

# Environment and Sustainability Solutions

4300003 – Winter 2023

Semester 1 Study Material

*Detailed Solutions and Explanations*

## Question 1(a) [03 marks]

Explain ecological footprint.

### Solution

Ecological footprint measures the demand on nature by individuals, communities, or nations in terms of biologically productive land and water area required to sustain their lifestyle.

Table 1: Components of Ecological Footprint

Component	Description
<b>Carbon Footprint</b>	Land needed to absorb CO <sub>2</sub> emissions
<b>Cropland</b>	Area for food production
<b>Grazing Land</b>	Area for livestock
<b>Forest Products</b>	Area for timber and paper
<b>Built-up Land</b>	Infrastructure and urban areas

- **Global hectares:** Standard unit for measurement
- **Overshoot:** When footprint exceeds biocapacity
- **Sustainability:** Balance between consumption and regeneration

### Mnemonic

“CGFBB” - Carbon, Cropland, Grazing, Forest, Built-up

## Question 1(b) [04 marks]

Explain Eltonian pyramid.

### Solution

Eltonian pyramid (Pyramid of Numbers) shows the number of organisms at each trophic level in an ecosystem, proposed by Charles Elton.

Diagram:

Tertiary Consumers  
(Few {- 10})}

Secondary Consumers  
(Moderate {- 100})}

Primary Consumers  
(Many {- 1000})}

Producers  
(Maximum {- 10000})

Table 2: Pyramid Types

Type	Basis	Shape
<b>Numbers</b>	Individual count	Usually upright

<b>Biomass</b>	Total weight	Can be inverted
<b>Energy</b>	Energy flow	Always upright

- **Trophic levels:** Feeding positions in food chain
- **10% rule:** Only 10% energy transfers to next level
- **Exceptions:** Tree ecosystem shows inverted number pyramid

### Mnemonic

“ELTON” - Energy Loss Through Organism Numbers

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## Question 1(c) [07 marks]

Explain Eco-system with its classification and component.

### Solution

Ecosystem is a functional unit of nature where living organisms interact with each other and their physical environment, involving energy flow and nutrient cycling.

Table 3: Ecosystem Components

Component	Type	Examples
<b>Abiotic</b>	Non-living	Air, water, soil, climate
<b>Biotic</b>	Living	Plants, animals, microorganisms
<b>Producers</b>	Autotrophs	Green plants, algae
<b>Consumers</b>	Heterotrophs	Herbivores, carnivores, omnivores
<b>Decomposers</b>	Recyclers	Bacteria, fungi

### Classification of Ecosystems:

#### Natural Ecosystems:

- **Terrestrial:** Forest, grassland, desert
- **Aquatic:** Freshwater (pond, river), Marine (ocean, sea)

#### Artificial Ecosystems:

- **Agricultural:** Crop fields, gardens
- **Urban:** Parks, artificial lakes

### Diagram: Energy Flow

```
flowchart LR
    A["Sun"] --> B["Producers"]
    B --> C["Primary Consumers"]
    C --> D["Secondary Consumers"]
    D --> E["Tertiary Consumers"]
    E --> F["Decomposers"]
    F --> B
```

- **Energy flow:** Unidirectional from sun to decomposers
- **Nutrient cycling:** Cyclical movement of elements
- **Food chains:** Linear energy transfer
- **Food webs:** Interconnected food chains

### Mnemonic

“PEACE” - Producers, Energy, Animals, Cycles, Environment

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## Question 1(c OR) [07 marks]

Explain Nitrogen cycle.

### Solution

Nitrogen cycle is the biogeochemical cycle that converts nitrogen compounds through various chemical forms as it circulates through atmosphere, terrestrial and aquatic systems.

#### Diagram: Nitrogen Cycle

```
flowchart LR
    A[Atmospheric N] --> B[Nitrogen Fixation]
    B --> C[Ammonia NH]
    C --> D[Nitrification]
    D --> E[Nitrites NO]
    E --> F[Nitrates NO]
    F --> G[Plant Uptake]
    G --> H[Animal Consumption]
    H --> I[Decomposition]
    I --> C
    F --> J[Denitrification]
    J --> A
```

Table 4: Nitrogen Cycle Processes

Process	Conversion	Organisms
<b>Fixation</b>	$N \rightarrow NH$	Rhizobium, Azotobacter
<b>Nitrification</b>	$NH \rightarrow NO \rightarrow NO$	Nitrosomonas, Nitrobacter
<b>Assimilation</b>	$NO \rightarrow Proteins$	Plants
<b>Decomposition</b>	$Proteins \rightarrow NH$	Bacteria, fungi
<b>Denitrification</b>	$NO \rightarrow N$	Anaerobic bacteria

- Biological fixation:** 80% of total fixation
- Industrial fixation:** Haber process for fertilizers
- Lightning:** Natural atmospheric fixation
- Pollution:** Excess nitrates cause eutrophication

### Mnemonic

“FNADD” - Fixation, Nitrification, Assimilation, Decomposition, Denitrification

## Question 2(a) [03 marks]

List the waste water quality parameter.

