Allama Iqbal Open University
Solved Assignments Spring 2026

Course Code:	**1421/5443 Code**
Course Name:	**Introduction to Environmental Science**
Class:	**BS/BA**
Total Credit Hours	**3**
Total Assignments	**2**

Assignment 2

Q. 1 Why is freshwater considered a limited resource, and what are the major challenges in its management?

Freshwater is considered a limited resource because although Earth is flooded with water (covering 71% of the planet), only a tiny fraction is available for human use. About 97.5% of all water is salt water in oceans and seas. Of the remaining 2.5% fresh water, more than two-thirds (87%) is locked in polar ice caps and glaciers. Thus, only 0.77% of total Earth's water is found in lakes, wetlands, rivers, groundwater, biota, soil, and the atmosphere. This easily accessible fresh water is continually renewed by the solar-powered hydrologic cycle, but its quantity is finite and unevenly distributed.

Major Challenges in Freshwater Management:

1. **Uneven Distribution and Scarcity:**
   - Rainfall is unevenly distributed globally. Some countries (Brazil, Canada) have abundant water, while others (Kuwait, Libya) have severe scarcity.
   - In Pakistan, despite the Indus River system, annual rainfall is only 240 mm on average, and much of the country is arid.
2. **Population Growth and Increased Demand:**
   - Human water use has been increasing twice as fast as population growth.
   - In many areas, groundwater is being withdrawn faster than it can be replenished (e.g., Libya and Israel withdraw >100% of renewable supply).
3. **Inefficient Agricultural Use:**
   - Agriculture claims about 69% of global water withdrawal. In developing countries, 60–70% of water withdrawn for irrigation never reaches crops due to evaporation, seepage from unlined canals, and inefficient flooding methods.
4. **Groundwater Depletion:**
   - Aquifers (porous layers of sand and gravel) are being depleted. Recharge zones are blocked by urbanization and road building.

- Pollution from fertilizers, pesticides, and industrial effluents contaminates groundwater, making it unsafe for drinking.

5. **Climate Change and Glacier Retreat:**

- Global warming causes glaciers to retreat. In the short term, increased melting causes floods and landslides. In the long term, reduced meltwater will turn perennial rivers into seasonal streams, causing water scarcity.
- Pakistan's agriculture and power generation depend on meltwater from Karakorum glaciers. Continued climate change threatens this supply.

6. **Water Pollution and Degradation:**

- Water quality is degraded by sewage, industrial effluents, agricultural runoff, and solid waste.
- Over 1 billion people lack access to clean drinking water globally, and 2.5 billion lack sanitation. Waterborne diseases cause over 3 million deaths annually (mostly children under 5).

7. **Conflicts and Transboundary Issues:**

- Water disputes raise tensions at local, national, and international levels. The Indus River system is shared between provinces and with India, requiring careful management.

8. **Loss of Water Bodies:**

- Lakes and rivers are relatively temporary features; they are filled with silt or drained.
- In Pakistan, natural lakes like Uchali, Khabeki, and Jhallar have shrunk due to deforestation, coal mining, and oil/gas exploration.

Conclusion:

Freshwater is a renewable but limited resource. The challenges of uneven distribution, overuse, pollution, climate change, and population pressure require urgent attention to ensure sustainable water management for future generations.

Q. 2 Draw and explain the Carbon and Phosphorus cycle.

(Note: As I cannot draw images, I will describe the cycles in detail. You should draw diagrams based on the descriptions below, labeling each process and storage pool.)

Carbon Cycle

The carbon cycle describes the movement of carbon between the atmosphere, oceans, biosphere, and geosphere. Carbon is essential for life (all organic molecules contain carbon). It exists as carbon dioxide gas (CO_2), limestone ($CaCO_3$), fossil fuels, wood, and living organisms.

Stages and Processes of the Carbon Cycle:

1. **Geological Carbon Cycle (millions of years):**
   - CO_2 in the atmosphere reacts with water to form carbonic acid (weak acid).
   - Acid rain chemically weathers rocks, releasing ions (calcium, bicarbonate).
   - Ions are carried by rivers to the ocean, where they precipitate as calcium carbonate (calcite), forming limestone.
   - Seafloor spreading pushes limestone under continents (subduction). Heat and pressure melt the rock, releasing CO_2 back to the atmosphere through volcanoes and vents.
2. **Biological Carbon Cycle (days to thousands of years):**
   - **Photosynthesis:** Plants (and phytoplankton in oceans) take CO_2 from the atmosphere and, using sunlight, convert it into carbohydrates (sugars). This stores carbon in plant tissues.
     Equation: Energy (sunlight) + $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
   - **Respiration:** Plants, animals, and microbes break down carbohydrates to release energy, returning CO_2 to the atmosphere.
     Equation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy
   - **Decomposition:** When organisms die, decomposers (bacteria, fungi) break down organic matter, releasing CO_2 back to the atmosphere or storing carbon in soil.
   - **Fossil fuel formation:** Under certain conditions, buried organic matter transforms into coal, oil, and natural gas over millions of years.
3. **Human Alteration of the Carbon Cycle:**
   - Burning fossil fuels releases stored carbon rapidly, increasing atmospheric CO_2.

