Chemistry contributes to environmental science by explaining the composition of _____ and their reactions.

Box 2.2: Examples of chemistry and physics applications in environmental science

- Chemistry: air pollution analysis, water quality testing, soil chemistry
- Physics: energy transfer, climate modelling, renewable energy systems

2.2.3 Geology and geography

Geology studies the Earth's structure, rocks, soils, and natural resources. It helps environmental scientists understand processes such as erosion, earthquakes, and resource extraction. **Geography** examines spatial patterns of human–environment interactions, including land use, population distribution, and climate zones. These disciplines provide insights into how physical landscapes and human activities shape environmental outcomes.

Fill in the blank: Geography examines spatial patterns of human–environment interactions, including land use and _____ distribution.

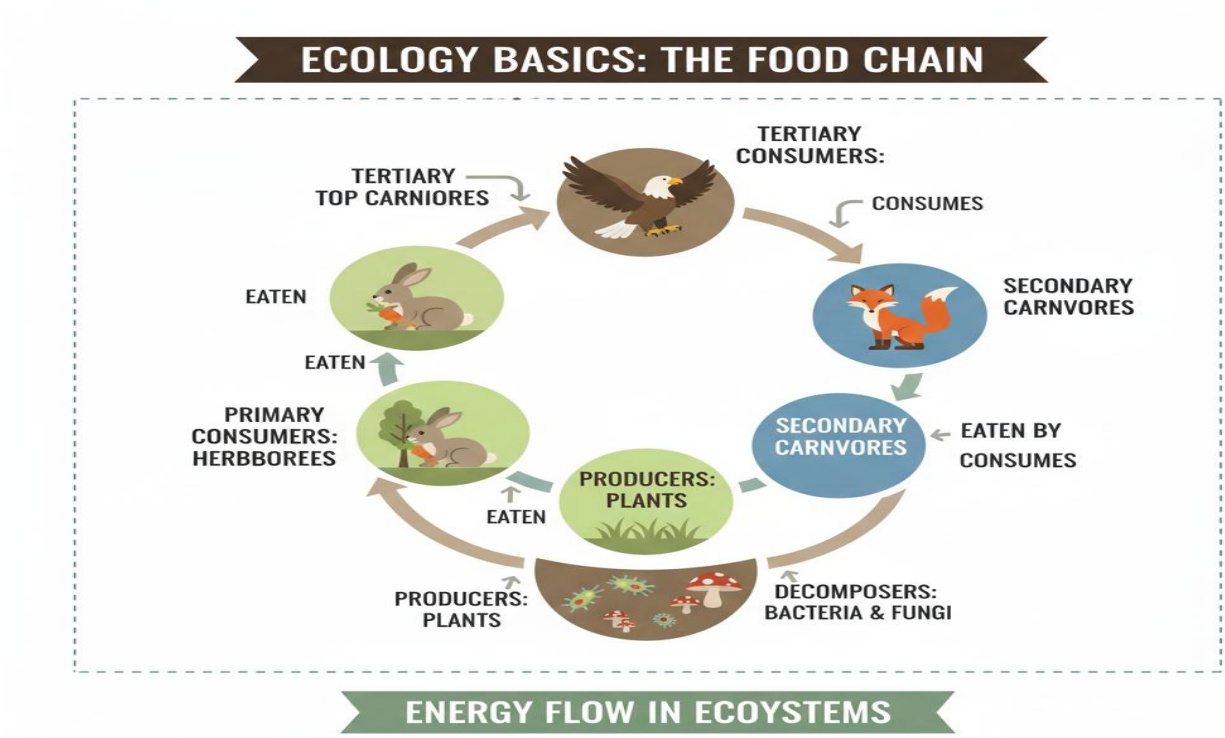


Plate 2.2: Geographic perspective on environment

Pilot questions 2.2

1. What is the role of biology and ecology in environmental science?
2. How does chemistry contribute to understanding environmental problems?
3. Give one example of how physics is applied in environmental studies.
4. What does geology study in relation to the environment?
5. How does geography help in understanding human–environment interactions?

2.3 Social Science Contributions To Environmental Studies

2.3.1 Economics and resource management

Economics plays a vital role in environmental science by analysing how resources are used, distributed, and conserved. It helps evaluate the costs and benefits of environmental policies, such as carbon taxes or renewable energy subsidies. Resource management, a branch of economics, focuses on the sustainable use of natural resources like forests, fisheries, and minerals.

For example, economists study how overfishing affects both ecosystems and livelihoods, and propose strategies such as quotas or incentives for sustainable practices.

Fill in the blank: Economics helps evaluate the costs and _____ of environmental policies.

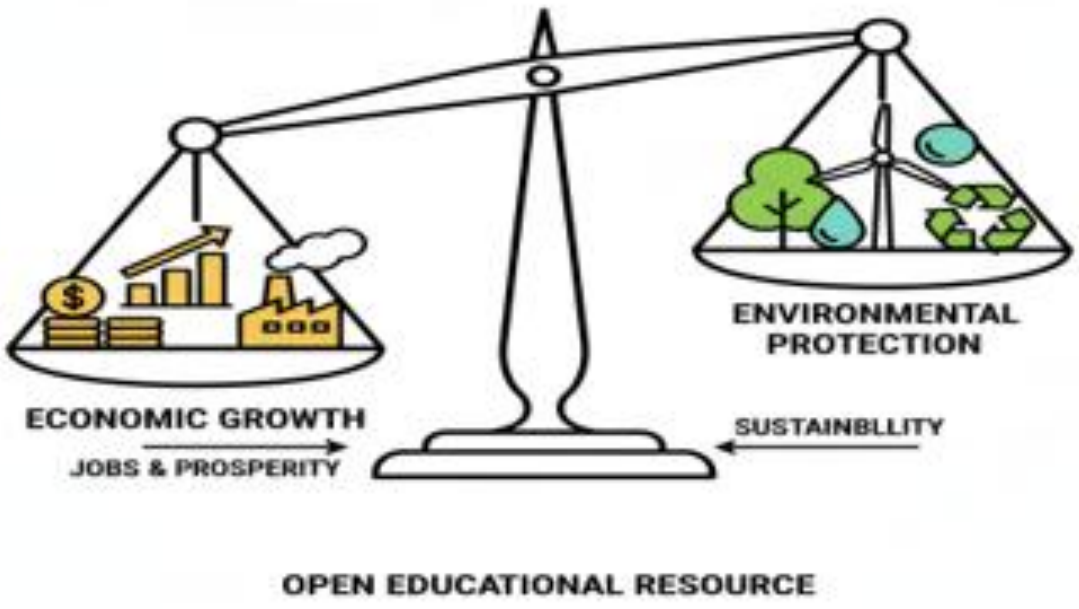


Figure 2.3: Economics and resource management in environmental science

2.3.2 Sociology and human behaviour

Sociology examines how human behaviour, culture, and social structures influence the environment. It helps explain why people adopt certain practices, such as recycling or deforestation, and how social norms shape environmental outcomes.

For instance, sociologists study how urbanisation affects waste generation, or how community participation can improve conservation projects. Understanding human behaviour is crucial for designing effective environmental policies and education programmes.

Fill in the blank: Sociology examines how human behaviour, culture, and _____ structures influence the environment.

Sociology plays a critical role in environmental science by shifting the focus from the physical environment to the human behaviors, social structures, and power dynamics that drive environmental change. It helps us understand why societies make specific

choices regarding resource use and how those choices affect different groups of people.

Sociology's Role in Environmental Science

Sociological Focus	Contribution to Environmental Knowledge
Environmental Justice	Examines how environmental hazards (like landfills or pollution) are disproportionately located in marginalized or low-income communities.
Human Behavior	Investigates the social drivers of consumption, identifying why people adopt or resist sustainable lifestyles and "green" technologies.
Policy & Governance	Analyzes how social institutions, laws, and corporate interests influence environmental legislation and global climate treaties.
Risk Perception	Studies how different cultures and social groups perceive environmental threats (like nuclear energy or GMOs) versus scientific data.
Urban Sociology	Explores the social organization of "green cities," looking at how public transport, housing density, and green spaces affect community well-being.
Social Movements	Tracks the rise of environmentalism and how grassroots activism influences public opinion and corporate accountability.

Box 2.3: Examples of sociology in environmental science

- Studying community participation in conservation
- Analysing urbanisation and waste generation
- Understanding cultural attitudes toward resource use

2.3.3 Political science and policy development

Political science contributes by analysing governance, laws, and policies that shape environmental management. Governments create regulations to control pollution, protect biodiversity, and manage resources. International agreements such as the Paris Climate Accord are examples of political action addressing global environmental issues.

Political science also studies how power, institutions, and public opinion influence environmental decision-making. Effective policies require collaboration between scientists, policymakers, and communities.

Fill in the blank: International agreements such as the _____ Climate Accord are examples of political action addressing global environmental issues.

Pilot questions 2.3

1. How does economics contribute to environmental science?
2. What is the role of sociology in understanding environmental issues?
3. Give one example of how human behaviour affects the environment.
4. What does political science study in relation to environmental management?
5. Why are international agreements important in addressing global environmental challenges?

2.4 Integrating Disciplines For Environmental Problem-Solving

2.4.1 Case studies of multidisciplinary solutions

Environmental problems are complex and require input from multiple disciplines. For example, addressing **climate change** involves:

- Physics (understanding energy balance and greenhouse effect),
- Chemistry (analysing carbon dioxide and methane reactions),
- Biology (studying impacts on ecosystems),
- Economics (evaluating costs of mitigation),
- Political science (developing international agreements).

Another case is **waste management**, which combines engineering (designing recycling systems), sociology (encouraging community participation), and economics (assessing cost-effectiveness).

Fill in the blank: Addressing climate change requires input from physics, chemistry, biology, economics, and _____ science.

Figure 2.4: Multidisciplinary approach to climate change

2.4.2 Challenges in integration

While multidisciplinary approaches are powerful, they face challenges. Different disciplines often use distinct methods, terminologies, and priorities. For instance, scientists may focus on data accuracy, while policymakers emphasise feasibility and public acceptance.

Coordination among experts can be difficult, and conflicts may arise when economic interests clash with ecological concerns. Limited resources and political will also hinder integration.

Fill in the blank: One challenge in multidisciplinary approaches is that different disciplines often use distinct _____ and priorities.

Challenges in Multidisciplinary Integration
• **Communication Barriers:** Different fields use specialized terminology and technical jargon, which can lead to misunderstandings or "lost in translation" moments between experts.

• **Conflicting Methodologies:** Disciplinary silos often have different standards for evidence, data collection, and research methods (e.g., qualitative social science vs. quantitative physical science).
• **Institutional Structures:** Many universities and funding agencies are organized by traditional departments, making it difficult to secure support or career credit for cross-cutting work.
• **Scale Mismatch:** Physical sciences might focus on global or long-term geological time scales, while social sciences or policy-making may focus on local, short-term human impacts.
• **Varying Values and Priorities:** Different disciplines may prioritize different outcomes, such as economic efficiency versus biodiversity preservation, leading to friction in decision-making.

Box 2.4: Challenges in integrating disciplines

- Different terminologies and methods
- Conflicting priorities (economic vs ecological)
- Limited resources
- Political and institutional barriers
  AI prompt suggestion: “Generate a text box listing challenges in integrating disciplines for environmental problem-solving.”
  Search string: “challenges multidisciplinary environmental science OER”

2.4.3 Future directions for multidisciplinary approaches

The future of environmental science lies in stronger integration of disciplines. Emerging fields such as **environmental engineering**, **climate economics**, and **sustainability studies** combine knowledge from multiple areas. Advances in technology, such as big data and artificial intelligence, also support multidisciplinary research by linking diverse datasets.

Global collaboration is essential, as environmental problems cross national boundaries. Universities and institutions are increasingly promoting interdisciplinary programmes to train future experts.

Fill in the blank: Emerging fields such as environmental engineering and climate economics combine knowledge from multiple _____.

Plate 2.4: Future directions in multidisciplinary environmental science

Pilot questions 2.4

1. Give one example of a multidisciplinary solution to an environmental problem.
2. What is one challenge faced when integrating disciplines?
3. How do economic interests sometimes clash with ecological concerns?
4. Name one emerging field that combines multiple disciplines in environmental science.
5. Why is global collaboration important for future environmental problem-solving?

Series Summary

In this Series, we explored how environmental science draws strength from multiple disciplines to provide a holistic understanding of environmental issues.

We began by defining the **multidisciplinary approach**, explaining that environmental science integrates knowledge from both natural and social sciences. We identified the wide range of contributing disciplines—biology, chemistry, physics, geology, geography,

economics, sociology, and political science—and highlighted the benefits of combining their perspectives, such as comprehensive problem-solving and innovative collaboration.

Next, we examined the **natural science contributions**, showing how biology and ecology explain ecosystems and biodiversity, chemistry and physics clarify pollution and energy dynamics, and geology and geography provide insights into Earth's structure and human–environment interactions.

We then turned to the **social sciences**, where economics helps evaluate resource use and costs, sociology explains human behaviour and cultural impacts, and political science addresses governance and international agreements. These perspectives demonstrate that environmental problems are not only scientific but also social, economic, and political in nature.

Finally, we discussed the **integration of disciplines for problem-solving**, using case studies such as climate change and waste management to illustrate how multiple fields must work together. We also considered challenges in integration, such as conflicting priorities and limited resources, and looked ahead to future directions, including emerging interdisciplinary fields and global collaboration.

Altogether, this Series has shown that environmental science is inherently multidisciplinary, requiring cooperation across diverse fields to address the complexity of environmental challenges. This foundation prepares you to appreciate the interconnectedness of knowledge as you move into later Series, where we will study energy dynamics, ecosystems, and human impacts in greater depth.

Glossary of Terms

- **Multidisciplinary approach**: The integration of knowledge, methods, and perspectives from different academic disciplines to address complex issues such as environmental problems.
- **Biology**: The study of living organisms, their structures, functions, and interactions. In environmental science, biology helps explain ecosystems, biodiversity, and species conservation.
- **Ecology**: A branch of biology that studies how organisms interact with each other and with their environment, focusing on ecosystems and energy flow.
- **Chemistry**: The study of matter and its interactions. In environmental science, chemistry explains pollutants, chemical reactions in the atmosphere, and processes like acid rain formation.
- **Physics**: The study of energy, matter, and their interactions. Physics contributes to understanding climate dynamics, radiation balance, and renewable energy technologies.

- **Geology**: The study of Earth's structure, rocks, soils, and natural resources. Geology helps explain processes such as erosion, earthquakes, and resource extraction.
- **Geography**: The study of spatial patterns and human–environment interactions, including land use, climate zones, and population distribution.
- **Economics**: The study of resource allocation, production, and consumption. In environmental science, economics evaluates costs and benefits of policies and promotes sustainable resource management.
- **Resource management**: The planning and regulation of natural resource use to ensure sustainability and prevent depletion.
- **Sociology**: The study of human behaviour, culture, and social structures. Sociology helps explain how social norms and practices influence environmental outcomes.
- **Political science**: The study of governance, laws, and policies. In environmental science, it examines how institutions and international agreements shape environmental management.
- **Integration of disciplines**: The process of combining knowledge from multiple fields to solve environmental problems more effectively.
- **Interdisciplinary research**: A collaborative approach that merges methods and insights from different disciplines to address complex issues like climate change and sustainability.

Concept Check Questions

Upon completing this Series, you should be able to attempt the following questions. Each question is linked to the Series Learning Outcomes (SLOs).

Objective Questions

1. (Linked to SLO 3.1) Which of the following best describes a multidisciplinary approach in environmental science?

a. Studying only plants and animals
b. Combining insights from multiple disciplines
c. Focusing only on economic growth
d. Limiting studies to physical sciences

2. (Linked to SLO 3.2) Which natural science discipline helps explain the composition of pollutants and their reactions?

a. Biology
b. Chemistry
c. Physics

d. Geography

3. (Linked to SLO 3.3) Which social science discipline studies human behaviour, culture, and social structures in relation to the environment?

a. Economics
b. Sociology
c. Political science
d. Geology

Short-Answer Questions

1. (Linked to SLO 3.1) Briefly explain why environmental science is considered multidisciplinary.
2. (Linked to SLO 3.2) Describe one way physics contributes to environmental science.
3. (Linked to SLO 3.3) How does sociology help in designing effective environmental policies?

Long-Answer Questions

1. (Linked to SLO 3.4) Discuss a case study (e.g., climate change or waste management) that demonstrates the integration of multiple disciplines in solving environmental problems.
2. (Linked to SLO 3.4) Evaluate the challenges of integrating disciplines in environmental science and suggest possible solutions for overcoming these challenges.

Pilot questions 2.1

1. A multidisciplinary approach in environmental science means integrating knowledge from different academic disciplines to solve complex environmental problems.
2. Three disciplines that contribute to environmental science are biology, chemistry, and economics.
3. Chemistry contributes by explaining the composition of pollutants and their chemical reactions in the environment.
4. One benefit of adopting a multidisciplinary perspective is comprehensive problem-solving that considers scientific, social, and economic dimensions.
5. Collaboration is important because it brings together diverse expertise, leading to innovative and practical solutions.

Pilot questions 2.2

1. Biology and ecology help explain ecosystems, biodiversity, and how organisms interact with their environment.
2. Chemistry contributes by analysing pollutants, water quality, and processes such as acid rain formation.
3. Physics is applied in environmental studies to understand energy transfer, radiation balance, and renewable energy systems.
4. Geology studies Earth's structure, rocks, soils, and natural resources in relation to environmental processes.
5. Geography helps by examining spatial patterns of human–environment interactions, such as land use and climate zones.

Pilot questions 2.3

1. Economics contributes by evaluating resource use, costs, and benefits of environmental policies.
2. Sociology helps by studying human behaviour, culture, and social structures that influence environmental practices.
3. An example of human behaviour affecting the environment is deforestation driven by agricultural expansion.
4. Political science studies governance, laws, and policies that shape environmental management.
5. International agreements are important because they encourage collective global action to address environmental challenges.

Pilot questions 2.4

1. A multidisciplinary solution example is climate change mitigation, which requires physics, chemistry, biology, economics, and political science.
2. One challenge faced when integrating disciplines is the use of different terminologies and priorities.
3. Economic interests sometimes clash with ecological concerns when resource exploitation provides short-term profits but harms ecosystems.
4. An emerging field that combines multiple disciplines is sustainability studies.
5. Global collaboration is important because environmental problems cross national boundaries and require collective solutions.

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Course code: GEO 105
Course title: Introduction to Environmental Sciences
Course credit load: 2 Units

Series 3 Systems and Components of the Environment

Series Outline

- **3.1 The Earth's major environmental systems**
- **3.2 The atmosphere and its components**
- **3.3 The hydrosphere and its components**
- **3.4 The lithosphere and its components**
- **3.5 The biosphere and its components**

Introduction

The environment is made up of interconnected systems that sustain life on Earth. These systems—atmosphere, hydrosphere, lithosphere, and biosphere—function together to regulate climate, support ecosystems, and provide resources for human survival. Each system has unique components and processes, but none operates in isolation.