### Solution

Table 5: Wastewater Quality Parameters

Physical	Chemical	Biological
Turbidity	BOD	Coliform count
Color	COD	Pathogenic bacteria
Odor	pH	Algae
Temperature	DO	Virus
Total Solids	Ammonia	Protozoa

- Primary parameters:** BOD, COD, pH, suspended solids
- Secondary parameters:** Heavy metals, nutrients
- Indicator organisms:** E.coli for fecal contamination

## Mnemonic

“PCB” - Physical, Chemical, Biological parameters

## Question 2(b) [04 marks]

Explain E-waste classification and effects.

### Solution

Electronic waste (E-waste) refers to discarded electrical and electronic equipment containing hazardous materials.

Table 6: E-waste Classification

Category	Examples	Hazardous Materials
<b>Large Appliances</b>	Refrigerators, washing machines	CFCs, heavy metals
<b>Small Appliances</b>	Microwaves, toasters	Lead, mercury
<b>IT Equipment</b>	Computers, printers	Cadmium, chromium
<b>Telecom Equipment</b>	Mobile phones, cables	Beryllium, flame retardants
<b>Consumer Electronics</b>	TVs, radios	Polyvinyl chloride (PVC)

### Effects of E-waste:

- Environmental:** Soil and water pollution, air contamination
- Health:** Cancer, neurological disorders, respiratory problems
- Resource depletion:** Loss of valuable metals like gold, silver
- Ecosystem damage:** Bioaccumulation in food chain

## Mnemonic

“LSITC” - Large, Small, IT, Telecom, Consumer electronics

## Question 2(c) [07 marks]

Explain Electrostatic precipitators.

### Solution

Electrostatic precipitators (ESP) are air pollution control devices that remove particulate matter from industrial gas streams using electrical charges.

#### Diagram: ESP Working

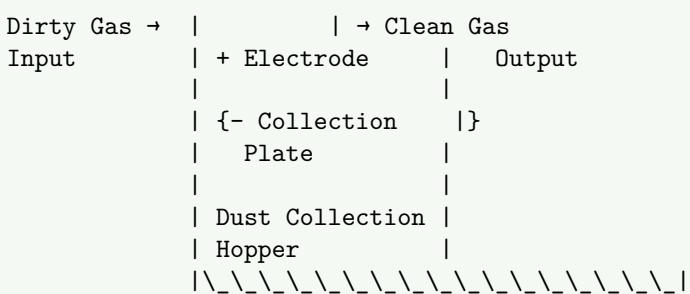


Table 7: ESP Components and Functions

Component	Function	Material
<b>Discharge Electrode</b>	Creates corona discharge	Tungsten wire
<b>Collection Plate</b>	Attracts charged particles	Steel plates
<b>High Voltage Supply</b>	Provides 30-100 kV DC	Transformer-rectifier

<b>Rapper System</b>	Removes collected dust	Mechanical vibrator
<b>Hopper</b>	Collects fallen particles	Steel container

#### Working Principle:

1. **Ionization:** High voltage creates corona discharge
2. **Charging:** Particles acquire negative charge
3. **Collection:** Charged particles move to positive plates
4. **Removal:** Rapping dislodges collected dust

#### Applications:

- **Power plants:** Coal-fired boilers
- **Cement industry:** Kiln gas cleaning
- **Steel industry:** Blast furnace gas
- **Chemical plants:** Process gas treatment

#### Advantages:

- **High efficiency:** 99%+ removal for fine particles
- **Low pressure drop:** Energy efficient operation
- **Handles high temperatures:** Up to 400°C

#### Mnemonic

“CHARGE” - Corona, High-voltage, Attract, Rapper, Gas, Efficiency

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### Question 2(a OR) [03 marks]

Explain (1) BOD (2) COD

#### Solution

Table 8: BOD vs COD

Parameter	BOD	COD
<b>Full Form</b>	Biochemical Oxygen Demand	Chemical Oxygen Demand
<b>Method</b>	Biological oxidation	Chemical oxidation
<b>Time</b>	5 days at 20°C	2-3 hours
<b>Oxidizing Agent</b>	Microorganisms	Potassium dichromate

#### (1) BOD (Biochemical Oxygen Demand):

- **Definition:** Oxygen required by microorganisms to decompose organic matter
- **Standard conditions:** 5 days, 20°C, dark conditions
- **Units:** mg/L or ppm

#### (2) COD (Chemical Oxygen Demand):

- **Definition:** Oxygen equivalent to oxidize organic matter chemically
- **Oxidizing agent:** K Cr O<sub>7</sub> in acidic medium
- **Higher than BOD:** Includes non-biodegradable compounds

#### Mnemonic

“BTCO” - Biological Time, Chemical Oxidation

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### Question 2(b OR) [04 marks]

Explain Recycle of E waste.