- Deforestation reduces photosynthesis, so less CO_2 is removed.
- Result: Atmospheric CO_2 is higher than in the last half-million years, causing global warming.

4. **Ocean Carbon Storage:**

- Phytoplankton use carbon to make calcium carbonate shells. When they die, shells settle to the ocean floor, forming limestone deposits.

Drawing Tips for Carbon Cycle:

- Draw arrows showing CO_2 between atmosphere and plants (photosynthesis) and between plants/animals and atmosphere (respiration).
- Show decomposition returning CO_2 from dead matter.
- Show fossil fuels and limestone as storage pools, with arrows from burning (CO_2 release) and volcanic activity.
- Label the sun as energy source.

Phosphorus Cycle

The phosphorus cycle is different from the carbon cycle because phosphorus has **no atmospheric form** (it does not exist as a gas). It cycles through water, soil, and sediments. Phosphorus is essential for DNA, RNA, ATP (energy molecules), and cell membranes, as well as bones and teeth.

Stages and Processes of the Phosphorus Cycle:

1. **Weathering of Rocks (Very slow process):**

- Phosphorus is stored in rocks and minerals (e.g., phosphate ores).
- Over long periods, weathering (rain, physical breakdown) releases inorganic phosphorus (phosphate ions PO_4^{3-} and HPO_4^{2-}) into the soil and water.

2. **Uptake by Producers:**

- Plants absorb inorganic phosphorus from the soil through their roots.
- Plants incorporate phosphorus into organic molecules (DNA, ATP).

3. **Movement through Food Chain:**

- Herbivores eat plants, obtaining phosphorus. Carnivores eat herbivores, passing phosphorus along.

4. **Return to Environment by Decomposition:**

- When organisms die or excrete waste, decomposers break down organic matter, returning inorganic phosphorus to the soil and water.

5. **Long-term Storage in Oceans and Sediments:**

- Phosphorus is carried by runoff and rivers to the oceans, where it settles into deep sediments.
- Over millions of years, these sediments become phosphate rocks, completing the cycle when rocks are uplifted and weathered again.

6. **Human Impact:**

- Phosphate ores are mined to make fertilizers and detergents.
- Excess phosphates from agricultural runoff cause **eutrophication** (explosive growth of algae and bacteria) in lakes and coastal waters, upsetting ecosystem stability.

Drawing Tips for Phosphorus Cycle:

- Draw rocks as the main reservoir, with an arrow from rocks to soil/water (weathering).
- Show uptake by plants (producers), then arrows to herbivores, carnivores, and decomposers.
- Show decomposition returning phosphorus to soil.
- Show runoff carrying phosphorus to oceans, then sedimentation to rocks.
- No atmospheric arrows.

Comparison:

- Carbon cycle has a gaseous phase (CO_2), moves quickly, and is affected by burning fossil fuels and deforestation.
- Phosphorus cycle has no gaseous phase, is very slow (millions of years), and is mainly affected by mining and fertilizer use.

Q. 3 Why is biodiversity important for ecosystem resilience and human well-being?

Biodiversity (biological diversity) is the variety of life in all its forms, levels, and combinations. It includes genetic diversity, species diversity, and ecosystem diversity. Biodiversity is essential for both ecosystem resilience (the ability of an ecosystem to recover from disturbances) and human well-being (health, livelihoods, culture).

Importance for Ecosystem Resilience:

1. **Redundancy and Stability:** In a diverse ecosystem, multiple species perform similar functions (e.g., nitrogen fixation, pollination). If one species is lost, others can take over, maintaining ecosystem processes. Monocultures (single crop) are vulnerable; if a disease attacks, the entire crop fails.
2. **Recovery from Disturbances:** Healthy, diverse ecosystems recover better from natural catastrophes (fires, floods, earthquakes, cyclones) and human-caused disasters. Degraded or isolated populations with low genetic diversity are less likely to recover.
3. **Maintenance of Ecological Processes:**

- **Nutrient cycling:** Decomposers (bacteria, fungi) recycle wastes and dead matter into nutrients. Plants take up nutrients, and animals return them through excretion. Without biodiversity, nutrient cycles break down.
- **Energy flow:** Diverse food webs are more stable than simple food chains. If one species declines, predators can switch to alternative prey.
- **Biological control:** Predators (ladybirds eat aphids; birds eat caterpillars) keep pest populations in check. Loss of predators leads to pest outbreaks.