Understanding these systems and their components is essential for environmental science. It helps us appreciate the complexity of Earth's natural processes and the delicate balance that sustains life.

This Series introduces the Earth's major environmental systems, examines their components, and explains how they interact to form a dynamic and interconnected whole.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** identify the Earth's major environmental systems,
- **SLO 3.2** describe the structure and components of the atmosphere,
- **SLO 3.3** explain the hydrosphere and its role in sustaining life,
- **SLO 3.4** analyse the lithosphere and its resources,
- **SLO 3.5** evaluate the biosphere and its interactions with other systems.

3.1 The Earth's Major Environmental Systems

3.1.1 Definition of environmental systems

Environmental systems are large, interconnected units of the Earth that regulate natural processes and sustain life. They include the **atmosphere, hydrosphere, lithosphere, and biosphere**. Each system has distinct components, but they interact continuously to form a dynamic whole.

Fill in the blank: The four major environmental systems are atmosphere, hydrosphere, lithosphere, and _____.

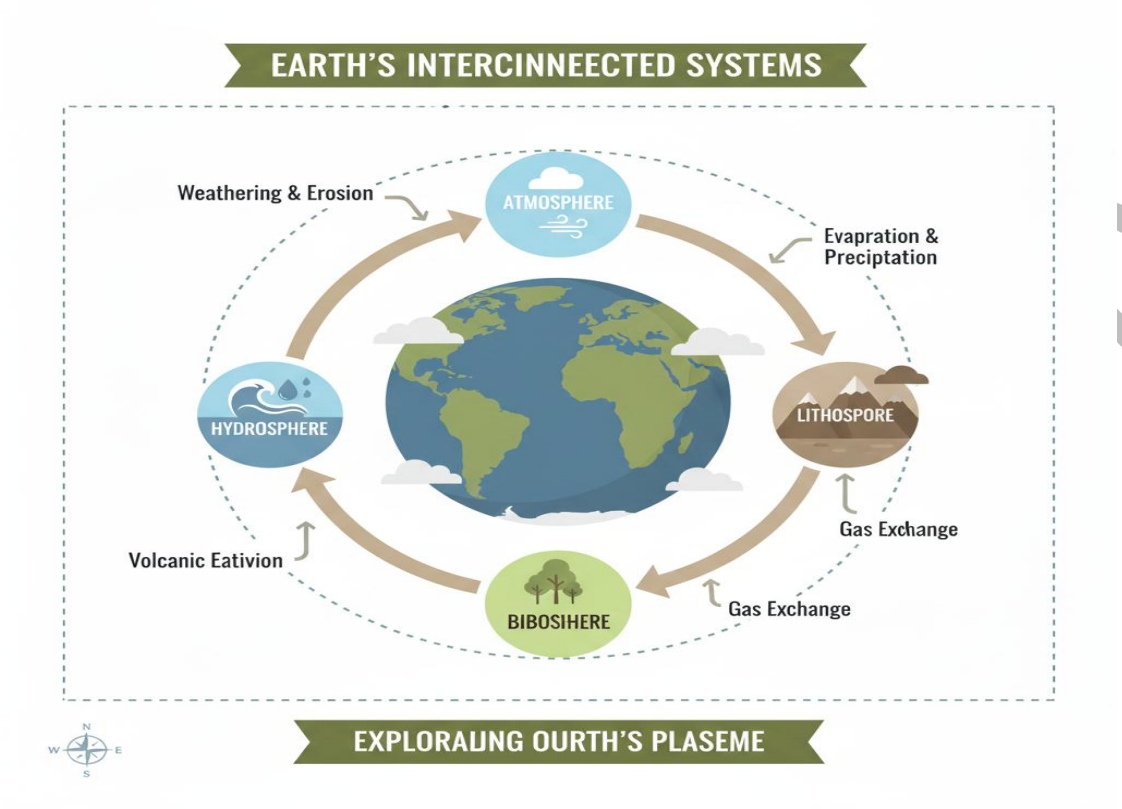


Figure 3.1: The Earth's major environmental systems

3.1.2 Interactions among environmental systems

These systems are not isolated; they interact constantly:

- The **atmosphere** influences climate and weather, which affect the biosphere.
- The **hydrosphere** provides water for organisms and shapes landscapes in the lithosphere.
- The **lithosphere** supplies nutrients and minerals to the biosphere.
- The **biosphere** depends on and modifies all other systems through living processes.

Fill in the blank: The atmosphere influences climate and weather, which directly affect the _____.

Earth's four spheres—the **atmosphere**, **hydrosphere**, **lithosphere**, and **biosphere**—do not exist in isolation. They are constantly exchanging matter and energy through complex interactions.

Examples of Earth System Interactions

- **Atmosphere ↔ Hydrosphere:** Evaporation of water from oceans (hydrosphere) provides moisture for clouds and precipitation in the air (atmosphere). Conversely, winds drive surface ocean currents.
- **Biosphere ↔ Atmosphere:** Plants (biosphere) take in carbon dioxide and release oxygen during photosynthesis. Animals then breathe that oxygen and release CO_2.
- **Lithosphere ↔ Hydrosphere:** Water (hydrosphere) causes the physical and chemical weathering of rocks (lithosphere), carving out river valleys and transporting sediment to the sea.
- **Lithosphere ↔ Atmosphere:** Volcanic eruptions (lithosphere) release massive amounts of ash and gases into the air (atmosphere), which can temporarily cool the planet's climate.
- **Biosphere ↔ Lithosphere:** Decaying organic matter from plants and animals (biosphere) mixes with weathered rock to form soil (lithosphere), while roots help break apart stones.
- Atmosphere ↔ Hydrosphere: rainfall and evaporation
- Hydrosphere ↔ Lithosphere: rivers shaping valleys
- Lithosphere ↔ Biosphere: soil providing nutrients for plants
- Biosphere ↔ Atmosphere: respiration and photosynthesis

3.1.3 Importance of environmental systems

Understanding environmental systems is crucial because:

- They regulate Earth’s climate and weather.
- They provide essential resources (air, water, soil, minerals).
- They sustain biodiversity and ecosystems.
- They maintain balance through cycles (carbon, nitrogen, water).

Fill in the blank: Environmental systems provide essential resources such as air, water, soil, and _____.

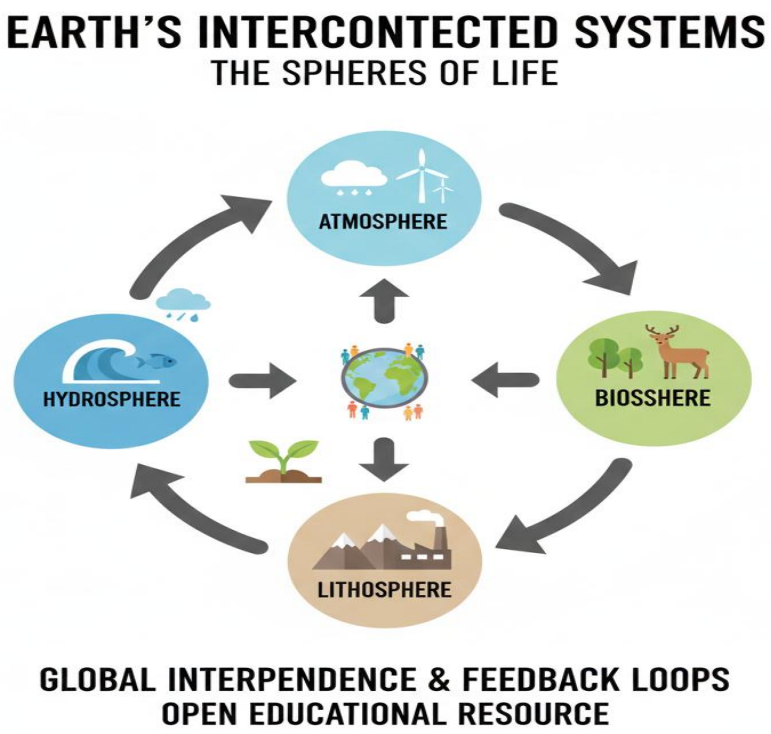


Plate 3.1: Importance of environmental systems in sustaining life

Pilot questions 3.1

1. What are the four major environmental systems?
2. Give one example of interaction between the atmosphere and hydrosphere.
3. Why are environmental systems important for sustaining life?
4. Which system provides nutrients and minerals to the biosphere?
5. How does the biosphere interact with the atmosphere?

3.2 The Atmosphere and Its Components

3.2.1 Definition of the atmosphere

The **atmosphere** is the layer of gases surrounding the Earth, held in place by gravity. It protects life by absorbing harmful solar radiation, regulating temperature, and enabling weather and climate systems.

Fill in the blank: The atmosphere is the layer of _____ surrounding the Earth, held in place by gravity.

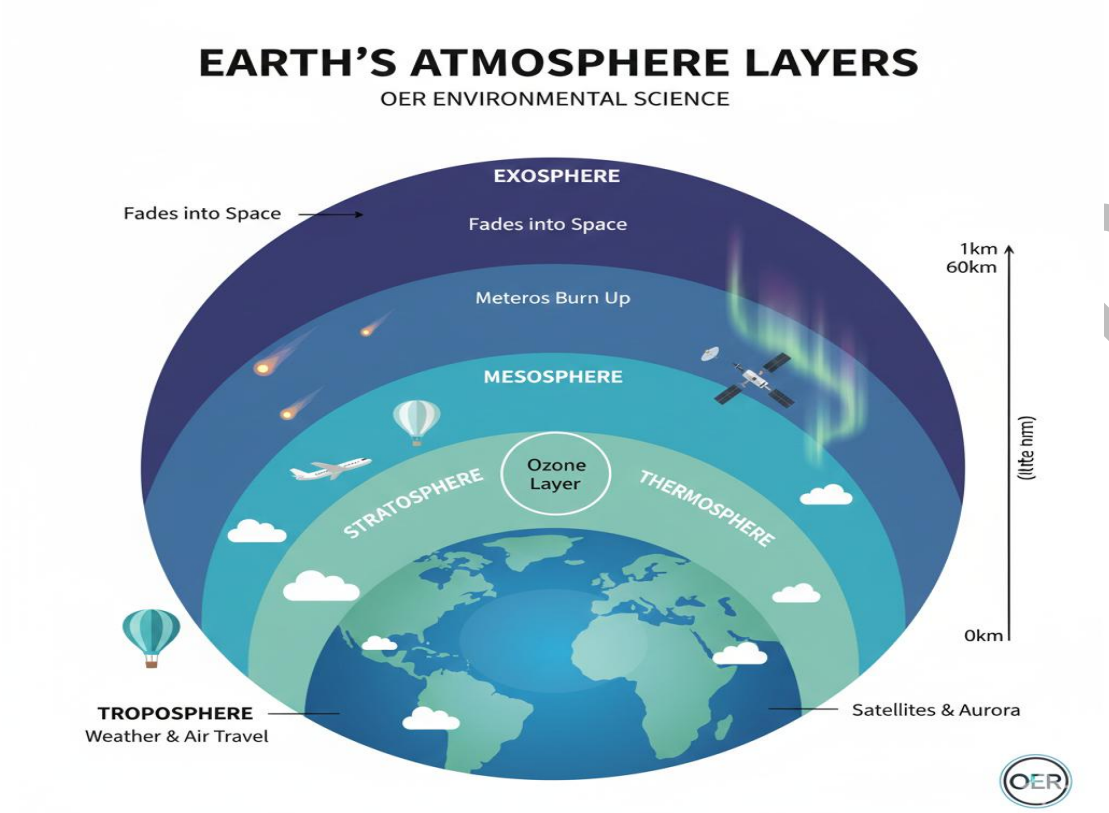


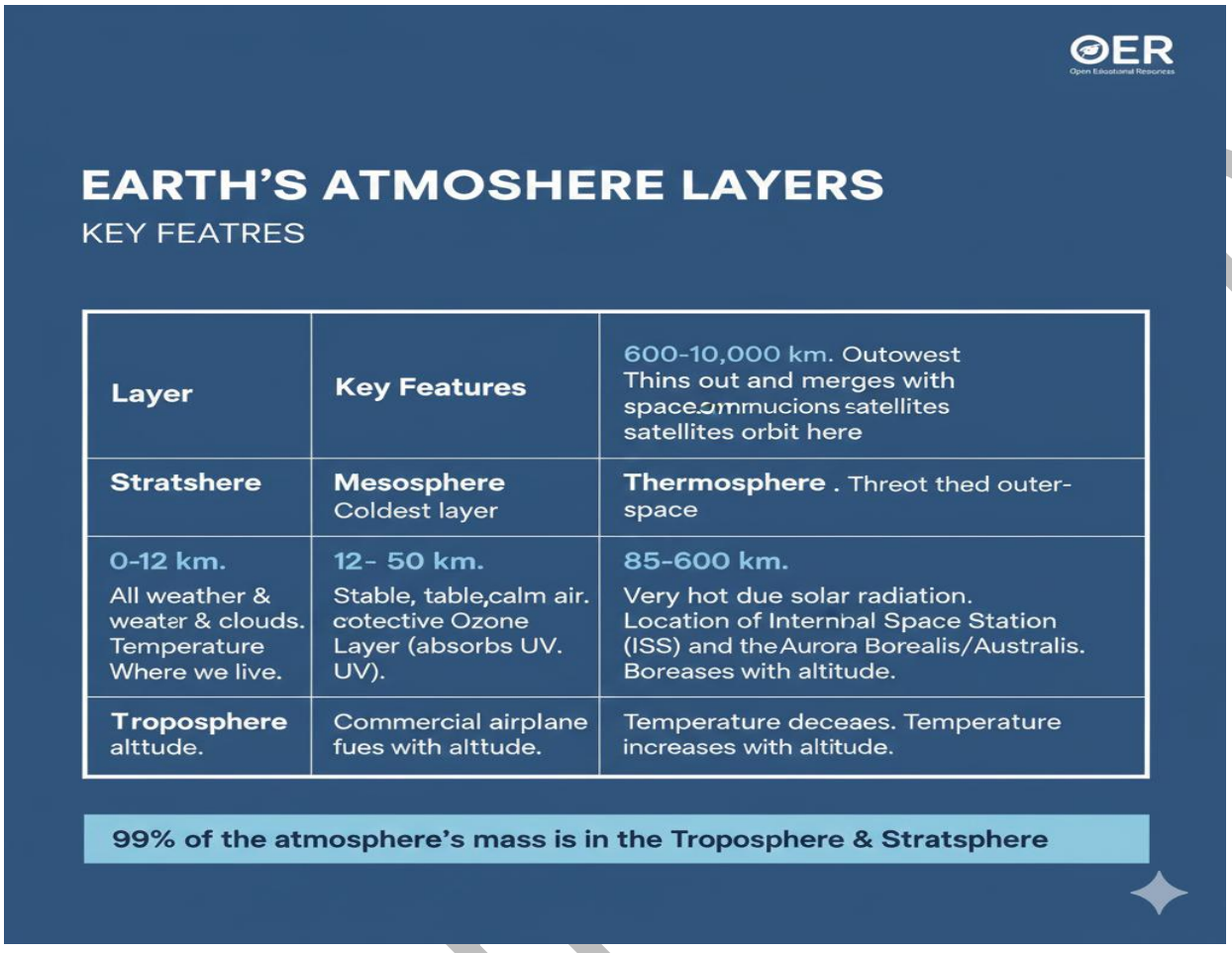
Figure 3.2: The atmosphere surrounding Earth

3.2.2 Layers of the atmosphere

The atmosphere is divided into five main layers:

- **Troposphere**: closest to Earth, where weather occurs.
- **Stratosphere**: contains the ozone layer, which absorbs harmful UV radiation.
- **Mesosphere**: where meteors burn up.
- **Thermosphere**: contains auroras and satellites orbit.
- **Exosphere**: outermost layer, merging into space.

Fill in the blank: The ozone layer is found in the _____.



Box 3.2: Layers of the atmosphere

- Troposphere → weather
- Stratosphere → ozone layer
- Mesosphere → meteors burn
- Thermosphere → auroras, satellites
- Exosphere → outer space boundary

3.2.3 Composition of the atmosphere

The atmosphere is composed mainly of:

- **Nitrogen (78%)**
- **Oxygen (21%)**
- **Argon (0.93%)**
- **Carbon dioxide (0.04%)**
- Trace gases (neon, helium, methane, ozone, water vapour).

Fill in the blank: Oxygen makes up about _____% of the Earth's atmosphere.

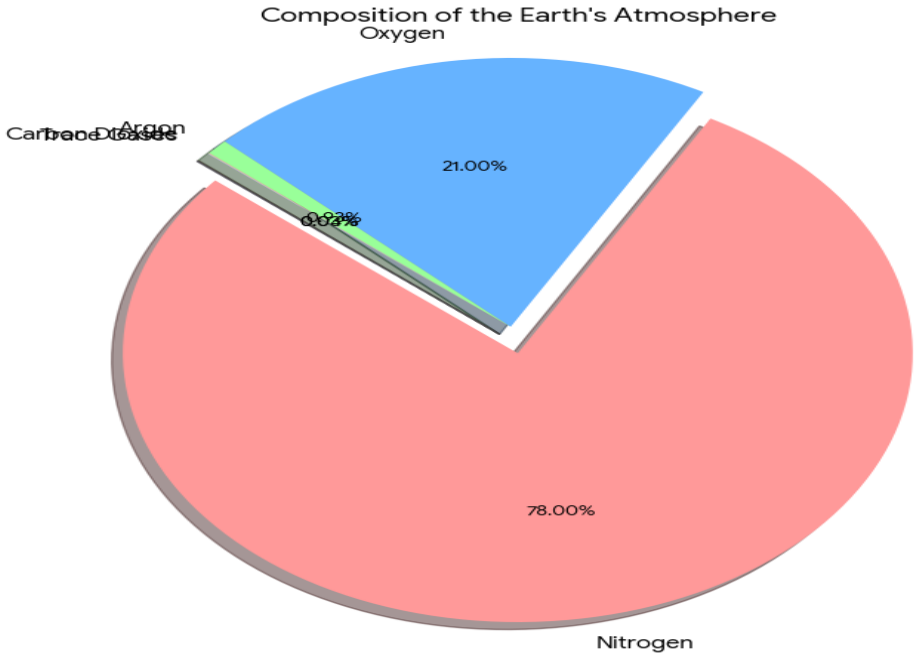


Plate 3.2: Composition of the atmosphere

3.2.4 Importance of the atmosphere

The atmosphere is vital because it:

- Provides oxygen for respiration and carbon dioxide for photosynthesis.
- Protects life from harmful solar radiation.
- Regulates Earth's temperature through the greenhouse effect.
- Enables weather and climate systems.