## Solution

E-waste recycling is the process of recovering valuable materials from electronic waste while safely disposing of hazardous substances.

Table 9: E-waste Recycling Process

Stage	Process	Recovery
<b>Collection</b>	Gathering from households, offices	Whole devices
<b>Dismantling</b>	Manual separation of components	Plastics, metals, circuit boards
<b>Shredding</b>	Mechanical size reduction	Mixed material streams
<b>Separation</b>	Magnetic, density, optical sorting	Ferrous, non-ferrous metals
<b>Refining</b>	Chemical processing	Pure metals (Au, Ag, Cu, Pd)

### Recycling Methods:

- **Mechanical:** Physical separation and size reduction
- **Pyrometallurgy:** High-temperature metal recovery
- **Hydrometallurgy:** Chemical leaching processes
- **Biotechnology:** Microbial metal extraction

### Benefits:

- **Resource conservation:** Recovery of precious metals
- **Environmental protection:** Prevents soil and water contamination
- **Economic value:** Job creation and revenue generation
- **Energy savings:** Less energy than primary production

## Mnemonic

“CDSPR” - Collection, Dismantling, Shredding, Separation, Refining

## Question 2(c OR) [07 marks]

Define pollution and its source. Explain the classification of pollutants.

## Solution

**Definition:** Pollution is the introduction of harmful substances or energy into the environment, causing adverse changes to air, water, soil, or living organisms.

Table 10: Sources of Pollution

Source Type	Examples	Pollutants Released
<b>Point Sources</b>	Industrial chimneys, sewage outfalls	Specific location discharge
<b>Non-point Sources</b>	Agricultural runoff, urban stormwater	Diffuse area pollution
<b>Mobile Sources</b>	Vehicles, ships, aircraft	Exhaust emissions
<b>Stationary Sources</b>	Power plants, factories	Stack emissions

### Classification of Pollutants:

#### 1. By Nature:

Table 11: Pollutant Classification by Nature

Type	Characteristics	Examples
<b>Biodegradable</b>	Decompose naturally	Organic waste, sewage
<b>Non-biodegradable</b>	Persist in environment	Plastics, heavy metals
<b>Slowly degradable</b>	Decompose over years	Pesticides, radioactive materials

#### 2. By Form:

- **Primary:** Directly emitted (SO<sub>2</sub>, CO, particulates)
- **Secondary:** Formed by reactions (O<sub>3</sub>, acid rain, smog)

#### 3. By Source:

- **Natural:** Volcanic eruptions, forest fires
- **Anthropogenic:** Human activities, industrial processes