4. **Climate and Water Regulation:** Forests maintain rainfall through evapotranspiration, moderate local climates, and prevent floods and droughts. Wetlands and mangroves purify water and trap silt. Loss of vegetation leads to desertification and water quality decline.
5. **Soil Formation and Protection:** Roots break up soil, improve porosity, and prevent erosion. Earthworms and termites aerate soil. Loss of plant cover leads to topsoil erosion and desertification.

Importance for Human Well-being (Benefits of Biodiversity):

A. Biological Resources:

- **Food:** 5,000 plant species have been used as food, but fewer than 20 feed most of the world. Genetic diversity within crops is vital for breeding disease-resistant, high-yield varieties.
- **Medicines:** About 80% of the world's population depends on natural medicines. Aspirin from willow, taxol from yew tree (anti-cancer), and digitalin from foxglove (heart treatment) are examples. Many modern drugs are derived from plants, animals, and microbes.
- **Agriculture:** Insects pollinate crops; earthworms aerate soil; amphibians and birds eat insect pests. A single ladybird eats over 100 aphids per day. Termites break down organic matter.
- **Wood products:** Timber for construction, furniture, and paper; fuel wood for energy.
- **Ornamental plants:** New hybrids for horticulture.

B. Ecosystem Services:

- **Water protection:** Vegetation in catchments maintains water quality, prevents siltation, and regulates underground water tables.
- **Soil formation and protection:** Prevents landslides, safeguards coastlines, and preserves soil fertility.
- **Nutrient storage and cycling:** Microorganisms transform wastes into usable nutrients.
- **Pollution breakdown:** Ecosystems break down sewage, garbage, and oil spills. Bacteria and fungi assimilate pollutants.
- **Climate stability:** Forests maintain rainfall and moderate temperatures.
- **Habitat provision:** Mangroves provide breeding grounds for commercial fish species.

C. Social Benefits:

- **Research and education:** Natural areas are living laboratories for ecology and evolution.
- **Recreation and tourism:** Hunting, fishing, camping, hiking, wildlife watching provide physical exercise and psychological restoration. Nature-based tourism is a major income source for local communities.

- **Cultural and spiritual value:** In many cultures, particular species or landscapes are linked to identity, meaning, and spirituality. Conservation of biodiversity preserves cultural heritage.

Threats to Biodiversity (for context):

- Habitat destruction (deforestation, urbanization)
- Overharvesting (overfishing, poaching)
- Invasive alien species (paper mulberry in Islamabad causes asthma)
- Pollution (pesticides, lead poisoning)
- Climate change

Conclusion:
Biodiversity is not just a luxury; it is the foundation of ecosystem services that sustain human life. Loss of biodiversity reduces ecosystem resilience, making ecosystems more vulnerable to collapse, and directly harms human health, food security, and economic well-being.

Q. 4 Discuss the four principles of ecosystem sustainability.

To move toward a sustainable society, human activities must be oriented to meet our needs efficiently and fairly within the means of nature. Based on scientific consensus, four principles guide sustainable living:

Principle 1: Reduce dependence upon fossil fuels, underground metals, and minerals.

- Today we live in a fossil fuel-based society, dependent on mining for energy, transportation, and resources.
- Mining threatens national parks, requires massive energy, produces toxic chemicals that leak into groundwater, generates radioactive waste, and displaces communities.
- Burning fossil fuels causes acid rain, smog, ozone depletion, and global climate change. It also contributes to health problems (asthma, cancer, learning disabilities, weak immune systems).

- For sustainability, the flow of substances from the lithosphere (Earth's crust) to the ecosphere (living world) must not systematically increase in concentration. We must shift to renewable energy (solar, wind) and reduce mining.

Principle 2: Reduce encroachment upon nature.

- Encroachment means physical destruction and manipulation of the biosphere, including:
  - Paving over productive land (urban sprawl)
  - Overharvesting forests and fisheries
  - Converting natural habitats to agriculture or development
- This principle calls for:
  - Protecting natural habitats and bioregions
  - Practicing "smart growth" (planned, compact development)
  - Supporting sustainable fishing, agriculture, and timber harvesting
- Encroachment reduces nature's ability to provide ecosystem services (clean water, air, soil formation, pollination). We must leave enough space for natural systems to function.