Fill in the blank: The atmosphere regulates Earth's temperature through the _____ effect.

Pilot questions 3.2

1. What is the atmosphere and what does it do?
2. Name the five layers of the atmosphere.
3. In which layer is the ozone found?
4. What are the two most abundant gases in the atmosphere?
5. Why is the atmosphere important for sustaining life?

3.3 The Hydrosphere and Its Components

3.3.1 Definition of the hydrosphere

The **hydrosphere** refers to all the water present on Earth, including oceans, seas, rivers, lakes, glaciers, groundwater, and water vapour in the atmosphere. It covers about 71% of the Earth's surface and is essential for sustaining life and regulating climate.

Fill in the blank: The hydrosphere covers about _____% of the Earth's surface.

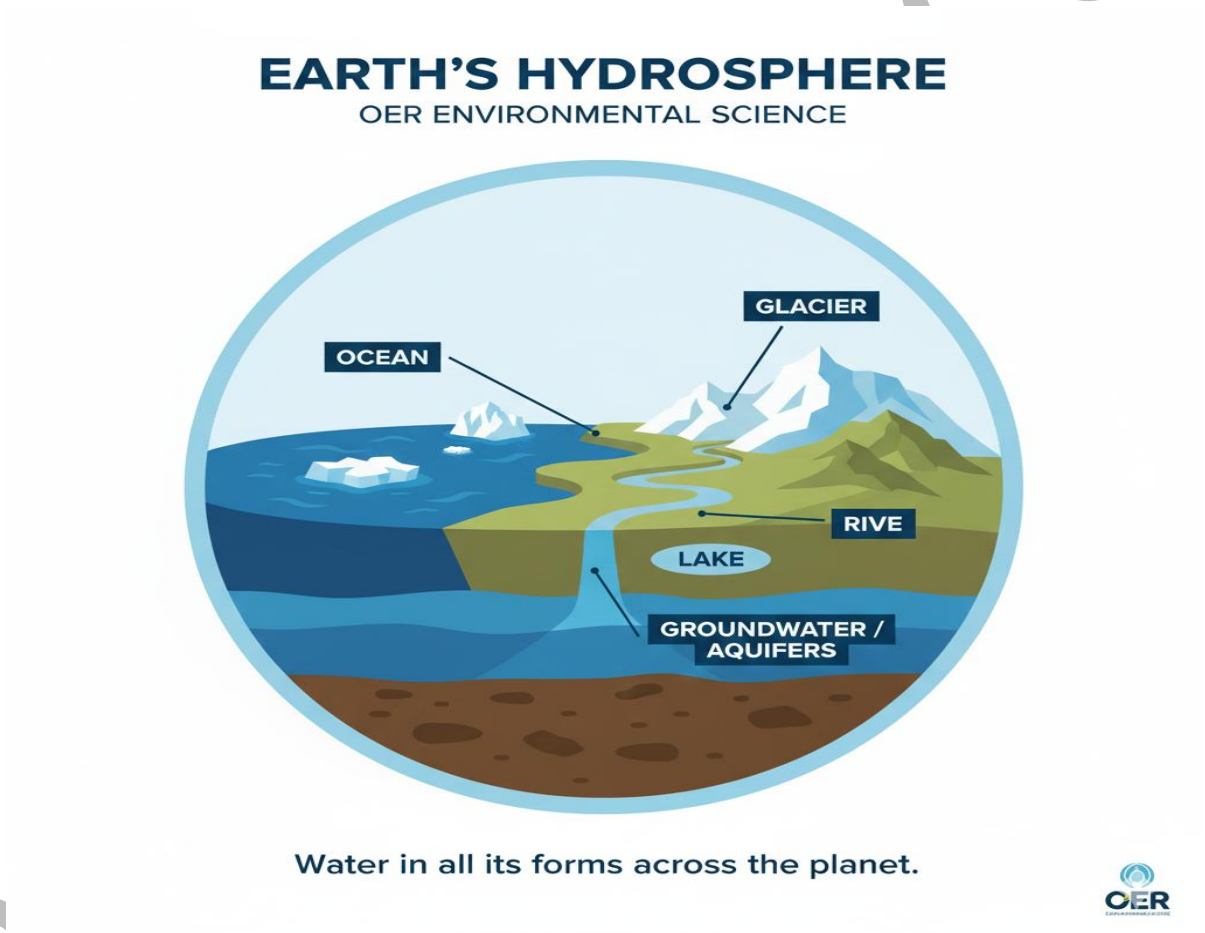


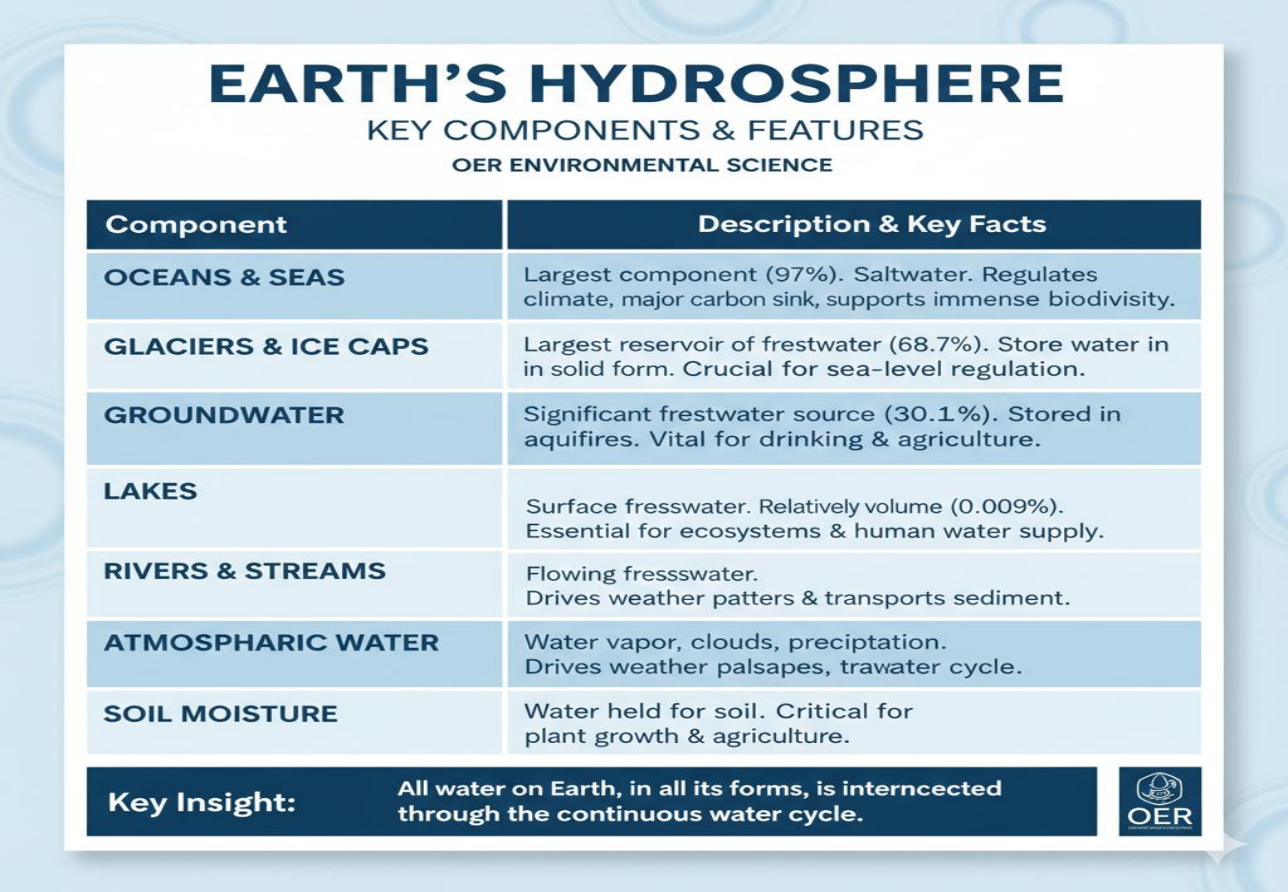
Figure 3.3: The hydrosphere of Earth

3.3.2 Components of the hydrosphere

The hydrosphere includes:

- **Oceans and seas**: largest reservoirs of water, influencing climate and weather.
- **Rivers and lakes**: freshwater sources for ecosystems and human use.
- **Glaciers and ice caps**: store freshwater and regulate sea levels.
- **Groundwater**: water stored beneath the Earth's surface in aquifers.
- **Atmospheric water vapour**: drives the water cycle through evaporation and precipitation.

Fill in the blank: Water stored beneath the Earth's surface in aquifers is called _____.



Box 3.3: Components of the hydrosphere

- Oceans and seas
- Rivers and lakes
- Glaciers and ice caps
- Groundwater
- Atmospheric water vapour

3.3.3 Importance of the hydrosphere

The hydrosphere is vital because it:

- Provides water for drinking, agriculture, and industry.
- Supports aquatic ecosystems and biodiversity.
- Regulates Earth's climate through ocean currents and the water cycle.
- Shapes landscapes through erosion and deposition.
- Acts as a medium for transportation and trade.

Fill in the blank: The hydrosphere regulates Earth's climate through ocean currents and the _____ cycle.

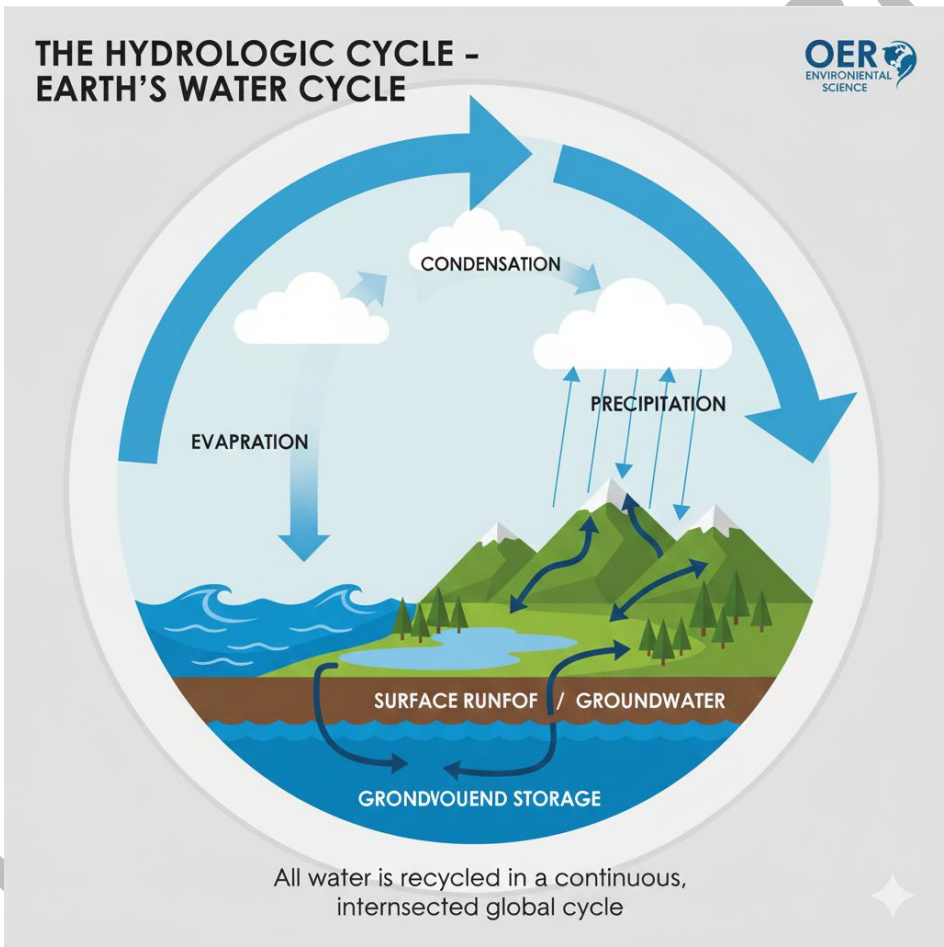


Plate 3.3: The hydrosphere and its role in sustaining life

Pilot questions 3.3

1. What is the hydrosphere?
2. Name three components of the hydrosphere.
3. What is groundwater and where is it stored?

4. How does the hydrosphere regulate Earth's climate?
5. Give one example of how the hydrosphere supports human activities.

3.4 The Lithosphere and Its Components

3.4.1 Definition of the lithosphere

The **lithosphere** is the rigid outer layer of the Earth, consisting of the crust and the uppermost mantle. It forms the solid surface on which we live and provides essential resources such as soil, minerals, and fossil fuels.

Fill in the blank: The lithosphere is made up of the Earth's crust and the uppermost part of the _____.

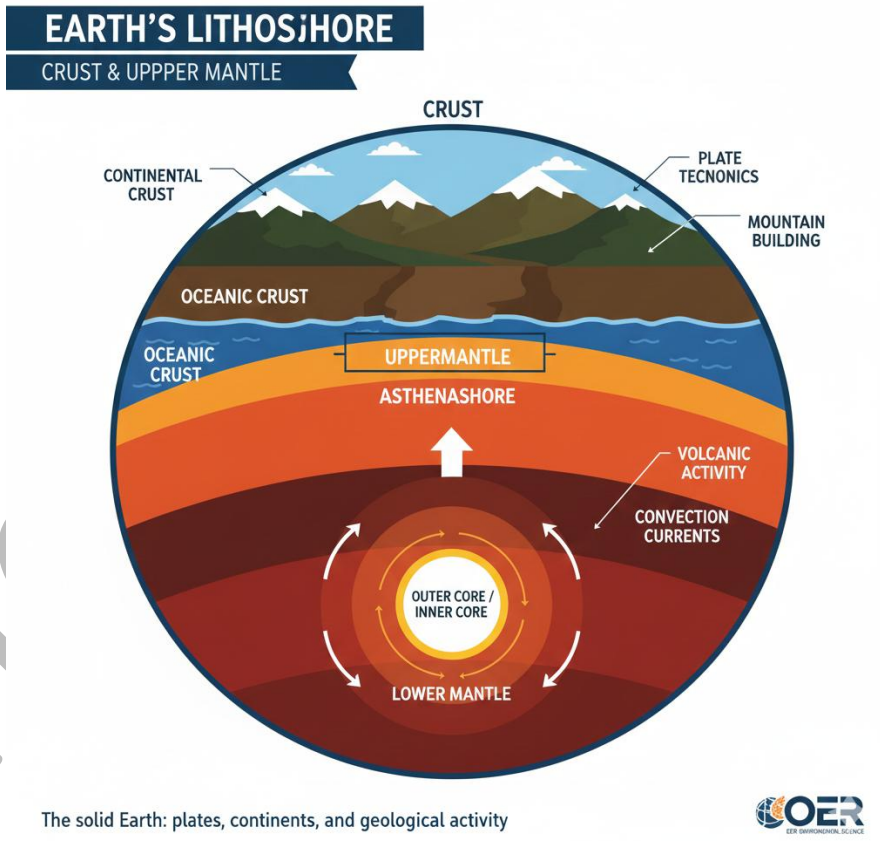


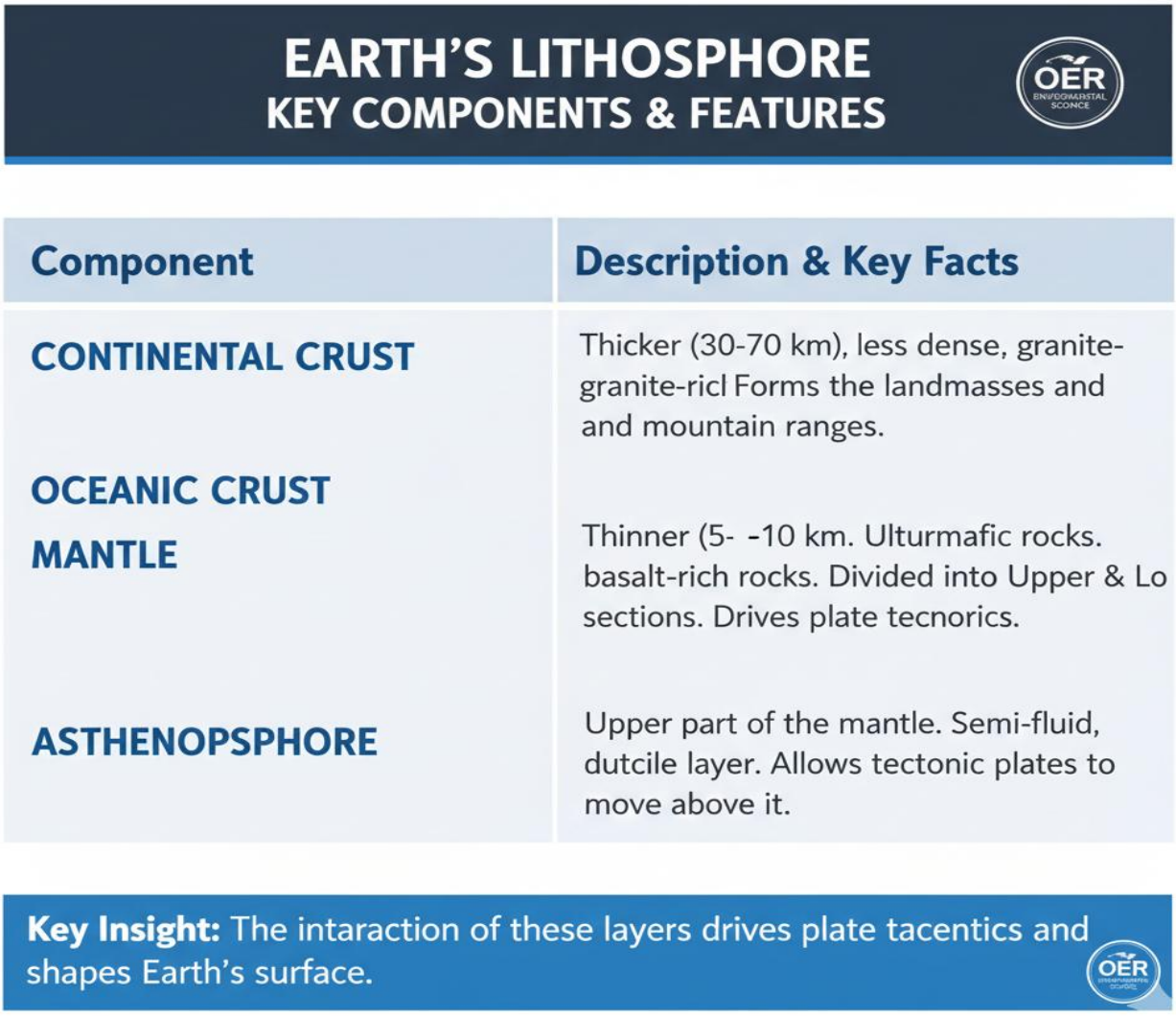
Figure 3.4: The lithosphere of Earth

3.4.2 Components of the lithosphere

The lithosphere includes:

- **Continental crust**: thick, less dense, composed mainly of granite.
- **Oceanic crust**: thinner, denser, composed mainly of basalt.
- **Upper mantle**: rigid portion beneath the crust.
- **Soil**: formed from weathered rock, essential for plant growth.
- **Minerals and rocks**: provide raw materials for human use.