#### Diagram: Pollution Classification

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting} []
graph TD
    A[Pollutants] --> B[By Nature]
    A --> C[By Form]
    A --> D[By Source]
    B --> E[Biodegradable]
    B --> F[Non-biodegradable]
    C --> G[Primary]
    C --> H[Secondary]
    D --> I[Natural]
    D --> J[Anthropogenic]
{Highlighting}
{Shaded}
```

#### Effects of Pollution:

- **Environmental:** Ecosystem disruption, species extinction
- **Health:** Respiratory diseases, cancer, genetic disorders
- **Economic:** Healthcare costs, reduced productivity
- **Social:** Quality of life degradation

#### Mnemonic

“BNS-PFC” - Biodegradable, Non-biodegradable, Slowly degradable - Primary, Form, Classification

### Question 3(a) [03 marks]

State the working of solar cell.

#### Solution

Solar cell converts light energy directly into electrical energy through photovoltaic effect using semiconductor materials.

Table 12: Solar Cell Working Process

Step	Process	Result
<b>Photon Absorption</b>	Light hits semiconductor	Electron excitation

<b>Electron-Hole Generation</b>	Energy breaks bonds	Free charge carriers
<b>Charge Separation</b>	Built-in electric field	Electrons to n-side, holes to p-side
<b>Current Collection</b>	External circuit connection	Electrical current flow

- **p-n junction:** Creates internal electric field
- **Depletion region:** Area with charge separation
- **External load:** Completes electrical circuit

### Mnemonic

“PECS” - Photon, Electron, Charge, Separation

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### Question 3(b) [04 marks]

Give the comparison between Horizontal Axis and Vertical Axis wind mills.

### Solution

Table 13: HAWT vs VAWT Comparison

Parameter	Horizontal Axis (HAWT)	Vertical Axis (VAWT)
<b>Blade Orientation</b>	Horizontal rotation	Vertical rotation
<b>Wind Direction</b>	Must face wind	Accepts from any direction
<b>Efficiency</b>	Higher (35-45%)	Lower (20-35%)
<b>Height</b>	Tower mounted, high	Ground level installation
<b>Maintenance</b>	Difficult, high altitude	Easy, ground accessible
<b>Noise</b>	Moderate	Lower
<b>Cost</b>	Higher initial	Lower installation
<b>Power Output</b>	Higher for large scale	Suitable for small scale

**Advantages:** HAWT: Higher efficiency, proven technology, better power-to-weight ratio VAWT: Omnidirectional, easier maintenance, quieter operation, urban friendly

**Applications:** HAWT: Large wind farms, utility-scale power generation VAWT: Urban areas, small-scale applications, distributed generation

### Mnemonic

“HEAVEN” - Height, Efficiency, Accessibility, Versatility, Economics, Noise

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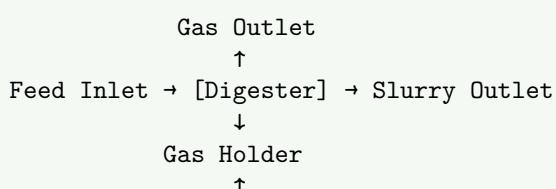
### Question 3(c) [07 marks]

Explain construction and working of Biogas plant with sketch.

### Solution

Biogas plant produces methane-rich gas through anaerobic digestion of organic waste materials by methanogenic bacteria.

**Diagram: Biogas Plant**



## Underground Chamber

Table 14: Biogas Plant Components

Component	Function	Material
<b>Digester</b>	Anaerobic fermentation chamber	Concrete/steel
<b>Gas Holder</b>	Gas storage and pressure regulation	Steel/plastic
<b>Inlet Chamber</b>	Feed material entry	Masonry
<b>Outlet Chamber</b>	Slurry discharge	Masonry
<b>Mixing Tank</b>	Raw material preparation	Concrete

### Construction Details:

#### Underground Digester:

- **Shape:** Cylindrical or dome-shaped
- **Capacity:** 10-100 m<sup>3</sup> for household plants
- **Wall thickness:** 10-15 cm concrete
- **Insulation:** Prevents heat loss

#### Working Process:

Table 15: Biogas Production Stages

Stage	Process	Duration	Products
<b>Hydrolysis</b>	Large molecules breakdown	1-3 days	Simple sugars, amino acids
<b>Acidogenesis</b>	Acid formation	3-7 days	Organic acids, alcohols
<b>Methanogenesis</b>	Methane production	15-30 days	CH (60%), CO (40%)

#### Operating Conditions:

- **Temperature:** 30-40°C (mesophilic)
- **pH:** 6.8-7.2 (neutral)
- **C:N ratio:** 25-30:1 optimal
- **Retention time:** 20-30 days

#### Applications:

- **Cooking:** Clean burning fuel
- **Lighting:** Gas lamps
- **Heating:** Space and water heating
- **Electricity:** Generator sets

#### Advantages:

- **Renewable energy:** Sustainable fuel source
- **Waste management:** Organic waste disposal
- **Fertilizer production:** Nutrient-rich slurry
- **Environmental benefits:** Reduces greenhouse gases

## Mnemonic

“BIGHM” - Biological, Input, Gas, Holder, Methane

## Question 3(a OR) [03 marks]

List the advantages of flat plate collector.

## Solution

Table 16: Flat Plate Collector Advantages

Category	Advantages
<b>Technical</b>	Simple design, no moving parts, low maintenance
<b>Economic</b>	Low cost, mass production possible

<b>Operational</b>	Works with diffuse light, handles both direct and indirect radiation
<b>Durability</b>	Long life (15-20 years), weather resistant
<b>Versatility</b>	Multiple applications, modular installation

**Key Benefits:**

- **Reliability:** No complex mechanisms or controls required