Principle 3: Meet human needs fairly and efficiently, giving priority to basic needs.

- Natural systems are inherently efficient (e.g., a tree's "waste" leaves become food for decomposers; energy flows in cycles).
- Human systems today are linear: take → use → dispose. This is inefficient and wasteful.
- We must shift from linear models (infinite resource use and growth) to cyclical models (infinite transformation and change), mimicking nature.
- Basic needs (food, clean water, shelter, health, education) must be prioritized over luxury consumption.
- Efficiency means using less resources to provide the same or better services (e.g., drip irrigation instead of flooding fields; energy-efficient appliances).

Principle 4: Reduce dependence upon chemicals and synthetic compounds.

- Many synthetic chemicals (pesticides, plastics, CFCs, industrial solvents) are non-biodegradable. Nature has no experience breaking them down.

- Production and accumulation of human-made substances must not happen faster than they can be reintegrated into natural cycles.
- The Earth has a limited capacity to assimilate waste. Current waste production far exceeds this capacity.
- Consequences of synthetic chemicals include:
  - Ozone depletion (CFCs)
  - Hormone disruption, cancer, and developmental problems
  - Irreversible environmental damage
- Solutions: Use safe, biodegradable alternatives. Reduce waste generation. Design products that can be broken down naturally.

Additional Context from the Book:

- Ecosystems achieve sustainability by using renewable solar energy and recycling chemical nutrients.
- Human interference changes this ideal condition because we exploit resources faster than they are restored.
- To stabilize the converging trends of deteriorating natural systems and rising consumption, we must reorient human activity.

Summary of the Four Principles:

1. Get off fossil fuels and reduce mining.
2. Stop encroaching on natural habitats.
3. Use resources efficiently and meet basic needs fairly.
4. Stop using non-biodegradable synthetic chemicals.

These principles, if implemented, can help create a society that lives within ecological means, using renewable resources no faster than they are replenished and producing waste no faster than it can be absorbed.

Q. 5 Describe the physiographic and climatic regions of Pakistan.

Pakistan has a great variety of landscapes, ranging from high mountain ranges to vast plains, deserts, plateaus, and coastal areas. Its climate varies from arid to humid, depending on topography and location.

Physiographic Regions of Pakistan

The physical framework of Pakistan has been built by two major geomorphic processes: (1) mountain building (tectonic) creating the Western Highlands, and (2) deposition by the Indus River and its tributaries creating the Indus Plains.

A. The Western Highlands

Cover most of Balochistan, NWFP, Northern Areas (Gilgit Agency), and parts of Punjab. Divided into five entities:

1. **Mountainous North:**
   - Parallel mountain ranges with narrow, deep river valleys.
   - East of Indus: ranges run east–west. West of Indus: ranges run north–south.
   - **Important ranges:**
     - **Himalayas** (sub-Himalayas 600–1,200 m; Lesser Himalayas 1,800–4,600 m; Great Himalayas >4,600 m). Westernmost parts in Pakistan.
     - **Karakorams** (average 6,100 m). K-2 (Mount Godwin Austen) is 8,610 m – second highest peak in the world.
     - **Hindu Kush** (west of Pamir Plateau). Noshag (7,369 m) and Tirich Mir (7,690 m).
2. **Koh-e-Safaid and Waziristan Hills:**
   - Koh-e-Safaid (east–west trend, average 3,600 m; highest peak Sikaram 4,760 m).
   - Waziristan Hills (1,500–3,000 m).
   - Important passes: Khyber Pass connects Peshawar to Kabul.
3. **Sulaiman and Kirthar Mountains:**

- Extend south of Gomal River, between Balochistan Plateau and Indus Plains.
- Sulaiman Mountains average 600 m; highest peaks Takht-e-Sulaiman (3,487 m) and Takatu (3,470 m).
- Kirthar Mountains merge into Kohistan area of Sindh.

4. **Balochistan Plateau:**

- West of Sulaiman-Kirthar Mountains.
- Sub-parallel ranges: Makran Coast Range (600 m), Central Makran Range (900–1,200 m).
- Highest peak Ras Koh (3,010 m).

5. **Pothwar Plateau and Salt Range:**

- South of Mountainous North, between Indus River (west) and Jhelum River (east).
- Northern boundary: Kala Chitta Range (450–900 m) and Margalla Hills.
- Southern boundary: Salt Range (750–900 m). Highest point Sakesar Peak (1,527 m).
- Pothwar Plateau is undulating (300–600 m). Islamabad and Rawalpindi sit on it.