Fill in the blank: The oceanic crust is thinner and denser, composed mainly of _____.



Box 3.4: Components of the lithosphere

- Continental crust → granite
- Oceanic crust → basalt
- Upper mantle → rigid rock

- Soil → supports plants
- Minerals and rocks → resources for humans

3.4.3 Importance of the lithosphere

The lithosphere is vital because it:

- Provides land for human settlement and agriculture.
- Supplies minerals, fossil fuels, and building materials.
- Supports ecosystems through soil formation.
- Influences tectonic activity (earthquakes, volcanoes, mountain building).

Fill in the blank: The lithosphere supports ecosystems through the formation of _____.

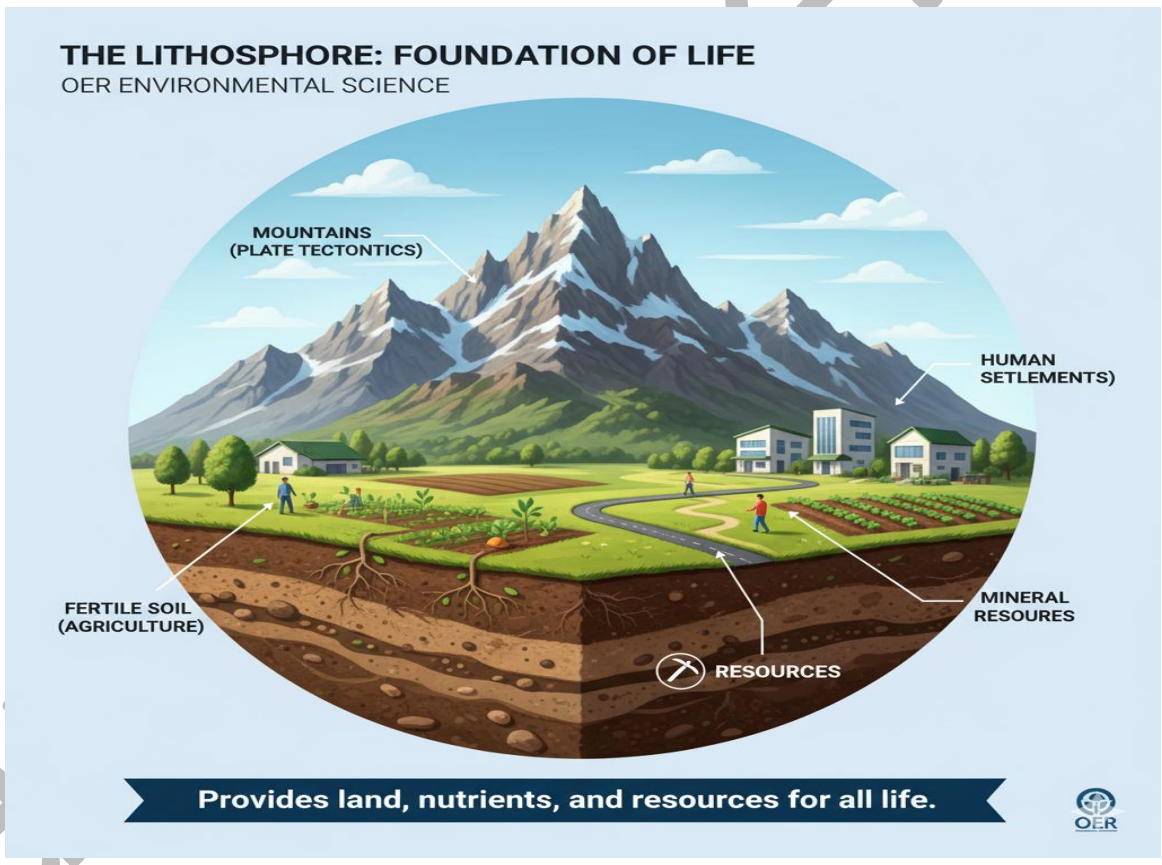


Plate 3.4: The lithosphere and its role in human and natural systems

Pilot questions 3.4

1. What is the lithosphere?
2. Name two differences between continental crust and oceanic crust.
3. What is soil and why is it important?
4. List two resources provided by the lithosphere.
5. How does the lithosphere influence tectonic activity?

3.4 The Lithosphere and Its Components

3.4.1 Definition of the lithosphere

The **lithosphere** is the rigid outer layer of the Earth, consisting of the crust and the uppermost mantle. It forms the solid surface on which humans and other organisms live and provides essential resources such as soil, minerals, and fossil fuels.

Fill in the blank: The lithosphere is made up of the Earth's crust and the uppermost part of the _____.

3.4.2 Components of the lithosphere

- Continental crust → thick, less dense, mainly granite.
- Oceanic crust → thinner, denser, mainly basalt.
- Upper mantle → rigid portion beneath the crust.
- Soil → formed from weathered rock, essential for plant growth.
- Minerals and rocks → raw materials for human use.

Fill in the blank: The oceanic crust is thinner and denser, composed mainly of _____.

3.4.3 Importance of the lithosphere

The lithosphere is vital because it:

- Provides land for human settlement and agriculture.
- Supplies minerals, fossil fuels, and building materials.
- Supports ecosystems through soil formation.
- Influences tectonic activity (earthquakes, volcanoes, mountain building).

Fill in the blank: The lithosphere supports ecosystems through the formation of _____.

3.4.4 Visuals

- **Figure 3.4**: Diagram showing Earth's internal structure highlighting the lithosphere.

- **Box 3.4**: Components of the lithosphere (continental crust, oceanic crust, upper mantle, soil, minerals).
- **Plate 3.4**: Image showing mountains, soil, and human settlements to illustrate the lithosphere's role.

Pilot Questions 3.4

1. What is the lithosphere?
2. Name two differences between continental crust and oceanic crust.
3. What is soil and why is it important?
4. List two resources provided by the lithosphere.
5. How does the lithosphere influence tectonic activity?

3.5 The Biosphere and Its Components

3.5.1 Definition of the biosphere

The **biosphere** is the global sum of all ecosystems, encompassing all living organisms (plants, animals, microorganisms) and the environments in which they interact. It is the zone of life on Earth, extending into the atmosphere, across the land, and within the oceans.

Fill in the blank: The biosphere is the global sum of all _____ on Earth.

3.5.2 Components of the biosphere

The biosphere includes:

- **Flora (plants)** → producers that convert solar energy into food through photosynthesis.
- **Fauna (animals)** → consumers that depend on plants and other organisms for energy.
- **Microorganisms** → decomposers that recycle nutrients back into ecosystems.
- **Habitats and ecosystems** → environments where organisms interact with each other and with non-living components.

Fill in the blank: Organisms that recycle nutrients back into ecosystems are called _____.

3.5.3 Importance of the biosphere

The biosphere is vital because it:

- Sustains biodiversity and ecological balance.
- Provides food, medicine, and raw materials.
- Regulates climate through carbon and oxygen cycles.
- Maintains soil fertility and water purification.
- Supports human life and cultural development.

Fill in the blank: The biosphere regulates climate through the carbon and _____ cycles.

3.5.4 Visuals

- **Figure 3.5**: Diagram showing the biosphere as the zone of life on Earth.
- **Box 3.5**: Components of the biosphere (flora, fauna, microorganisms, ecosystems).
- **Plate 3.5**: Image showing forests, oceans, and animals to illustrate the biosphere.

Pilot Questions 3.5

1. What is the biosphere?
2. Name three components of the biosphere.
3. What role do microorganisms play in the biosphere?
4. How does the biosphere regulate climate?
5. Why is the biosphere important for human survival?

Summary

In this Series, we examined the **four major environmental systems** that make up the Earth: the **atmosphere, hydrosphere, lithosphere, and biosphere**. Each system has unique components and functions, but they are interconnected and constantly interact to sustain life.

- The **atmosphere** is the layer of gases surrounding Earth. It regulates temperature, enables weather and climate, and provides oxygen and carbon dioxide essential for life.
- The **hydrosphere** includes all water on Earth—oceans, rivers, lakes, glaciers, and groundwater. It drives the water cycle, regulates climate, and supports ecosystems and human activities.
- The **lithosphere** is the rigid outer layer of Earth, consisting of the crust and upper mantle. It provides land, soil, minerals, and fossil fuels, and influences tectonic activity.
- The **biosphere** encompasses all living organisms and ecosystems. It sustains biodiversity, regulates cycles (carbon, oxygen), and supports human survival and cultural development.

Together, these systems form a **dynamic and interconnected whole**. Their interactions—such as rainfall linking atmosphere and hydrosphere, or soil linking lithosphere and biosphere—illustrate the delicate balance that sustains life on Earth.

Glossary

- **Atmosphere**: The layer of gases surrounding Earth, essential for climate, weather, and life support.
- **Troposphere**: The lowest atmospheric layer where weather occurs.
- **Stratosphere**: Atmospheric layer containing the ozone, which absorbs harmful UV radiation.
- **Hydrosphere**: All water on Earth, including oceans, rivers, lakes, glaciers, groundwater, and vapour.
- **Groundwater**: Water stored beneath Earth's surface in aquifers.
- **Lithosphere**: The rigid outer layer of Earth, made up of the crust and upper mantle.
- **Continental crust**: Thick, less dense crust composed mainly of granite.
- **Oceanic crust**: Thin, dense crust composed mainly of basalt.
- **Soil**: Weathered rock that supports plant growth and ecosystems.
- **Minerals**: Naturally occurring substances in the lithosphere used as resources.
- **Biosphere**: The global zone of life, including all living organisms and ecosystems.
- **Flora**: Plant life within the biosphere.
- **Fauna**: Animal life within the biosphere.
- **Microorganisms**: Decomposers that recycle nutrients in ecosystems.
- **Ecosystem**: A community of organisms interacting with each other and their environment.
- **Biodiversity**: The variety of life forms within the biosphere.

Concept Check Questions

Objective Questions

1. Which atmospheric layer contains the ozone?

a. Troposphere
b. Stratosphere
c. Mesosphere
d. Thermosphere

2. What percentage of Earth's surface is covered by the hydrosphere?

a. 50%
b. 71%
c. 80%
d. 90%

3. The lithosphere is composed of the crust and the _____.

a. Inner core
b. Outer core
c. Upper mantle
d. Lower mantle

4. Organisms that recycle nutrients back into ecosystems are called:

a. Producers
b. Consumers
c. Decomposers
d. Parasites

5. The atmosphere regulates Earth's temperature through the _____ effect.

a. Albedo
b. Greenhouse
c. Coriolis
d. Doppler

Short-Answer Questions

1. Define the biosphere.
2. Name two components of the hydrosphere.
3. What is the main difference between continental crust and oceanic crust?
4. Why is soil important for ecosystems?
5. List two gases that make up the majority of the atmosphere.

Long-Answer Questions

1. Explain how the atmosphere, hydrosphere, lithosphere, and biosphere interact to sustain life.
2. Discuss the importance of the hydrosphere in regulating climate and supporting human activities.
3. Analyse the role of microorganisms in the biosphere.
4. Evaluate the significance of the lithosphere in providing resources and influencing tectonic activity.

5. Describe how the atmosphere contributes to both protecting life and enabling climate systems.

Answers

Answers to Pilot Questions

3.1 The Earth's Major Environmental Systems

1. The four major environmental systems are atmosphere, hydrosphere, lithosphere, and biosphere.
2. Rainfall is an example of interaction between the atmosphere and hydrosphere.
3. Environmental systems are important because they sustain life and regulate Earth's processes.
4. The lithosphere provides nutrients and minerals to the biosphere.
5. The biosphere interacts with the atmosphere through respiration and photosynthesis.

3.2 The Atmosphere and Its Components

1. The atmosphere is the layer of gases surrounding Earth; it protects life and regulates climate.
2. The five layers are troposphere, stratosphere, mesosphere, thermosphere, and exosphere.
3. The ozone layer is found in the stratosphere.
4. The two most abundant gases are nitrogen (78%) and oxygen (21%).
5. The atmosphere is important because it provides oxygen, protects from radiation, and regulates temperature.

3.3 The Hydrosphere and Its Components

1. The hydrosphere is all the water on Earth.
2. Oceans, rivers, and glaciers are components of the hydrosphere.
3. Groundwater is water stored beneath Earth's surface in aquifers.
4. The hydrosphere regulates climate through ocean currents and the water cycle.
5. It supports human activities such as agriculture, industry, and transportation.

3.4 The Lithosphere and Its Components

1. The lithosphere is the rigid outer layer of Earth, made up of crust and upper mantle.
2. Continental crust is thick and granite-based; oceanic crust is thin and basalt-based.

3. Soil is weathered rock that supports plant growth and ecosystems.
4. Resources include minerals, fossil fuels, and building materials.
5. The lithosphere influences tectonic activity through earthquakes, volcanoes, and mountain building.

3.5 The Biosphere and Its Components

1. The biosphere is the global sum of all ecosystems and living organisms.
2. Components include flora (plants), fauna (animals), and microorganisms.
3. Microorganisms act as decomposers, recycling nutrients.
4. The biosphere regulates climate through carbon and oxygen cycles.
5. It is important because it sustains biodiversity and supports human survival.

Objective Questions

a. Stratosphere
b. 71%
c. Upper mantle
d. Decomposers
e. Greenhouse

Short-Answer Questions

1. The biosphere is the zone of life on Earth, including all living organisms and ecosystems.
2. Oceans and rivers (any two components).
3. Continental crust is thick and granite-based; oceanic crust is thin and basalt-based.
4. Soil supports plant growth, provides nutrients, and sustains ecosystems.
5. Nitrogen and oxygen.

Long-Answer Questions

1. The four systems interact: atmosphere provides gases, hydrosphere supplies water, lithosphere provides land and nutrients, biosphere sustains life — together they maintain balance.
2. The hydrosphere regulates climate via ocean currents, supports biodiversity in aquatic ecosystems, and provides water for human use.
3. Microorganisms decompose organic matter, recycle nutrients, and maintain ecosystem balance.
4. The lithosphere provides resources (minerals, fuels), supports agriculture, and influences tectonic activity that shapes landscapes.

5. The atmosphere protects life by absorbing harmful radiation, regulates temperature via greenhouse effect, and enables weather and climate systems.

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Course code: GEO 105
Course title: Introduction to Environmental Sciences
Course credit load: 2 Units

Series 4 Energy Dynamics in Earth's Spheres

Series Outline

- **3.1 Energy and its forms in the environment**
- **3.2 The flow of energy in ecosystems**
- **3.3 Biogeochemical cycles and energy transfer**
- **3.4 Human use of energy and environmental impacts**

Introduction

Energy is the driving force behind all natural and human processes. From the sun fueling photosynthesis to humans harnessing fossil fuels and renewable sources, energy dynamics shape the environment and determine the sustainability of ecosystems. Understanding how energy flows through natural systems and how human activities alter these flows is central to environmental science.

The aim of this Series is to introduce you to the concept of energy in the environment, explain how it flows through ecosystems, examine its role in biogeochemical cycles, and evaluate the impacts of human energy use.

We shall commence this Series by defining energy and its forms in the environment. Next, we will explore how energy flows through ecosystems, focusing on food chains and trophic levels. Following that, we will examine biogeochemical cycles and their role in energy transfer. Finally, we will discuss human use of energy, comparing renewable and non-renewable sources, and assessing their environmental impacts.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** define energy and identify its forms in the environment,
- **SLO 4.2** explain how energy flows through ecosystems and describe trophic levels,
- **SLO 4.3** analyse the role of biogeochemical cycles in energy transfer,
- **SLO 4.4** evaluate human use of energy sources and assess their environmental impacts.

3.1 Energy And Its Forms In The Environment

3.1.1 Definition of energy

Energy is the capacity to do work. In environmental science, energy drives all natural and human processes. It powers ecosystems, fuels biogeochemical cycles, and sustains life. Without energy, organisms cannot grow, reproduce, or maintain their functions.

Fill in the blank: Energy is the capacity to do _____.