- **Efficiency:** 40-60% thermal efficiency in optimal conditions
- **Installation:** Easy mounting on roofs or ground

<b>Mnemonic</b>
“TEODV” - Technical, Economic, Operational, Durability, Versatility

### Question 3(b OR) [04 marks]

What is wind farm? List its advantages.

<b>Solution</b>	
<b>Definition:</b> Wind farm is a group of wind turbines installed in the same location for commercial electricity generation, connected to electrical grid through transmission lines.	
<b>Category</b>	<b>Advantages</b>
<b>Environmental</b>	Clean energy, zero emissions, reduces carbon footprint
<b>Economic</b>	Job creation, low operating costs, revenue for landowners
<b>Technical</b>	Scalable capacity, grid stability, energy independence
<b>Social</b>	Rural development, community benefits, educational opportunities

**Specific Benefits:**

- **Land use efficiency:** Farming can continue between turbines
- **Quick installation:** Faster than conventional power plants
- **Predictable costs:** Fixed fuel cost (wind is free)
- **Modular expansion:** Capacity can be increased incrementally

**Applications:**

- **Onshore:** Land-based installations
- **Offshore:** Ocean-based for higher wind speeds
- **Distributed:** Small-scale community projects

<b>Mnemonic</b>
“ECTS” - Environmental, Economic, Technical, Social benefits

### Question 3(c OR) [07 marks]

Explain in brief (1) Geothermal energy (2) Tidal energy

<b>Solution</b>	
<b>(1) Geothermal Energy:</b> Geothermal energy harnesses heat from Earth's interior for electricity generation and direct heating applications.	Table 18: Geothermal Energy Systems

Type	Temperature	Applications
<b>High Temperature</b>	>150°C	Electricity generation
<b>Medium Temperature</b>	90-150°C	Direct heating, cooling
<b>Low Temperature</b>	<90°C	Heat pumps, agriculture

#### Working Principle:

- **Heat source:** Radioactive decay in Earth's core
- **Extraction:** Wells drilled to access hot water/steam
- **Conversion:** Steam drives turbines for electricity
- **Reinjection:** Water returned to reservoir

#### (2) Tidal Energy:

Tidal energy converts kinetic and potential energy of ocean tides into electricity using predictable tidal movements.

Table 19: Tidal Energy Technologies

Technology	Principle	Installation
<b>Tidal Barrage</b>	Potential energy of tidal range	Dam across estuary
<b>Tidal Stream</b>	Kinetic energy of tidal currents	Underwater turbines
<b>Tidal Lagoon</b>	Artificial impoundment	Breakwater construction

**Advantages: Geothermal:** Baseload power, low emissions, small footprint, reliable **Tidal:** Predictable, high energy density, long lifespan, no fuel costs

**Challenges: Geothermal:** Location specific, high initial cost, induced seismicity **Tidal:** High capital cost, environmental impact, limited locations

#### Mnemonic

“GT-POWER” - Geothermal Temperature, Tidal Predictable Ocean Water Energy Resource

#### Question 4(a) [03 marks]

Explain Need of Renewable energy.

#### Solution

Table 20: Need for Renewable Energy

Driver	Reasons
<b>Environmental</b>	Climate change mitigation, reduced pollution
<b>Economic</b>	Energy security, price stability, job creation
<b>Technical</b>	Depleting fossil fuels, technological advancement
<b>Social</b>	Rural development, health benefits, energy access

#### Key Needs:

- **Climate commitments:** Meet Paris Agreement targets
- **Energy independence:** Reduce import dependence
- **Sustainable development:** Long-term energy security

#### Mnemonic

“EETS” - Environmental, Economic, Technical, Social needs

## Question 4(b) [04 marks]

Explain Depletion of ozone layer.

### Solution

Ozone layer depletion is the reduction of ozone concentration in stratosphere due to human-made chemicals, particularly chlorofluorocarbons (CFCs).

Table 21: Ozone Depletion Process

Stage	Process	Chemical Reaction
CFC Release	Industrial emissions	CFCs rise to stratosphere
UV Breakdown	Photodissociation	$\text{CFC} + \text{UV} \rightarrow \text{Cl} + \text{other products}$
Ozone Destruction	Catalytic cycle	$\text{Cl} + \text{O} \rightarrow \text{ClO} + \text{O}$
Chain Reaction	Continuous process	$\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2$

#### Causes:

- **Primary:** CFCs, halons, methyl bromide
- **Secondary:** HCFCs, nitrous oxide, carbon tetrachloride

#### Effects:

- **Increased UV-B radiation:** Skin cancer, cataracts
- **Environmental impact:** Reduced crop yields, marine ecosystem damage
- **Climate effects:** Altered atmospheric circulation

#### Solutions:

- **Montreal Protocol:** International agreement (1987)
- **CFC phase-out:** Replacement with ozone-friendly alternatives
- **HCFC transition:** Temporary substitutes being phased out

### Mnemonic

“CURE” - CFCs, UV, Reactions, Effects

## Question 4(c) [07 marks]

Explain: (1) Greenhouse effect (2) climate change management

### Solution

#### (1) Greenhouse Effect:

Natural process where certain atmospheric gases trap heat from sun, maintaining Earth's temperature suitable for life.

#### Diagram: Greenhouse Effect