B. The Indus Plains

Formed by alluvium deposited by Indus River and its tributaries. Slopes from north (300 m) to south (75 m at Panjnad) and into the Arabian Sea. Divided into:

- **Piedmont Plains:** Alluvial fans along Indus between river and Sulaiman-Kirthar mountains.
- **Alluvial Terraces:** Old alluvium (compact calcareous silty clays) separated by river-cut bluffs (5–15 m high).
- **Active Flood Plains:** Narrow strips (24–40 km wide) along Indus and tributaries, flooded annually, rich alluvium.
- **Deltaic Plains:** Indus Delta south of Thatta, with barrier bars, mud flats, and tidal channels.
- **Rolling Sand Plains and Dunes:** Cholistan (Punjab) and Thar (Sindh) deserts – no perennial streams, wind-dominated, agriculturally poor.

Climatic Regions of Pakistan

Depending on topography, Pakistan has extreme temperature variation. The country is essentially arid, except the southern slopes of the Himalayas and sub-mountainous tract (annual rainfall 760–1,270 mm) which have a humid sub-tropical climate. The extreme north has a highland climate due to great heights.

Controlling Factors of Climate:

1. Sub-tropical location → high summer temperatures.
2. Arabian Sea influence → reduces temperature contrast at the coast.
3. Higher altitudes in west and north → keep temperatures low year-round.
4. Monsoon winds → summer rainfall (July–September).
5. Western depressions (from Mediterranean) → winter rainfall (December–March).
6. Temperature inversion layer (1,500 m in south) → prevents moisture-laden air from rising.

Temperature Regions (Four broad types):

1. Hot summer (≥32°C), mild winter (10–21°C)
2. Warm summer (21–32°C), mild winter (10–21°C)
3. Warm summer (21–32°C), cool winter (0–10°C)
4. Mild summer (10–21°C), cool/cold winter (0–10°C)

Rainfall:

- Most of Pakistan receives <250 mm/year. Sindh, most of Balochistan, major parts of Punjab, and central Northern Areas receive <250 mm.
- Northern Sindh, southern Punjab, northwestern Balochistan receive <125 mm.
- Humid conditions appear when rainfall >750 mm in plains or >625 mm in highlands.
- Two sources: **Monsoon** (July–Sept) and **Western Depression** (Dec–March).

Köppen Climate Classification of Pakistan:

Pakistan falls mainly in **Category B: Dry Climates** (deficient precipitation most of the year).

Specific types:

- **BW – dry arid (desert):** True desert climate, xerophytic vegetation. Covers parts of southern Argentina? (No, in Pakistan: southern Balochistan, Sindh, Cholistan, Thar).
- **BS – dry semiarid (steppe):** Grassland climate, more precipitation than BW. Parts of Punjab, NWFP.

Seasons in Pakistan (Box 3.5):

1. **Cold season (Dec–Mar):** Fine weather, min 4°C, max 18°C. Winter rainfall.
2. **Hot season (Apr–June):** Dry, relative humidity 25–50%, temperature up to 40–53°C (Jacobabad 53°C). Coastal areas 25–35°C but humidity 70–80%.
3. **Monsoon season (July–Sept):** Southwest monsoon brings most of Pakistan's rain.
4. **Post-monsoon season (Oct–Nov):** Transitory period, pleasant weather, driest months.

Forest Types Based on Climate (from Section 9.3.4):

1. Alpine Forests (northern districts – Chitral, Swat, Dir, Kohistan)
2. Coniferous Forests (1,000–4,000 m – NWFP, Rawalpindi)
3. Sub-Tropical Dry Forests (up to 1,000 m – Attock, Rawalpindi, Jhelum, Gujrat, Mansehra, Abbottabad, Mardan, Peshawar, Kohat)
4. Tropical Thorn Forests (Punjab plains, southern Sindh, western Balochistan)
5. Irrigated Plantations (artificial – Changa Manga, 226,000 ha)
6. Riverain Forests (along Indus and tributaries)
7. Mangrove/Coastal Forests (Indus delta – Avicennia officinalis)

Summary:

Pakistan's physiography ranges from the world's second-highest peak (K-2) to sea level, with mountains, plateaus, plains, deserts, and a delta. Its climate is predominantly arid, with four well-marked seasons, influenced by monsoons and western depressions. This diversity creates a wide range of habitats, but also makes the country vulnerable to water scarcity, floods, and climate change impacts such as glacier retreat.