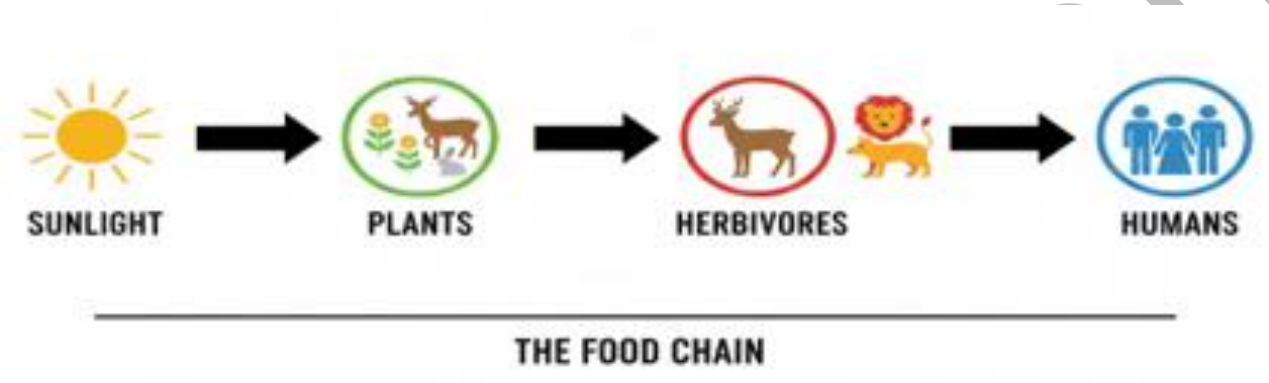


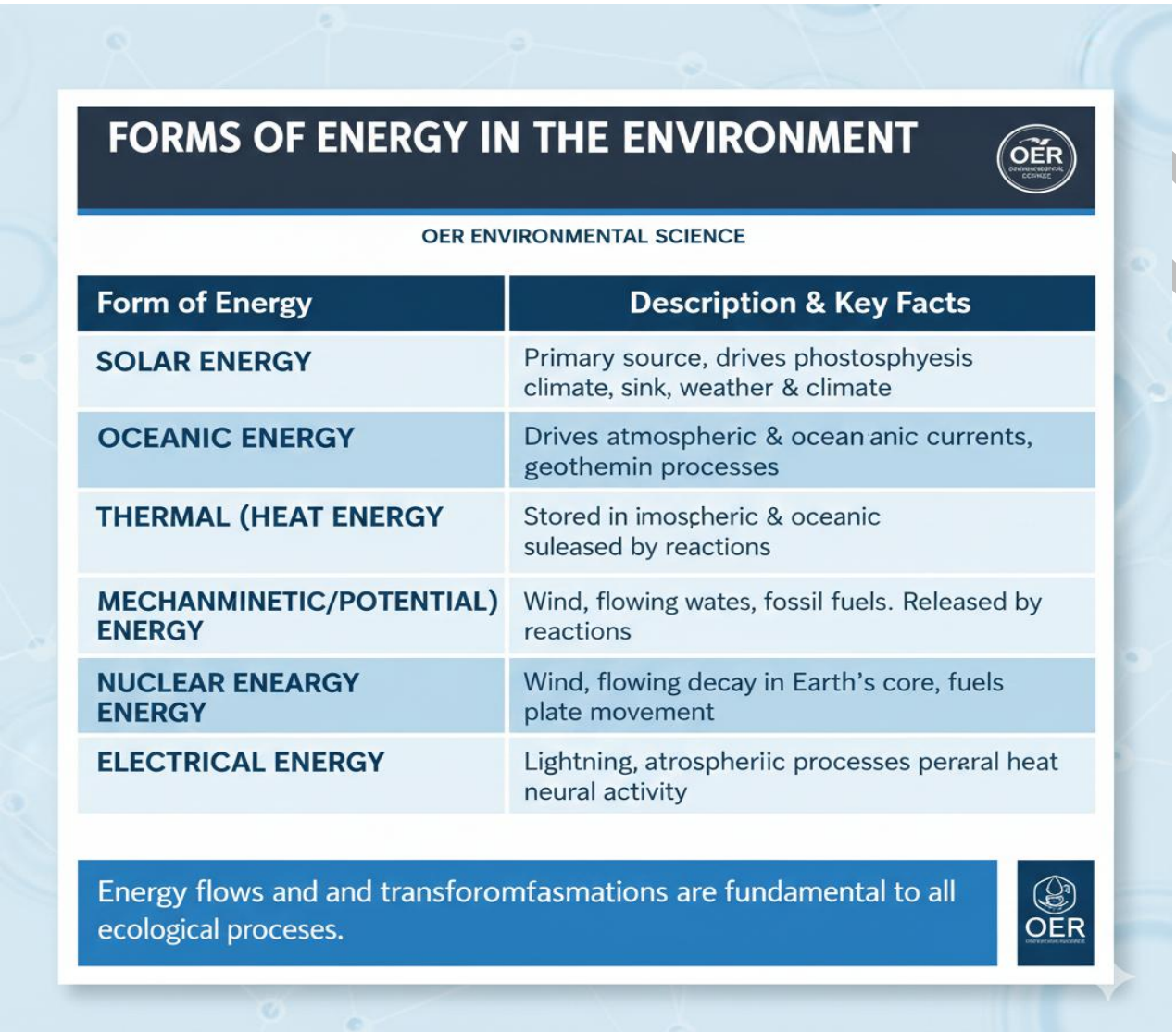
Figure 3.1: Energy as the driver of environmental processes

3.1.2 Forms of energy in the environment

Energy exists in different forms in the environment:

- **Solar energy**: energy from the sun, essential for photosynthesis and climate regulation.
- **Chemical energy**: stored in food, fuels, and organic matter.
- **Heat (thermal) energy**: energy transferred as heat, influencing weather and climate.
- **Mechanical energy**: energy of motion, such as wind or flowing water.
- **Electrical energy**: generated naturally (lightning) or through human technology.

Fill in the blank: Solar energy is essential for _____ and climate regulation.



Box 3.1: Forms of energy in the environment

- Solar energy
- Chemical energy
- Heat (thermal) energy
- Mechanical energy
- Electrical energy

3.1.3 Importance of energy in the environment

Energy is fundamental to sustaining ecosystems and human societies. Plants use solar energy to produce food, which animals consume, transferring energy through food chains. Human societies depend on energy for transportation, industry, and communication.

Energy also regulates climate systems and drives natural processes such as the water cycle and wind circulation. Understanding energy dynamics helps us manage resources sustainably and reduce environmental impacts.

Fill in the blank: Plants use solar energy to produce _____, which animals consume.

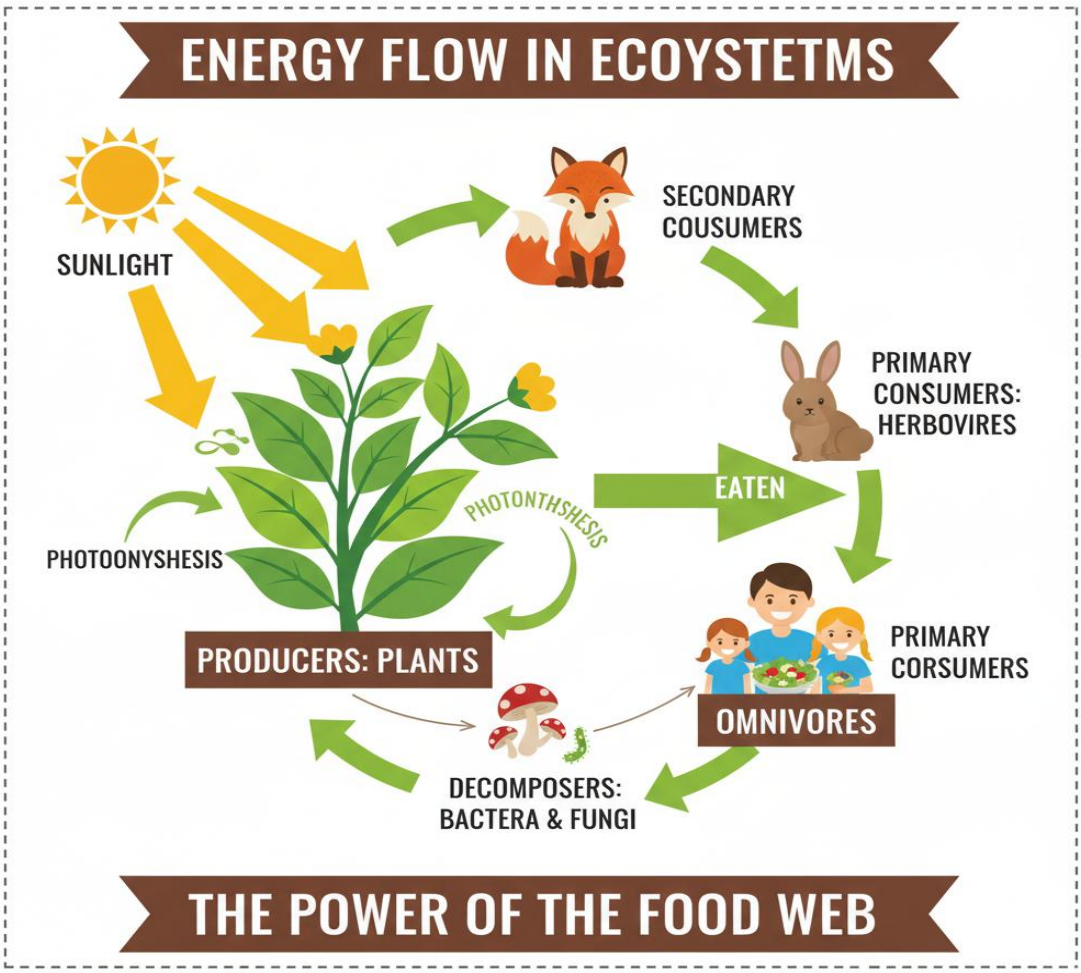


Plate 3.1: Importance of energy in sustaining life

Pilot questions 3.1

1. What is the definition of energy in environmental science?
2. Identify three forms of energy found in the environment.
3. Why is solar energy important for ecosystems?
4. How do plants use solar energy?
5. Give one example of how energy regulates natural processes.

3.2 The Flow Of Energy In Ecosystems

3.2.1 Energy flow through food chains and food webs

Energy enters ecosystems primarily through **photosynthesis**, where plants capture solar energy and convert it into chemical energy. This energy is then transferred through **food chains** (linear sequences of energy transfer) and **food webs** (interconnected networks of food chains).

For example, in a simple food chain:

- Plants (producers) → Grasshoppers (primary consumers) → Frogs (secondary consumers) → Snakes (tertiary consumers).

Fill in the blank: Energy enters ecosystems primarily through _____, where plants capture solar energy.

Diagram of a food chain showing producers, primary consumers, secondary consumers, and tertiary consumers.

3.2.2 Trophic levels and energy transfer

Ecosystems are organised into **trophic levels**, which represent positions in the food chain:

- **Producers**: plants and algae that capture solar energy.
- **Primary consumers**: herbivores that eat producers.
- **Secondary consumers**: carnivores that eat herbivores.
- **Tertiary consumers**: top predators.
- **Decomposers**: fungi and bacteria that recycle nutrients.

Energy transfer between trophic levels is inefficient. Only about **10% of energy** is passed on to the next level, while the rest is lost as heat or used for metabolic processes.

Fill in the blank: Only about _____% of energy is passed on to the next trophic level.

Box 3.2: Trophic levels in ecosystems

- Producers → capture solar energy
- Primary consumers → herbivores
- Secondary consumers → carnivores
- Tertiary consumers → top predators
- Decomposers → recycle nutrients

3.2.3 Ecological pyramids

Energy flow in ecosystems can be represented using **ecological pyramids**:

- **Pyramid of numbers**: shows the number of organisms at each trophic level.
- **Pyramid of biomass**: shows the total mass of organisms at each level.
- **Pyramid of energy**: shows the energy available at each level, always upright because energy decreases at higher levels.

These pyramids illustrate the inefficiency of energy transfer and the importance of producers in sustaining ecosystems.

Fill in the blank: The pyramid of energy is always _____ because energy decreases at higher trophic levels.

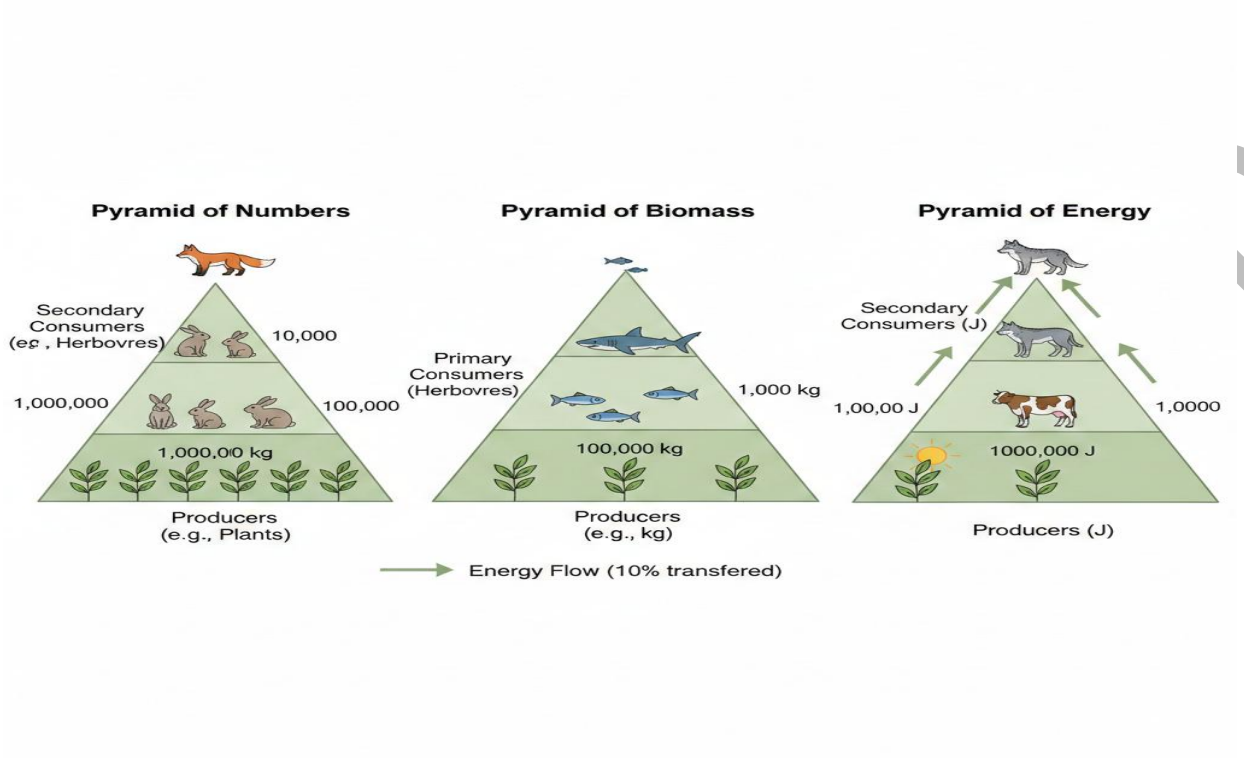


Plate 3.2: Ecological pyramids representing energy flow

Pilot questions 3.2

1. How does energy enter ecosystems?
2. What is the difference between a food chain and a food web?
3. Define trophic levels and give two examples.
4. How much energy is typically transferred from one trophic level to the next?
5. Name the three types of ecological pyramids.

3.3 Biogeochemical Cycles And Energy Transfer

3.3.1 The carbon cycle

The **carbon cycle** describes how carbon moves between the atmosphere, biosphere, hydrosphere, and lithosphere. Plants absorb carbon dioxide during photosynthesis, animals consume plants, and carbon returns to the atmosphere through respiration, decomposition, and combustion. Human activities such as burning fossil fuels and deforestation disrupt this cycle, leading to climate change.

Fill in the blank: Plants absorb carbon dioxide during _____, releasing oxygen in return.

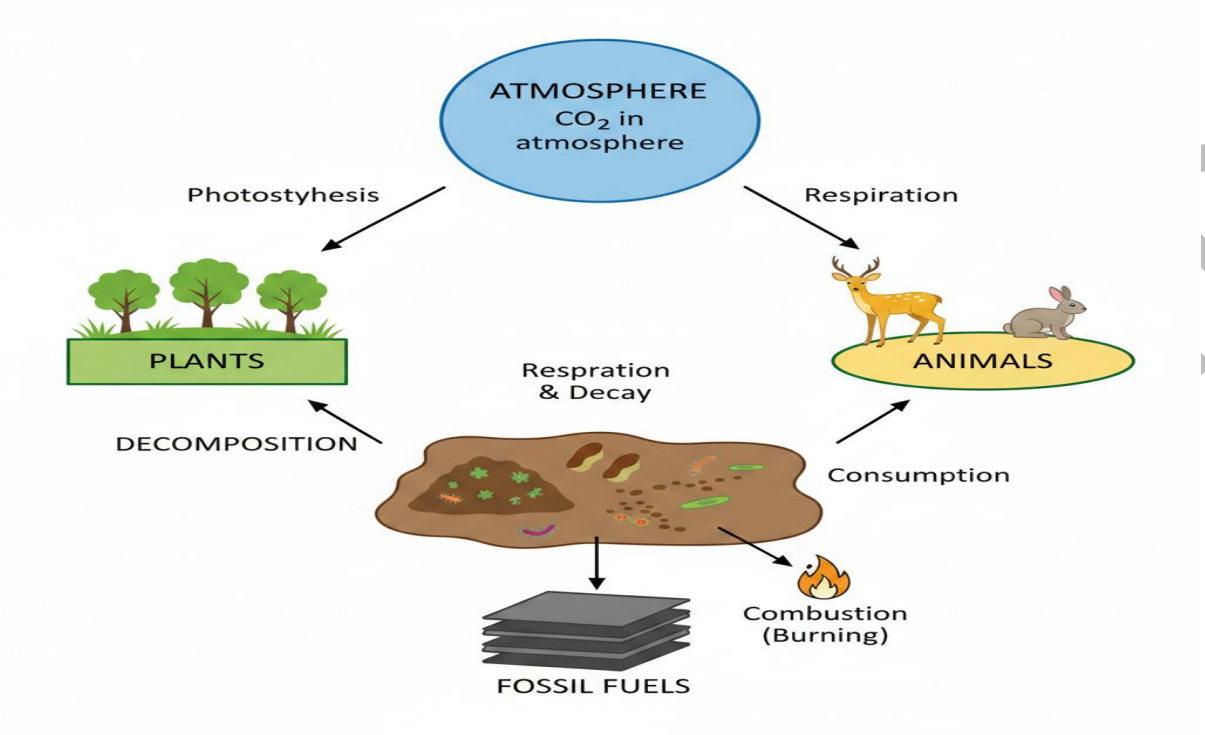


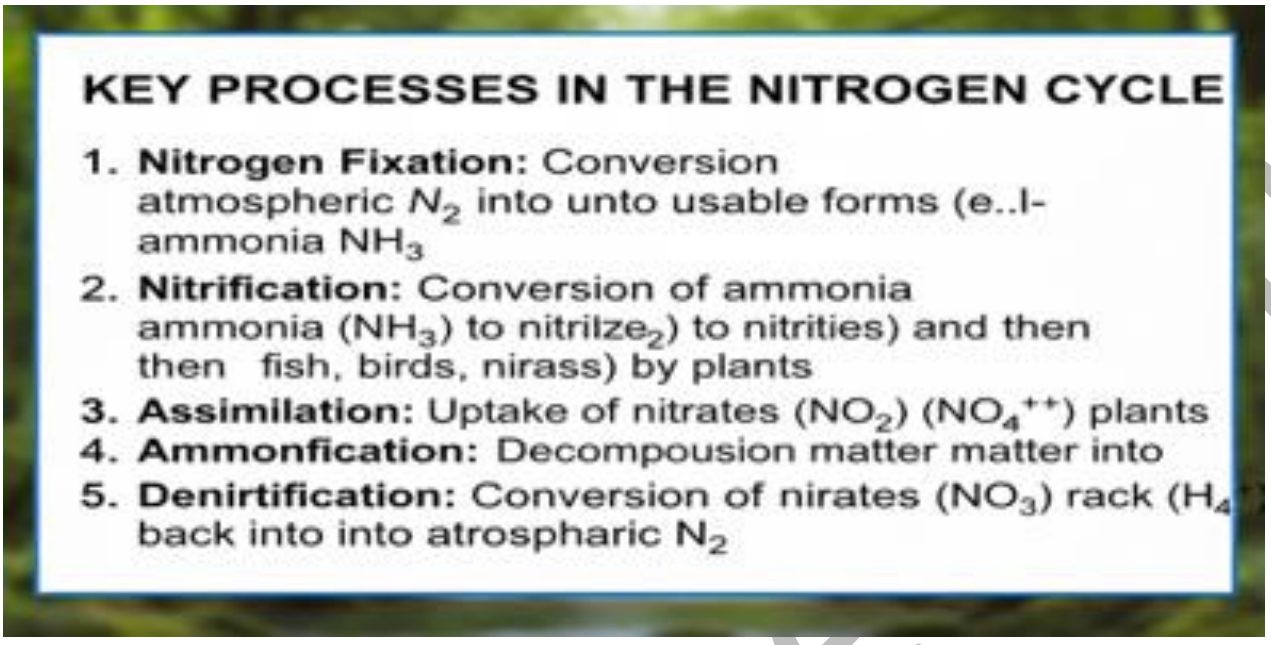
Figure 3.3: The carbon cycle in the environment

3.3.2 The nitrogen cycle

The **nitrogen cycle** explains how nitrogen circulates through the environment. Nitrogen gas in the atmosphere is fixed by bacteria into usable forms (ammonia, nitrates). Plants absorb these compounds, animals consume plants, and nitrogen returns to the soil through waste and decomposition. Denitrifying bacteria release nitrogen back into the atmosphere.