```
flowchart LR
    A[Solar Radiation] --> B[Earth's Surface]
    B --> C[Heat Radiation]
    C --> D[Greenhouse Gases]
    D --> E[Heat Trapped]
    E --> F[Radiated to Earth]
    F --> B
```

Table 22: Greenhouse Gases

Gas	Sources	Contribution	Lifetime
CO <sub>2</sub>	Fossil fuels, deforestation	76%	300-1000 years
CH <sub>4</sub>	Agriculture, landfills	16%	12 years
NO <sub>x</sub>	Fertilizers, combustion	6%	120 years
F-gases	Industrial processes	2%	Varies

**Enhanced Greenhouse Effect:**

- **Cause:** Increased GHG concentrations from human activities
- **Result:** Global temperature rise, climate change
- **Feedback loops:** Amplify warming effects

**(2) Climate Change Management:**

Comprehensive approach to address climate change through mitigation and adaptation strategies.

Table 23: Climate Change Management Strategies

Strategy	Approach	Examples
<b>Mitigation</b>	Reduce GHG emissions	Renewable energy, energy efficiency
<b>Adaptation</b>	Adjust to climate impacts	Sea walls, drought-resistant crops
<b>Technology</b>	Innovation solutions	Carbon capture, smart grids
<b>Policy</b>	Regulatory frameworks	Carbon pricing, emissions standards
<b>International</b>	Global cooperation	Paris Agreement, climate finance

**Mitigation Measures:**

- **Energy sector:** Renewable energy deployment, efficiency improvements
- **Transport:** Electric vehicles, public transport, biofuels
- **Industry:** Process optimization, low-carbon technologies
- **Buildings:** Green construction, smart systems
- **Agriculture:** Sustainable practices, reduced emissions

**Adaptation Measures:**

- **Infrastructure:** Climate-resilient design, flood protection
- **Ecosystem:** Conservation, restoration, corridors
- **Water resources:** Efficient use, storage, quality management
- **Health:** Disease surveillance, heat wave preparedness

**Management Framework:**

1. **Assessment:** Climate risk and vulnerability analysis
2. **Planning:** Integrated strategies and action plans
3. **Implementation:** Project execution and monitoring
4. **Evaluation:** Performance assessment and adjustment

**Mnemonic**

“GEMMA” - Gases, Enhanced, Mitigation, Management, Adaptation

**Question 4(a OR) [03 marks]**

Discuss Factors affecting climate change.

**Solution**

Table 24: Climate Change Factors

Factor Type	Examples	Impact
<b>Natural</b>	Solar variations, volcanic eruptions	Minor influence
<b>Anthropogenic</b>	GHG emissions, land use change	Major driver
<b>Feedback</b>	Ice-albedo, water vapor	Amplification

**Key Factors:**

- **Greenhouse gas concentrations:** Primary driver of warming
- **Aerosols:** Cooling effect, masks some warming
- **Land use changes:** Deforestation, urbanization effects

## Mnemonic

“NAF” - Natural, Anthropogenic, Feedback factors

## Question 4(b OR) [04 marks]

Explain climate change.

### Solution

Climate change refers to long-term shifts in global temperatures and weather patterns, primarily caused by human activities since mid-20th century.

Table 25: Climate Change Indicators

Indicator	Observed Changes	Trend
Temperature	+1.1°C since 1880	Rising
Sea Level	21-24 cm since 1880	Rising
Arctic Ice	13% per decade loss	Declining
Precipitation	Regional variations	Changing patterns

#### Causes:

- **Primary:** Greenhouse gas emissions from fossil fuels
- **Secondary:** Deforestation, industrial processes, agriculture

#### Impacts:

- **Physical:** Extreme weather, sea level rise, ice loss
- **Biological:** Species migration, ecosystem disruption
- **Human:** Food security, water resources, health

#### Evidence:

- **Temperature records:** Global warming trend
- **Ice core data:** Historical CO<sub>2</sub> levels
- **Satellite observations:** Ice sheet changes

## Mnemonic

“CHIP” - Causes, Human impacts, Indicators, Physical evidence

## Question 4(c OR) [07 marks]

Write short note on Global warming.

### Solution

Global warming is the long-term increase in Earth's average surface temperature due to enhanced greenhouse effect from human activities.

Table 26: Global Warming Components

Aspect	Details	Impact
<b>Definition</b>	Increase in global average temperature	+1.1°C since pre-industrial
<b>Primary Cause</b>	CO <sub>2</sub> emissions from fossil fuels	410+ ppm atmospheric CO <sub>2</sub>
<b>Timeline</b>	Accelerated since 1950s	Fastest warming in 10,000 years
<b>Regional Variation</b>	Arctic warming 2x global average	Polar amplification

## Causes of Global Warming:

Table 27: Emission Sources

Sector	Contribution	Main Activities