Human activities such as excessive fertiliser use disrupt the nitrogen cycle, causing water pollution and eutrophication.

Fill in the blank: Nitrogen gas is fixed by _____ into usable forms such as ammonia and nitrates.



Box 3.3: Key processes in the nitrogen cycle

- Nitrogen fixation
- Nitrification
- Assimilation
- Ammonification
- Denitrification

3.3.3 The water cycle and energy transfer

The **water cycle** involves the continuous movement of water through evaporation, condensation, precipitation, infiltration, and runoff. Energy from the sun drives evaporation, while gravity drives precipitation and runoff. This cycle regulates climate, supports ecosystems, and sustains life.

Human activities such as deforestation, urbanisation, and pollution alter the water cycle, affecting water availability and quality.

Fill in the blank: The water cycle is driven by energy from the _____ and gravity.

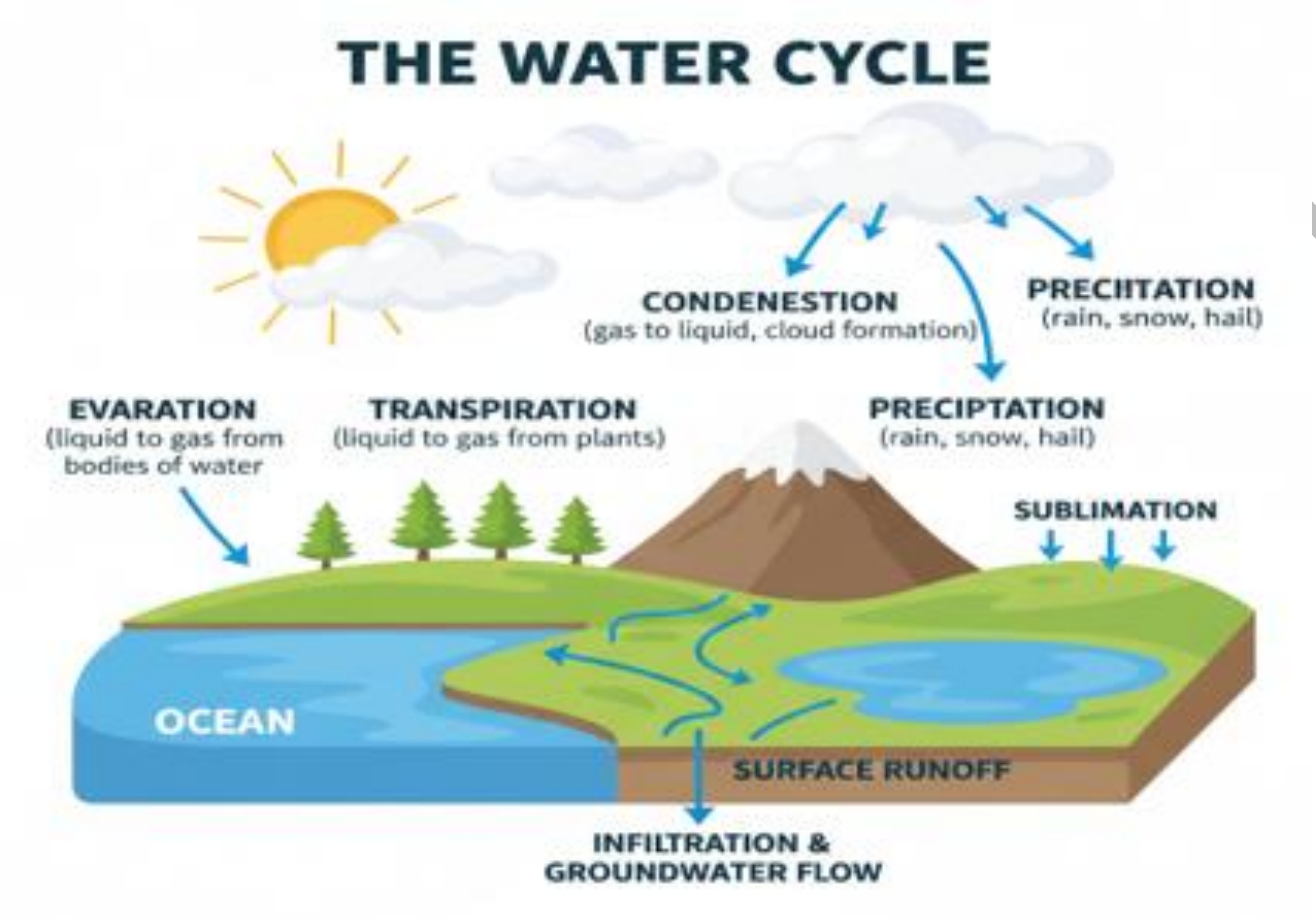


Plate 3.3: The water cycle and energy transfer

Pilot questions 3.3

1. What is the carbon cycle and why is it important?
2. Name two ways human activities disrupt the carbon cycle.
3. What role do bacteria play in the nitrogen cycle?
4. List three key processes in the nitrogen cycle.
5. What drives the water cycle?

3.4 Human Use Of Energy And Environmental Impacts

3.4.1 Renewable and non-renewable energy sources

Human societies rely on energy for transportation, industry, communication, and daily life. Energy sources are classified into:

- **Renewable energy sources**: solar, wind, hydro, geothermal, and biomass. These are naturally replenished and generally have lower environmental impacts.
- **Non-renewable energy sources**: fossil fuels (coal, oil, natural gas) and nuclear energy. These are finite and often associated with pollution, greenhouse gas emissions, and resource depletion.

Fill in the blank: Solar, wind, and hydro are examples of _____ energy sources.

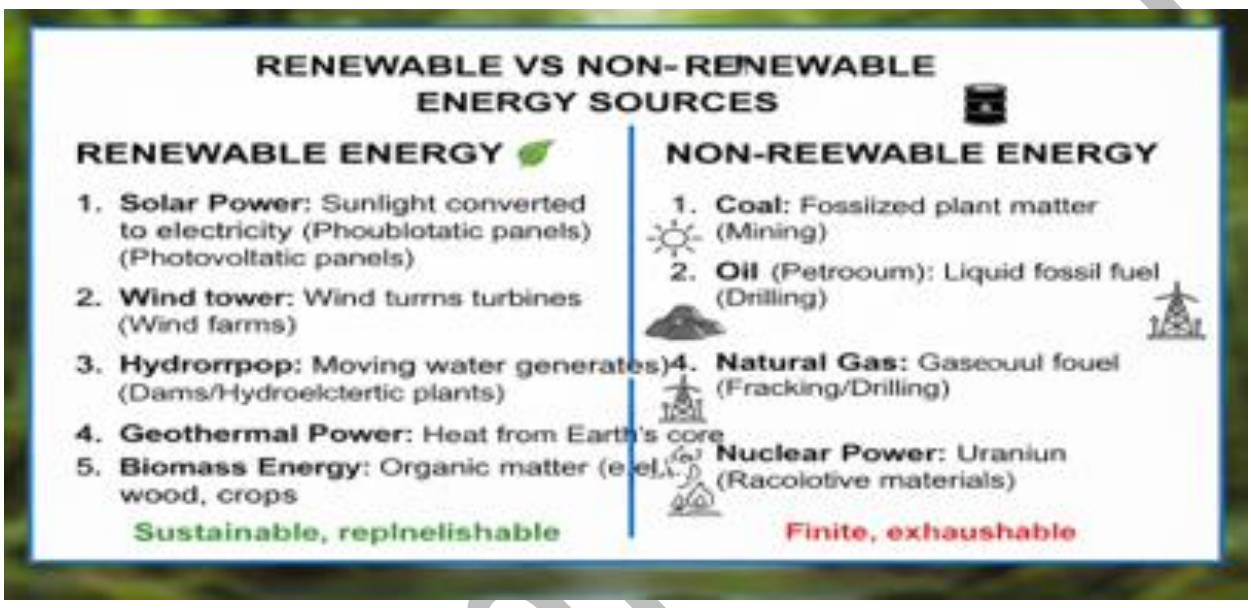


Figure 3.4: Renewable vs non-renewable energy sources

3.4.2 Environmental impacts of energy use

Energy use has significant environmental impacts:

- **Air pollution**: burning fossil fuels releases pollutants such as carbon dioxide, sulfur dioxide, and nitrogen oxides.
- **Climate change**: greenhouse gas emissions trap heat in the atmosphere, leading to global warming.
- **Water pollution**: oil spills and thermal pollution affect aquatic ecosystems.
- **Habitat destruction**: mining and dam construction alter landscapes and ecosystems.

Renewable energy sources generally reduce these impacts, though they also have challenges (e.g., land use for solar farms, impacts of wind turbines on birds).

Fill in the blank: Burning fossil fuels releases pollutants such as carbon dioxide and _____ oxides.

Environmental Impacts of Energy Use

The production and consumption of energy are the primary drivers of global environmental change. While energy powers our modern lives, its extraction and use lead to several significant ecological consequences:

- **Greenhouse Gas Emissions:** The combustion of fossil fuels (coal, oil, and natural gas) releases CO_2 and methane (CH_4), which are the leading causes of global climate change.
- **Air Pollution:** Energy production emits pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter, leading to smog, acid rain, and respiratory illnesses.
- **Water Quality and Scarcity:** Power plants require vast amounts of water for cooling. Additionally, processes like hydraulic fracturing (fracking) and coal mining can contaminate local groundwater supplies.
- **Land Degradation:** Infrastructure for energy, including mines, oil rigs, and large-scale solar or wind farms, can lead to habitat loss, deforestation, and soil erosion.
- **Waste Generation:** Nuclear energy produces radioactive waste that requires long-term secure storage, while coal plants produce "fly ash" containing heavy metals.

Box 3.4: Environmental impacts of energy use

- Air pollution
- Climate change
- Water pollution
- Habitat destruction

3.4.3 Sustainable energy strategies

To reduce environmental impacts, societies are adopting **sustainable energy strategies**:

- Transitioning to renewable energy sources.
- Improving energy efficiency in industries, buildings, and transportation.
- Promoting conservation through behavioural changes.
- Developing policies and international agreements to reduce emissions.

These strategies aim to balance human energy needs with environmental protection, ensuring long-term sustainability.

Fill in the blank: Improving energy _____ in industries and transportation is a key sustainable strategy.

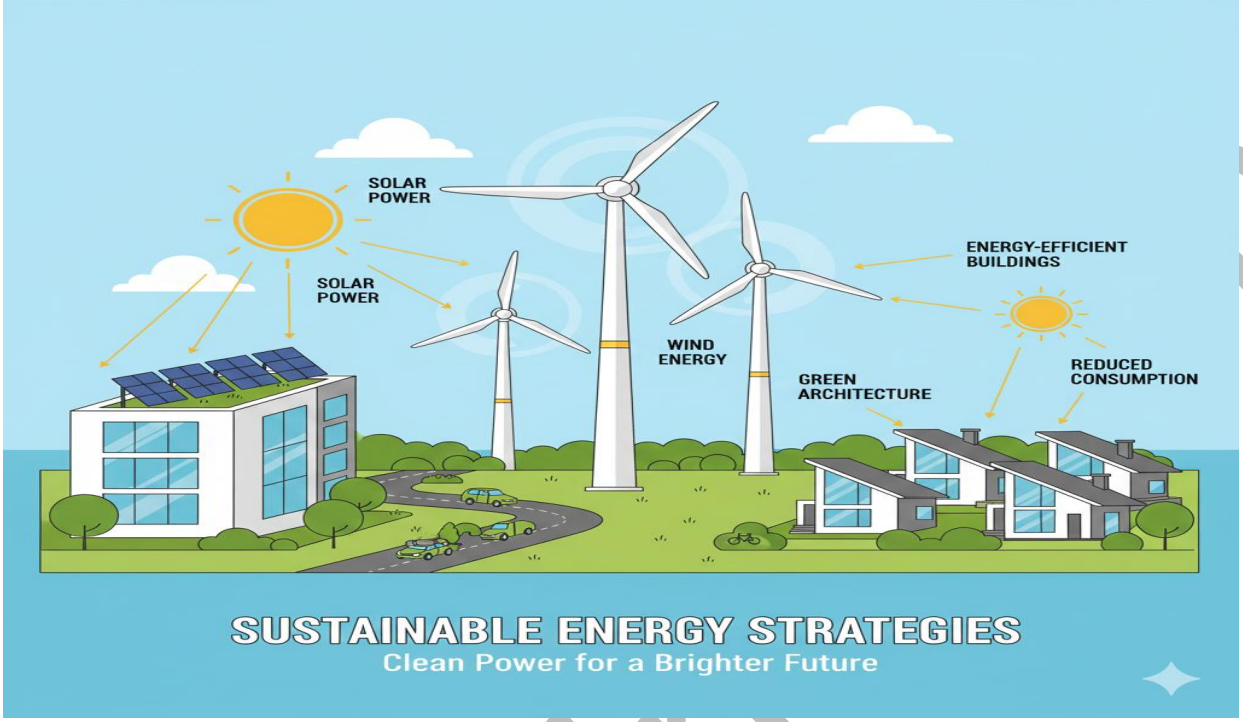


Plate 3.4: Sustainable energy strategies

Pilot questions 3.4

1. What are renewable and non-renewable energy sources?
2. Give two examples of renewable energy sources.
3. List two environmental impacts of fossil fuel use.
4. What is one challenge associated with renewable energy sources?
5. Name two strategies for sustainable energy use.

Summary

In this Series, we studied how energy drives environmental processes, sustains ecosystems, and influences human society.

We began by defining **energy and its forms in the environment**. Energy was described as the capacity to do work, existing in forms such as solar, chemical, thermal, mechanical, and electrical. These forms are essential for natural cycles and human activities.

Next, we explored **the flow of energy in ecosystems**, focusing on food chains, food webs, and trophic levels. We learned that only about 10% of energy is transferred from one

trophic level to the next, with the rest lost as heat. Ecological pyramids (numbers, biomass, and energy) were introduced to illustrate these dynamics.

We then examined **biogeochemical cycles and energy transfer**, including the carbon cycle, nitrogen cycle, and water cycle. Each cycle demonstrates how matter and energy circulate through ecosystems. Human activities such as fossil fuel combustion, fertiliser use, and deforestation were shown to disrupt these cycles, leading to environmental challenges like climate change and eutrophication.

Finally, we discussed **human use of energy and environmental impacts**. Renewable sources (solar, wind, hydro, geothermal, biomass) were contrasted with non-renewable sources (fossil fuels, nuclear). We analysed environmental impacts such as air pollution, climate change, water pollution, and habitat destruction. Sustainable energy strategies—transitioning to renewables, improving efficiency, and promoting conservation—were highlighted as pathways to balance human needs with environmental protection.

Altogether, this Series demonstrated that energy is the foundation of environmental systems and human societies. Understanding energy dynamics helps us appreciate the delicate balance of ecosystems and the urgent need for sustainable energy practices.

Glossary of Terms

- **Energy**: The capacity to do work; the driving force behind natural and human processes.
- **Solar energy**: Energy from the sun, essential for photosynthesis, climate regulation, and renewable power generation.
- **Chemical energy**: Energy stored in food, fuels, and organic matter, released during chemical reactions.
- **Thermal (heat) energy**: Energy transferred as heat, influencing weather, climate, and metabolic processes.
- **Mechanical energy**: Energy of motion, such as wind, flowing water, or moving machinery.
- **Electrical energy**: Energy produced naturally (lightning) or through human technology (power generation).
- **Food chain**: A linear sequence showing how energy flows from producers to consumers in an ecosystem.
- **Food web**: A network of interconnected food chains that illustrates complex energy flow in ecosystems.
- **Trophic levels**: Hierarchical positions in a food chain (producers, consumers, decomposers) that represent energy transfer.
- **Ecological pyramids**: Graphical representations of energy flow, biomass, or numbers at different trophic levels.

- **Carbon cycle**: The circulation of carbon through the atmosphere, biosphere, hydrosphere, and lithosphere.
- **Nitrogen cycle**: The circulation of nitrogen through fixation, nitrification, assimilation, ammonification, and denitrification.
- **Water cycle**: The continuous movement of water through evaporation, condensation, precipitation, infiltration, and runoff.
- **Renewable energy sources**: Energy sources that are naturally replenished, such as solar, wind, hydro, geothermal, and biomass.
- **Non-renewable energy sources**: Finite energy sources such as fossil fuels (coal, oil, natural gas) and nuclear energy.
- **Air pollution**: The release of harmful substances (e.g., carbon dioxide, sulfur dioxide, nitrogen oxides) into the atmosphere.
- **Climate change**: Long-term shifts in global or regional climate patterns, largely driven by greenhouse gas emissions.
- **Sustainable energy strategies**: Approaches to balance human energy needs with environmental protection, including efficiency, conservation, and renewable adoption.

Concept Check Questions

Upon completing this Series, you should be able to attempt the following questions. Each question is linked to the Series Learning Outcomes (SLOs).

Objective Questions

1. (Linked to SLO 4.1) Energy in environmental science is best defined as:

a. The ability to recycle matter
b. The capacity to do work
c. The flow of water in ecosystems
d. The movement of organisms

2. (Linked to SLO 4.2) Which of the following represents a trophic level?

a. Producers
b. Consumers
c. Decomposers
d. All of the above

3. (Linked to SLO 4.3) Which process in the nitrogen cycle converts nitrogen gas into usable forms?

a. Assimilation
b. Denitrification
c. Nitrogen fixation
d. Ammonification

4. (Linked to SLO 4.4) Which of the following is a renewable energy source?

a. Coal
b. Oil
c. Solar
d. Natural gas

Short-Answer Questions

1. (Linked to SLO 4.1) Identify three forms of energy found in the environment.
2. (Linked to SLO 4.2) Explain why only about 10% of energy is transferred from one trophic level to the next.
3. (Linked to SLO 4.3) Describe the role of bacteria in the nitrogen cycle.
4. (Linked to SLO 4.4) List two environmental impacts of fossil fuel use.

Long-Answer Questions

1. (Linked to SLO 4.2) Discuss the differences between food chains and food webs, and explain their importance in ecosystems.
2. (Linked to SLO 4.3) Analyse how human activities disrupt the carbon and water cycles, and suggest strategies to restore balance.
3. (Linked to SLO 4.4) Evaluate the advantages and challenges of renewable energy sources compared to non-renewable sources.

Answers to Pilot Questions

Pilot questions 3.1

1. Energy in environmental science is defined as the capacity to do work.
2. Three forms of energy in the environment are solar, chemical, and thermal (heat) energy.
3. Solar energy is important because it drives photosynthesis and regulates climate systems.
4. Plants use solar energy to produce food (glucose) through photosynthesis.
5. One example of energy regulating natural processes is solar energy driving the water cycle through evaporation.

Pilot questions 3.2

1. Energy enters ecosystems through photosynthesis, where plants capture solar energy.
2. A food chain is a linear sequence of energy transfer, while a food web is a network of interconnected chains.
3. Trophic levels are positions in a food chain; examples include producers (plants) and primary consumers (herbivores).
4. Only about 10% of energy is transferred from one trophic level to the next.
5. The three types of ecological pyramids are pyramid of numbers, pyramid of biomass, and pyramid of energy.

Pilot questions 3.3

1. The carbon cycle describes how carbon circulates through the atmosphere, biosphere, hydrosphere, and lithosphere. It is important for regulating climate and supporting life.
2. Human activities such as burning fossil fuels and deforestation disrupt the carbon cycle.
3. Bacteria play a role in nitrogen fixation, nitrification, and denitrification, making nitrogen usable for plants and returning it to the atmosphere.
4. Three key processes in the nitrogen cycle are nitrogen fixation, nitrification, and denitrification.
5. The water cycle is driven by energy from the sun and gravity.

Pilot questions 3.4

1. Renewable energy sources are naturally replenished (solar, wind, hydro), while non-renewable sources are finite (coal, oil, gas).
2. Two examples of renewable energy sources are solar and wind.
3. Two environmental impacts of fossil fuel use are air pollution and climate change.
4. One challenge of renewable energy sources is land use (e.g., solar farms) or impacts on wildlife (e.g., wind turbines).
5. Two strategies for sustainable energy use are improving energy efficiency and transitioning to renewable energy sources.

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Course code: GEO 105
Course title: Introduction to Environmental Sciences
Course credit load: 2 Units

Series 5: Human Role and Contemporary Environmental Issues

Part 5.1: Human Role in the Environment

- 5.1.1 Definition of Human Role
- 5.1.2 Components of Human Role (population growth, technology, consumption, culture, economy)
- 5.1.3 Importance of Human Role
- 5.1.4 Visuals & Examples

Part 5.2: Contemporary Environmental Issues

- 5.2.1 Definition of Environmental Issues
- 5.2.2 Components of Environmental Issues (pollution, deforestation, climate change, biodiversity loss, waste management)
- 5.2.3 Importance of Addressing Issues
- 5.2.4 Visuals & Examples

Part 5.3: Human Activities and Environmental Degradation

- 5.3.1 Definition of Environmental Degradation
- 5.3.2 Components of Degradation (industrialization, agriculture, urbanization, mining, overexploitation)

- 5.3.3 Importance of Understanding Degradation
- 5.3.4 Visuals & Examples

Part 5.4: Sustainable Development and Global Cooperation

- 5.4.1 Definition of Sustainable Development
- 5.4.2 Components of Sustainable Development (conservation, renewable energy, recycling, governance, community participation)
- 5.4.3 Importance of Sustainable Development
- 5.4.4 Global Cooperation and Future Challenges *(kept as a single sub-Part, not broken further to avoid 4th-level numbering*

Introduction

Human activities have become the most significant drivers of environmental change in today's world. From the way we consume resources to the technologies we develop and the policies we adopt, our choices shape ecosystems and determine whether they thrive or deteriorate. Understanding the human role in the environment is therefore essential, as it highlights both the challenges we face and the opportunities we have to create a sustainable future. This Series builds on the foundations laid earlier in the course by focusing on how people influence the environment and how societies can respond to pressing global issues.

The aim of this Series is to help you examine the impact of human actions on the environment, identify contemporary challenges, and evaluate strategies for sustainability and cooperation. By the end of the Series, you will be able to explain the human role in environmental change, analyse current issues, assess degradation processes, and propose solutions that balance human needs with ecological responsibility.

We shall commence this Series by exploring the human role in the environment, considering how population growth, technology, consumption, and cultural values shape ecological outcomes. Next, we will examine contemporary environmental issues such as pollution, deforestation, climate change, and biodiversity loss, highlighting their global significance. Following that, we will analyse how human activities contribute to environmental degradation and why understanding these processes is crucial for sustainable management. Finally, we will wrap up by discussing sustainable development and global cooperation, focusing on strategies that promote responsibility and collective action for a healthier planet.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** define the human role in the environment,
- **SLO 5.2** explain the key components of the human role such as population growth, technology, consumption, and cultural values,
- **SLO 5.3** describe major contemporary environmental issues including pollution, deforestation, climate change, biodiversity loss, and waste management,

- **SLO 5.4** analyse the impacts of contemporary environmental issues on ecosystems and human wellbeing,
- **SLO 5.5** explain how human activities such as industrialisation, agriculture, urbanisation, and mining contribute to environmental degradation,
- **SLO 5.6** evaluate the importance of understanding environmental degradation for conservation and sustainable management,
- **SLO 5.7** define sustainable development and its core principles,
- **SLO 5.8** assess strategies for sustainable development including conservation, renewable energy, recycling, governance, and community participation, and
- **SLO 5.9** evaluate the significance of global cooperation in addressing environmental challenges and promoting sustainability.

5.1 Human Role in the Environment

5.1.1 Definition of human role

Humans play a central role in shaping the environment through their activities, decisions, and interactions with natural systems. The **human role** refers to the ways in which population growth, technology, consumption patterns, cultural practices, and economic activities influence environmental processes and outcomes. This concept is important because it highlights how human behaviour can either sustain ecosystems or contribute to their degradation.

Fill in the blank: The human role refers to how _____ influence environmental processes and outcomes.

5.1.2 Components of human role

The human role can be broken down into several components:

- **Population growth**: Refers to the increase in the number of people, which raises demand for resources and space.
- **Technology**: Tools and innovations that enable development, but may also cause pollution or support sustainability.
- **Consumption patterns**: The way humans use resources, determining levels of waste and sustainability.
- **Culture and values**: Beliefs and practices that shape attitudes towards conservation or exploitation.
- **Economic activities**: Agriculture, industry, and trade, which directly impact ecosystems.

Fill in the blank: Rapid _____ growth increases demand for resources and space.

5.1.3 Importance of human role

The human role is important because it determines the balance between resource use and conservation. It influences environmental sustainability and degradation, drives innovation for solving environmental challenges, and shapes global cooperation and policy development. Ultimately, it affects the future of ecosystems and biodiversity.

Fill in the blank: The human role determines the balance between resource use and _____.

5.1.4 Visuals and examples

Visuals and practical examples help us to understand the human role more clearly. For instance, population growth in cities increases demand for housing and transport, which can lead to deforestation and air pollution. On the other hand, technological innovations such as renewable energy reduce reliance on fossil fuels and promote sustainability.

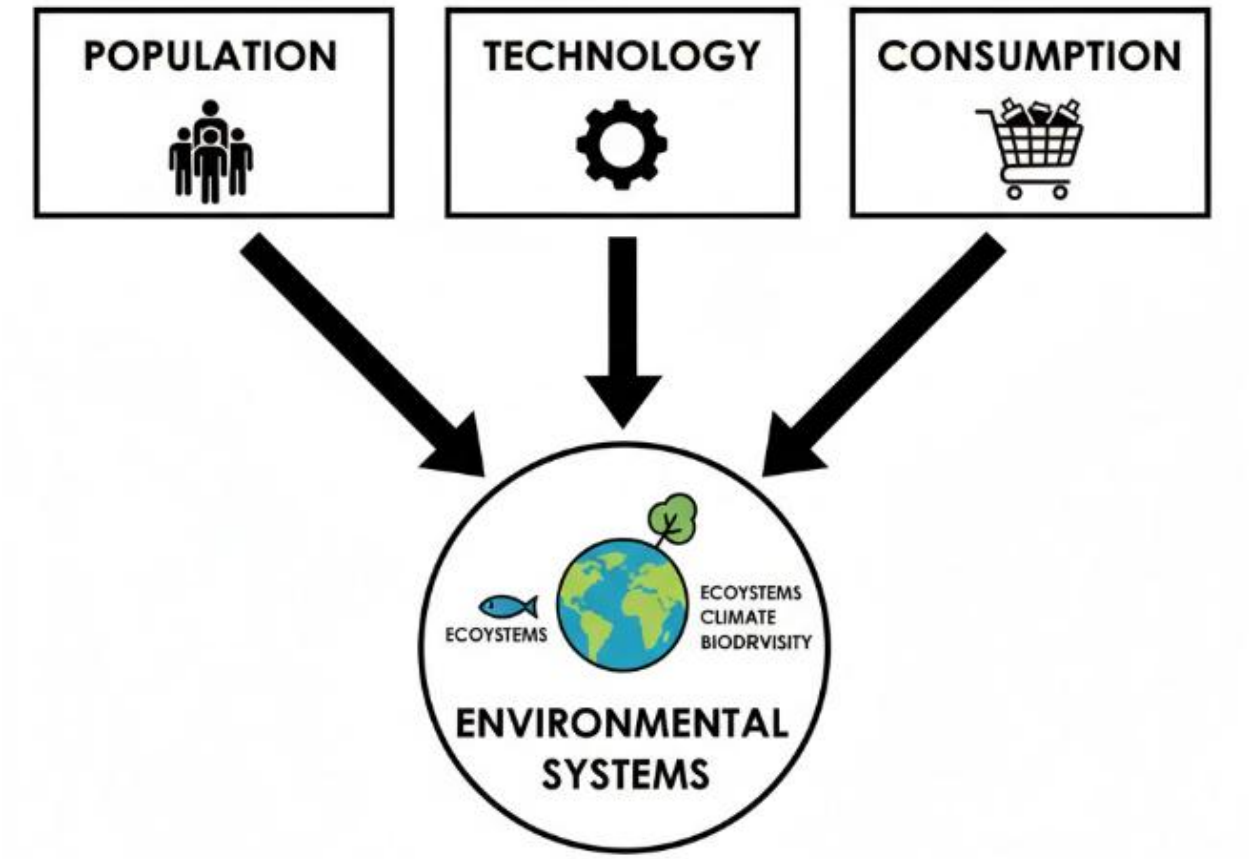


Figure 5.1 Human–environment interactions

Part 5.1 Human Role in the Environment

1. What is meant by the term *human role in the environment*?
2. List two components of the human role in the environment.
3. How does population growth affect resource demand?
4. Why is technology considered both helpful and harmful to the environment?
5. Give one example of how culture influences environmental attitudes.

5.2 Contemporary Environmental Issues

5.2.1 Definition of environmental issues

Contemporary environmental issues are current challenges facing the Earth's systems due to human activities and natural processes. These include problems such as pollution, deforestation, climate change, biodiversity loss, and waste management. They threaten ecological balance and human wellbeing, making them central to the study of environmental science.

Fill in the blank: Contemporary environmental issues are current challenges facing the Earth's systems due to _____ activities and natural processes.

5.2.2 Components of environmental issues

Several major components define contemporary environmental issues:

- **Pollution**: Contamination of air, water, and soil from industrial and domestic sources.
- **Deforestation**: Large-scale clearing of forests for agriculture, logging, and urbanisation.
- **Climate change**: Global warming and extreme weather events caused by greenhouse gas emissions.
- **Biodiversity loss**: Extinction of species and destruction of habitats.
- **Waste management problems**: Improper disposal of solid and hazardous waste.

Fill in the blank: The large-scale clearing of forests for agriculture and urbanisation is called _____.

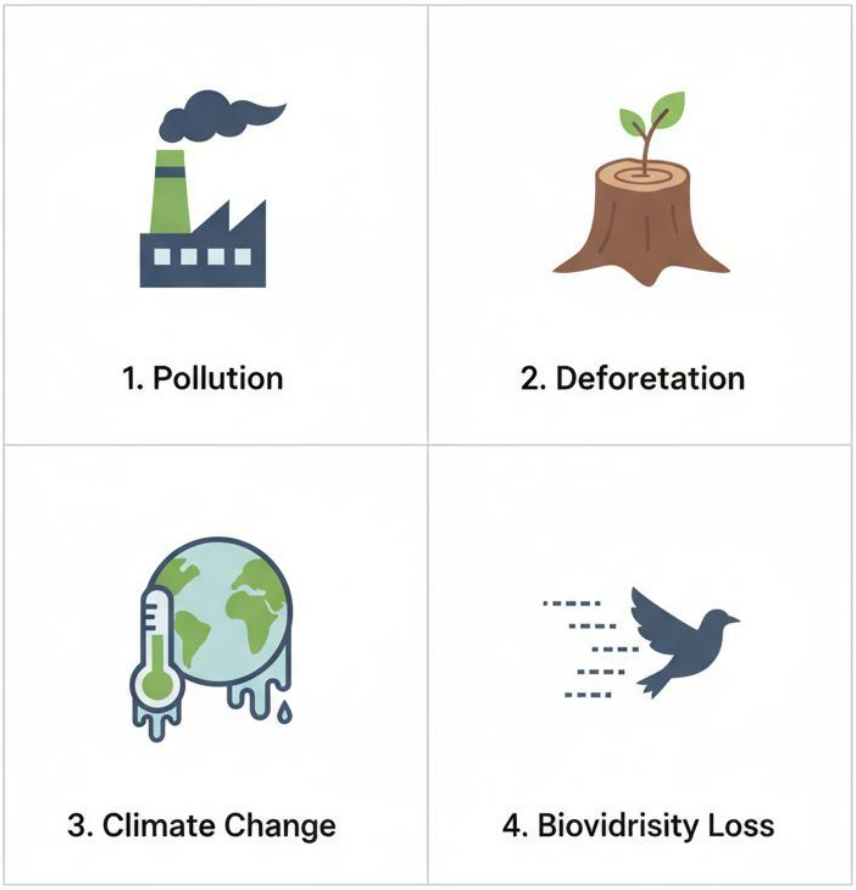


Figure 5.2 Major contemporary environmental issues

5.2.3 Importance of addressing environmental issues

Addressing contemporary environmental issues is important because they directly affect human health and survival. They disrupt ecosystems, reduce biodiversity, and contribute to global crises such as food insecurity and water scarcity. They also influence economic stability and development, requiring global cooperation for sustainable solutions.

Fill in the blank: Addressing environmental issues is important because they directly affect human _____ and survival.

5.2.4 Visuals and examples

Examples of contemporary environmental issues can be seen in everyday life. Smog in cities illustrates air pollution, while deforested land shows the impact of unsustainable agriculture. Endangered species highlight biodiversity loss, and rising global temperatures demonstrate the urgency of climate change.

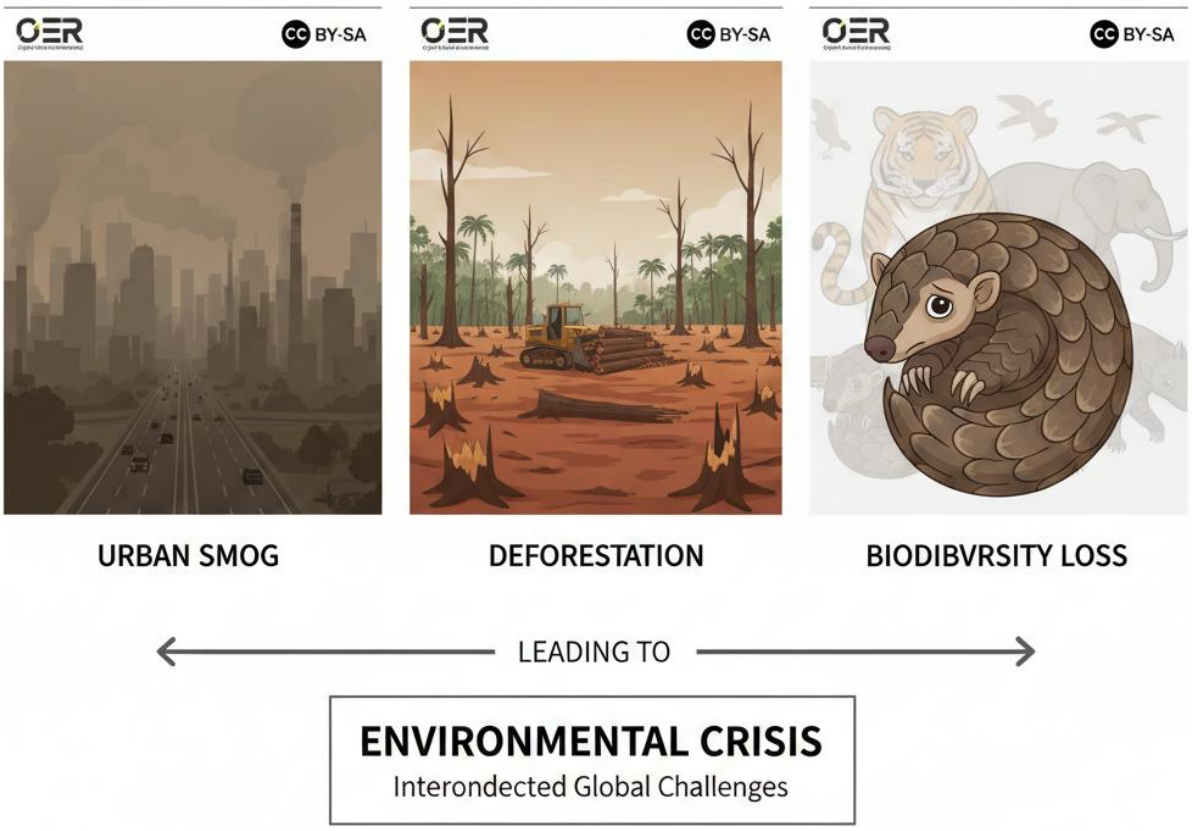


Plate 5.2 Examples of contemporary environmental issues

Part 5.2 Contemporary Environmental Issues

1. Define *contemporary environmental issues*.

2. Identify one example of pollution and its source.
3. What is the main cause of deforestation?
4. Name one way climate change affects human societies.
5. Why is biodiversity loss considered a serious environmental issue?

5.3 Human Activities and Environmental Degradation

5.3.1 Definition of environmental degradation

Environmental degradation refers to the deterioration of the natural environment due to unsustainable human activities such as industrialisation, agriculture, mining, and urbanisation. It results in the depletion of resources, destruction of ecosystems, and decline in environmental quality. This concept is central to environmental science because it shows how human development can undermine ecological balance.

Fill in the blank: Environmental degradation refers to the deterioration of the natural environment due to _____ activities.

5.3.2 Components of degradation

Several human activities contribute to environmental degradation:

- **Industrialisation**: Factories release pollutants into air, water, and soil, while poor waste disposal contaminates ecosystems.
- **Agriculture**: Overuse of fertilisers and pesticides, combined with deforestation for farmland, damages soil and biodiversity.
- **Urbanisation**: Expansion of cities leads to habitat loss, increased waste, and higher energy demand.
- **Mining**: Extraction of minerals causes soil erosion, water contamination, and landscape destruction.
- **Overexploitation of resources**: Unsustainable use of forests, fisheries, and water reduces long-term availability.