<b>Energy</b>	73%	Electricity, heat, transport
<b>Agriculture</b>	18%	Livestock, rice cultivation
<b>Industrial</b>	5%	Cement, steel, chemicals
<b>Waste</b>	3%	Landfills, wastewater
<b>Land Use</b>	1%	Deforestation, development

## Consequences:

- **Physical impacts:** Sea level rise, glacier retreat, permafrost thaw
- **Weather patterns:** More frequent heatwaves, altered precipitation
- **Ecosystem effects:** Species extinction, habitat loss, coral bleaching
- **Human impacts:** Agricultural disruption, water scarcity, health risks

## Feedback Mechanisms:

- **Ice-albedo feedback:** Less ice → more heat absorption
- **Water vapor feedback:** Warmer air holds more moisture
- **Permafrost feedback:** Thawing releases stored carbon

## Solutions:

- **Mitigation:** Reduce greenhouse gas emissions
- **Renewable energy:** Solar, wind, hydroelectric power
- **Energy efficiency:** Buildings, transport, industry
- **Carbon sequestration:** Forests, soil, technological capture
- **Policy measures:** Carbon pricing, regulations, incentives

## International Response:

- **UNFCCC:** Framework Convention on Climate Change
- **Kyoto Protocol:** First binding emission reduction agreement
- **Paris Agreement:** Current global climate accord (2015)
- **IPCC Reports:** Scientific assessment and guidance

## Future Projections:

- **Temperature rise:** 1.5-4.5°C by 2100 depending on emissions
- **Sea level rise:** 0.43-2.84 m by 2100
- **Tipping points:** Irreversible changes in climate system

## Mnemonic

“GWCF” - Global Warming Causes Consequences Feedback

## Question 5(a) [03 marks]

Explain the concept of “Eco Tourism”

## Solution

Eco-tourism is responsible travel to natural areas that conserves environment, sustains well-being of local people, and involves interpretation and education.

Table 28: Eco-tourism Principles

Principle	Description
<b>Conservation</b>	Protect natural habitats and wildlife
<b>Community</b>	Benefit local communities economically
<b>Education</b>	Environmental awareness and learning
<b>Sustainability</b>	Long-term environmental protection
<b>Responsibility</b>	Minimize negative impacts

- **Nature-based:** Focus on natural environments
- **Low-impact:** Minimal environmental disturbance
- **Cultural respect:** Value local traditions and customs

### Mnemonic

“ECERS” - Environment, Community, Education, Responsibility, Sustainability

## Question 5(b) [04 marks]

Comparison of conventional and nonconventional energy source.

### Solution

Table 29: Conventional vs Non-conventional Energy Sources

Parameter	Conventional	Non-conventional
<b>Examples</b>	Coal, oil, natural gas, nuclear	Solar, wind, hydro, biomass
<b>Availability</b>	Limited reserves	Abundant and renewable
<b>Environmental Impact</b>	High pollution, CO <sub>2</sub> emissions	Clean, minimal emissions
<b>Cost</b>	Initially lower, rising prices	High initial, decreasing costs
<b>Technology</b>	Mature, established	Developing, improving
<b>Reliability</b>	Consistent supply	Weather dependent
<b>Infrastructure</b>	Well-established	Requires development
<b>Depletion</b>	Exhaustible resources	Inexhaustible sources

**Advantages:** **Conventional:** Reliable supply, established infrastructure, high energy density **Non-conventional:** Sustainable, clean, job creation, energy independence  
**Challenges:** **Conventional:** Environmental damage, price volatility, finite resources **Non-conventional:** Intermittency, storage needs, initial investment

### Mnemonic

“CATERED” - Conventional Available Technology Established Reliable Environmental Depletion

## Question 5(c) [07 marks]

Explain (1) The water Act, 1974 (2) The Environment Act, 1986

### Solution

#### (1) The Water (Prevention and Control of Pollution) Act, 1974:

Comprehensive legislation to prevent and control water pollution and maintain/restore wholesomeness of water in India.

Table 30: Water Act 1974 - Key Provisions

Aspect	Details
<b>Objective</b>	Prevent and control water pollution
<b>Authority</b>	Central and State Pollution Control Boards
<b>Coverage</b>	All water bodies - rivers, streams, wells, groundwater
<b>Penalties</b>	Fines and imprisonment for violations

### **Key Features:**

- **Pollution Control Boards:** Establishment at central and state levels
- **Consent mechanism:** No-objection certificates for industries
- **Standards:** Water quality standards and effluent discharge limits
- **Monitoring:** Regular inspection and sampling of water bodies
- **Emergency provisions:** Power to handle pollution emergencies