Fill in the blank: The extraction of minerals that causes soil erosion and water contamination is called _____.

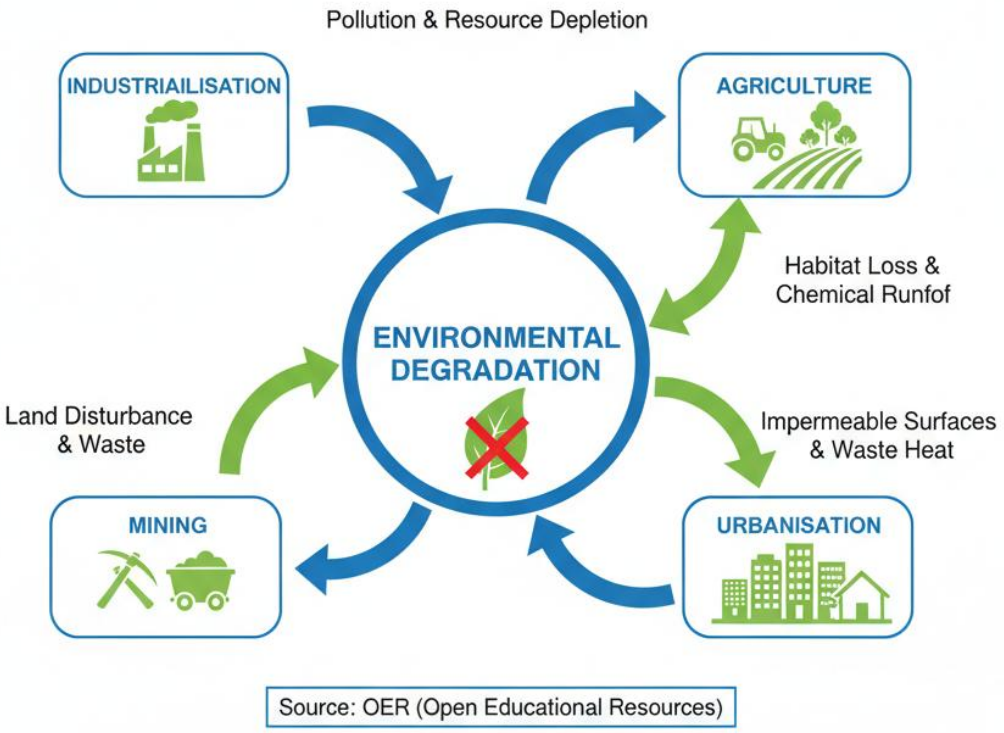


Figure 5.3 Human activities contributing to environmental degradation

5.3.3 Importance of understanding degradation

Understanding environmental degradation is important because it highlights the consequences of unsustainable human activities. It helps in designing policies for conservation and restoration, raises awareness about the need for sustainable practices, and shows the link between human development and ecological decline. Recognising these impacts emphasises the urgency of global cooperation to protect ecosystems.

Fill in the blank: Understanding environmental degradation is important because it highlights the consequences of _____ human activities.

5.3.4 Visuals and examples

Examples of degradation can be seen in polluted rivers, deforested landscapes, and sprawling urban centres. These illustrate how human actions alter natural systems and reduce environmental quality.

Plate 5.3 Examples of environmental degradation

Part 5.3 Human Activities and Environmental Degradation

1. What is meant by *environmental degradation*?

2. State one way industrialisation contributes to environmental degradation.
3. How does agriculture affect soil quality?
4. Give one example of how urbanisation impacts ecosystems.
5. What is meant by overexploitation of resources?

5.4 Sustainable Development and Global Cooperation

5.4.1 Definition of sustainable development

Sustainable development is the process of meeting present human needs without compromising the ability of future generations to meet their own needs. It emphasises balancing economic growth, environmental protection, and social equity. This principle is central to environmental science because it provides a framework for responsible resource use and long-term ecological stability.

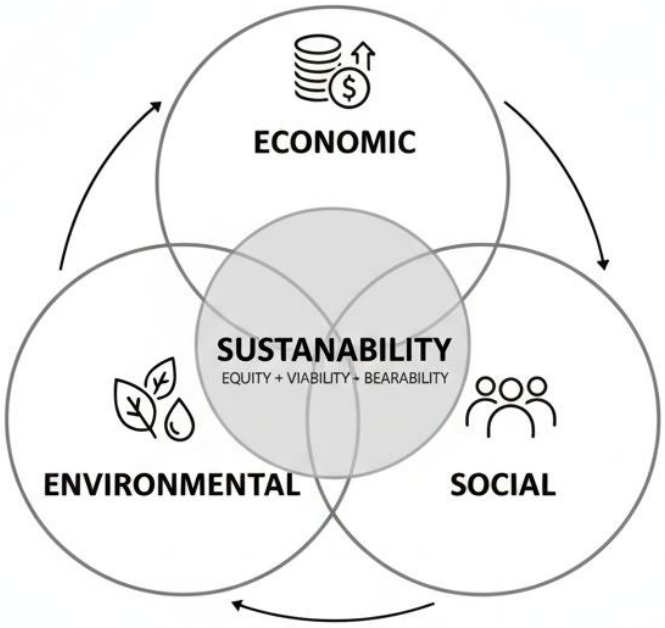
Fill in the blank: Sustainable development is the process of meeting present human needs without compromising the ability of _____ generations to meet their own needs.

5.4.2 Components of sustainable development

Key components of sustainable development include:

- **Conservation of resources**: Protecting forests, water, soil, and biodiversity.
- **Renewable energy adoption**: Using solar, wind, and hydro power instead of fossil fuels.
- **Recycling and waste management**: Reducing waste and reusing materials.
- **Policy and governance**: Laws and regulations that promote sustainability.
- **Community participation**: Individuals and groups taking responsibility for environmental protection.

Fill in the blank: Using solar, wind, and hydro power instead of fossil fuels is an example of adopting _____ energy.



Sunday, January 25, 2026

5.4 The three pillars of sustainable development

5.4.3 Importance of sustainable development

Sustainable development is important because it ensures long-term availability of resources, reduces environmental degradation, and promotes fairness between present and future generations. It also supports economic stability while protecting ecosystems, and fosters global cooperation and responsibility.

Fill in the blank: Sustainable development is important because it ensures long-term availability of _____.

5.4.4 Global cooperation and future challenges

Global cooperation refers to the collective efforts of nations, organisations, and communities to address environmental challenges that transcend borders. Examples include international agreements such as the Paris Agreement on climate change, the work of non-governmental organisations (NGOs), and community initiatives that contribute to global sustainability.

Future challenges include climate change, resource scarcity, pollution, and biodiversity loss. Addressing these requires shared responsibility, knowledge exchange, and coordinated action.

Fill in the blank: Global cooperation refers to the collective efforts of _____, organisations, and communities to address environmental challenges.

Source: OER, 2026

Plate 5.4 Examples of global cooperation for sustainability

Part 5.4 Sustainable Development and Global Cooperation

1. Define *sustainable development*.
2. Name one component of sustainable development.
3. Why is renewable energy important for sustainability?
4. What is meant by *global cooperation* in environmental science?
5. Mention one future challenge that requires global cooperation.

Series Summary

This Series has focused on the human role in shaping the environment and the pressing challenges that arise from our interactions with natural systems. Its purpose has been to highlight how human activities influence ecological balance, to examine contemporary issues, and to explore pathways towards sustainability and cooperation. By situating human responsibility at the centre of environmental science, the Series has shown why understanding these dynamics is essential for both present and future generations.

We began by defining the human role in the environment and identifying its components such as population growth, technology, consumption, culture, and economic activities. We then examined contemporary environmental issues including pollution, deforestation, climate change, biodiversity loss, and waste management, before moving on to analyse how industrialisation, agriculture, mining, and urbanisation contribute to environmental degradation. Finally, we considered sustainable development and global cooperation, emphasising conservation, renewable energy, recycling, governance, and international collaboration. In line with the Series Learning Outcomes, you should now be able to define and explain the human role, describe and analyse contemporary issues, explain and evaluate degradation processes, and assess strategies for sustainability and cooperation.

Glossary of Terms

Agriculture: The practice of cultivating land, growing crops, and raising animals, which can both support human needs and contribute to environmental degradation when done unsustainably.

Biodiversity loss: The reduction or disappearance of species and habitats, often caused by human activities such as deforestation, pollution, and climate change.

Climate change: Long-term shifts in global or regional climate patterns, largely driven by greenhouse gas emissions from human activities.

Community participation: The involvement of individuals and groups in environmental protection and decision-making, helping to promote sustainability at local levels.

Consumption patterns: The ways in which people use resources, including food, energy, and materials, which influence levels of waste and sustainability.

Deforestation: The large-scale clearing of forests for agriculture, logging, or urbanisation, leading to habitat loss and environmental imbalance.

Economic activities: Human actions such as industry, trade, and services that drive development but also impact the environment.

Environmental degradation: The deterioration of the natural environment due to unsustainable human activities, resulting in resource depletion and ecosystem damage.

Global cooperation: Collective efforts by nations, organisations, and communities to address environmental challenges that cross borders, such as climate change.

Industrialisation: The growth of industries and factories, which can increase economic output but often leads to pollution and resource depletion.

Mining: The extraction of minerals and other resources from the earth, which can cause soil erosion, water contamination, and landscape destruction.

Pollution: The contamination of air, water, or soil by harmful substances, often from industrial, agricultural, or domestic sources.
Population growth: The increase in the number of people, which raises demand for resources, housing, and energy, often leading to environmental stress.
Recycling: The process of reusing materials to reduce waste and conserve resources, contributing to sustainable development.
Renewable energy: Energy derived from natural sources such as sunlight, wind, and water, which can be replenished and are less harmful to the environment than fossil fuels.
Sustainable development: Meeting present human needs without compromising the ability of future generations to meet their own needs, by balancing economic, environmental, and social priorities.
Technology: Tools, machines, and innovations developed by humans, which can either harm the environment through pollution or support sustainability through cleaner alternatives.
Urbanisation: The expansion of cities and towns, often leading to habitat loss, increased waste, and higher energy demand.
Waste management: The collection, treatment, and disposal of waste materials, which is essential for reducing pollution and protecting the environment.

Concept Check Questions [Series 5]

Objective Questions

1. Define the term *human role in the environment*. (Linked to SLO 5.1)
2. Which of the following is NOT a component of the human role in the environment?
   a) Population growth
   b) Technology
   c) Recycling
   d) Consumption patterns (Linked to SLO 5.2)
3. Identify one major contemporary environmental issue that directly affects biodiversity. (Linked to SLO 5.3)
4. Environmental degradation caused by unsustainable farming practices is an example of:
   a) Industrialisation
   b) Agriculture
   c) Mining
   d) Urbanisation (Linked to SLO 5.5)
5. Which pillar of sustainable development focuses on fairness and equality among people? (Linked to SLO 5.7)

Short-Answer Questions

6. Explain how population growth contributes to environmental stress. (Linked to SLO 5.2)
7. Describe one example of pollution and its impact on human health. (Linked to SLO 5.3)

8. State two ways in which urbanisation leads to environmental degradation. (Linked to SLO 5.5)
9. Assess why renewable energy is considered a key component of sustainable development. (Linked to SLO 5.8)
10. Briefly explain the importance of global cooperation in addressing climate change. (Linked to SLO 5.9)

Long-Answer Questions
11. Analyse the impacts of deforestation as a contemporary environmental issue, highlighting both ecological and social consequences. (Linked to SLO 5.4)
12. Evaluate the importance of understanding environmental degradation for designing conservation policies. (Linked to SLO 5.6)
13. Discuss strategies for sustainable development and explain how they can be applied in local communities. (Linked to SLO 5.8)
14. Examine the role of international agreements in promoting global cooperation for environmental sustainability. (Linked to SLO 5.9)

Answers to Concept Check Questions [Series 5]
Objective Questions
1. Human role in the environment refers to how human activities influence environmental processes and outcomes.
2. c) Recycling
3. Deforestation or climate change.
4. b) Agriculture
5. Social pillar

Short-Answer Questions
6. Population growth increases demand for resources such as food, water, and housing, leading to deforestation, pollution, and higher energy use.
7. Air pollution from vehicle emissions can cause respiratory diseases such as asthma and bronchitis.
8. Urbanisation leads to habitat loss and increased waste generation.
9. Renewable energy reduces reliance on fossil fuels, lowers greenhouse gas emissions, and supports long-term sustainability.
10. Global cooperation ensures shared responsibility, knowledge exchange, and collective action to reduce emissions and mitigate climate change.

Long-Answer Questions
11. Analyse the impacts of deforestation
- *Basic response*: Deforestation destroys habitats, reduces biodiversity, and contributes to climate change. It also affects local communities by reducing access to forest resources.
- *Value-added response*: Beyond ecological loss, deforestation disrupts water cycles, increases soil erosion, and contributes to global carbon emissions. Socially,

it can displace indigenous communities and undermine cultural practices tied to forests.

12. Evaluate the importance of understanding environmental degradation

- *Basic response*: Understanding degradation helps identify causes and effects, guiding conservation and restoration policies.
- *Value-added response*: It also supports sustainable planning, informs international negotiations, and encourages innovation in green technologies.

13. Discuss strategies for sustainable development

- *Basic response*: Strategies include conservation, renewable energy, recycling, governance, and community participation.
- *Value-added response*: In local communities, these strategies can be applied through eco-friendly farming, solar energy projects, waste recycling initiatives, and participatory governance that empowers citizens.

14. Examine the role of international agreements

- *Basic response*: Agreements such as the Paris Agreement encourage countries to reduce emissions and cooperate on climate action.
- *Value-added response*: They also establish monitoring frameworks, provide financial support for developing nations, and foster innovation through shared research and technology transfer.

Answers to Pilot Questions [Series 5]

Part 5.1 Human Role in the Environment

1. The human role in the environment refers to how human activities influence environmental processes and outcomes.
2. Two components are population growth and technology.
3. Population growth increases demand for resources such as food, water, and housing.
4. Technology is helpful when it supports sustainability (e.g., renewable energy) but harmful when it causes pollution.
5. Culture influences environmental attitudes by shaping beliefs and practices, such as conservation or exploitation.

Part 5.2 Contemporary Environmental Issues

1. Contemporary environmental issues are current challenges facing the Earth's systems due to human activities and natural processes.
2. An example of pollution is air pollution from vehicle emissions.
3. The main cause of deforestation is clearing land for agriculture and urbanisation.
4. Climate change affects human societies by causing extreme weather events such as floods and droughts.
5. Biodiversity loss is serious because it reduces species variety and disrupts ecosystems.

Part 5.3 Human Activities and Environmental Degradation

1. Environmental degradation is the deterioration of the natural environment due to unsustainable human activities.
2. Industrialisation contributes by releasing pollutants into air, water, and soil.
3. Agriculture affects soil quality through overuse of fertilisers and pesticides.
4. Urbanisation impacts ecosystems by causing habitat loss and increasing waste.
5. Overexploitation of resources means using forests, fisheries, or water beyond sustainable limits.

Part 5.4 Sustainable Development and Global Cooperation

1. Sustainable development is meeting present human needs without compromising the ability of future generations to meet their own needs.
2. One component is conservation of resources.
3. Renewable energy is important because it reduces reliance on fossil fuels and lowers greenhouse gas emissions.
4. Global cooperation in environmental science means collective efforts by nations, organisations, and communities to address shared challenges.
5. One future challenge requiring global cooperation is climate change.

References and Attributions [Series 5]

This section provides references for the concepts discussed in Series 5: *Human Role and Contemporary Environmental Issues*, as well as attributions for illustrations suggested or generated. The referencing style used here follows **APA (7th edition)** for clarity and consistency.

Textual References

- Brundtland Commission. (1987). *Our Common Future*. Oxford University Press.
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Illustration Attributions

- **Figure 5.1 Human–environment interactions**
  - Suggested as AI-generated. Prompt: *"Generate a diagram showing population, technology, and consumption arrows pointing to environmental systems."*
  - Platform: Microsoft Copilot image generation.
  - Alternative OER search string: *"human role in environment diagram OER"*.
- **Box 5.1 Key components of human role in the environment**

    - Suggested as AI-generated. Prompt: *"Generate a text box listing population growth, technology, consumption, culture, and economy as components of human role."*
    - Platform: Microsoft Copilot image generation.
    - Alternative OER search string: *"components of human role in environment OER"*.
- **Plate 5.1 Human activities and their environmental impact**
    - Suggested as AI-generated. Prompt: *"Generate an image showing a city skyline, farmland, and solar panels to illustrate human impact."*
    - Platform: Microsoft Copilot image generation.
    - Alternative OER search string: *"urbanisation agriculture renewable energy environment OER image"*.
- **Figure 5.2 Major contemporary environmental issues**
    - Suggested as AI-generated. Prompt: *"Generate a simple diagram with icons for pollution, deforestation, climate change, and biodiversity loss."*
    - Platform: Microsoft Copilot image generation.
    - Alternative OER search string: *"diagram of contemporary environmental issues OER"*.
- **Plate 5.2 Examples of contemporary environmental issues**
    - Suggested as AI-generated. Prompt: *"Generate an image showing smog in a city, a deforested area, and an endangered animal."*
    - Platform: Microsoft Copilot image generation.
    - Alternative OER search string: *"images of pollution deforestation biodiversity loss OER"*.
- **Figure 5.3 Human activities contributing to environmental degradation**
    - Suggested as AI-generated. Prompt: *"Generate a diagram showing arrows from industrialisation, agriculture, mining, and urbanisation pointing to environmental degradation."*
    - Platform: Microsoft Copilot image generation.
    - Alternative OER search string: *"diagram of human activities causing environmental degradation OER"*.
- **Plate 5.3 Examples of environmental degradation**
    - Suggested as AI-generated. Prompt: *"Generate an image showing a deforested area, a polluted river, and a crowded urban settlement."*
    - Platform: Microsoft Copilot image generation.
    - Alternative OER search string: *"images of deforestation pollution urbanisation OER"*.
- **Figure 5.4 The three pillars of sustainable development**
    - Suggested as AI-generated. Prompt: *"Generate a diagram with three overlapping circles labelled economic, environmental, and social."*
    - Platform: Microsoft Copilot image generation.
    - Alternative OER search string: *"three pillars of sustainable development diagram OER"*.
- **Plate 5.4 Examples of global cooperation for sustainability**

- Suggested as AI-generated. Prompt: *"Generate an image showing a climate summit, a local clean-up, and solar panels as cooperation examples."*
- Platform: Microsoft Copilot image generation.
- Alternative OER search string: *"images of global cooperation climate summit renewable energy OER"*.