### **Powers of Boards:**

- **Planning:** Pollution prevention and control programs
- **Standard setting:** Water quality and discharge standards
- **Consent granting:** Permission for waste discharge
- **Monitoring:** Water quality surveillance
- **Enforcement:** Legal action against violators

### **(2) The Environment (Protection) Act, 1986:**

Umbrella legislation providing framework for environmental protection and improvement in India, enacted after Bhopal gas tragedy.

Table 31: Environment Act 1986 - Key Provisions

Aspect	Details
<b>Objective</b>	Comprehensive environmental protection
<b>Scope</b>	Air, water, land pollution and hazardous substances
<b>Authority</b>	Central Government and designated agencies
<b>Penalties</b>	Imprisonment up to 5 years and/or fine up to 1 lakh

### **Key Features:**

- **General powers:** Central government authority for environmental protection
- **Standards:** Environmental quality standards for air, water, soil
- **Impact assessment:** Environmental clearance for projects
- **Hazardous substances:** Regulation of handling and disposal
- **Public participation:** Right to information and participation

### **Important Rules:**

- **EIA Notification 2006:** Environmental Impact Assessment
- **Hazardous Waste Rules:** Management and handling
- **Noise Pollution Rules:** Ambient noise standards
- **Coastal Regulation Zone:** Coastal area protection

### **Comparison:**

Table 32: Water Act vs Environment Act

Aspect	Water Act 1974	Environment Act 1986
<b>Scope</b>	Water pollution only	All environmental media
<b>Approach</b>	Sectoral	Comprehensive
<b>Implementation</b>	PCBs	Central Government
<b>Penalties</b>	Moderate	Stringent

### **Enforcement Mechanisms:**

- **Monitoring:** Regular inspection and compliance checking
- **Legal action:** Prosecution of violators
- **Closure orders:** Shutting down polluting units
- **Compensation:** Environmental damage assessment

### **Mnemonic**

“WEPCA” - Water Environmental Protection Comprehensive Act

### **Question 5(a OR) [03 marks]**

Explain the concept “Carbon Credit”

## Solution

Carbon credit is a tradeable certificate representing one tonne of CO<sub>2</sub> equivalent reduced or removed from atmosphere through emission reduction or carbon sequestration projects.

Table 33: Carbon Credit Mechanism

Component	Description
<b>Unit</b>	1 credit = 1 tonne CO <sub>2</sub> equivalent
<b>Generation</b>	Emission reduction/removal projects
<b>Trading</b>	Buy/sell in carbon markets
<b>Verification</b>	Third-party validation required

- **CDM:** Clean Development Mechanism under Kyoto Protocol
- **Voluntary markets:** Private sector initiatives
- **Compliance markets:** Regulatory requirements

## Mnemonic

“CUTV” - Credit Unit Trading Verification

## Question 5(b OR) [04 marks]

Explain in brief “Solid waste Management”

## Solution

Solid waste management is systematic collection, transport, processing, recycling, and disposal of solid materials discarded by human activities.

Table 34: Solid Waste Management Hierarchy

Priority	Method	Description
1st	<b>Reduce</b>	Minimize waste generation
2nd	<b>Reuse</b>	Use items multiple times
3rd	<b>Recycle</b>	Convert waste to new products
4th	<b>Recovery</b>	Energy recovery from waste
5th	<b>Disposal</b>	Safe landfilling

### Management Process:

- **Collection:** Door-to-door pickup, segregation at source
- **Transportation:** Transfer stations, bulk transport
- **Treatment:** Composting, recycling, incineration
- **Disposal:** Sanitary landfills, waste-to-energy

### Technologies:

- **Composting:** Organic waste decomposition
- **Incineration:** High-temperature burning with energy recovery
- **Anaerobic digestion:** Biogas production from organic waste
- **Material recovery:** Separation and recycling of materials

### Challenges:

- **Increasing quantities:** Population and consumption growth
- **Mixed waste:** Lack of source segregation
- **Infrastructure:** Inadequate collection and treatment facilities
- **Financing:** High capital and operational costs

## Mnemonic

“CTTD” - Collection, Transportation, Treatment, Disposal

### **Question 5(c OR) [07 marks]**

**Explain the concept of “5R”**

#### **Solution**

The 5R concept is a comprehensive waste management hierarchy that promotes sustainable consumption and waste reduction through five interconnected strategies.

Table 35: 5R Waste Management Hierarchy

R	Strategy	Definition	Examples
<b>1.</b> <b>Refuse</b>	Reject unnecessary items	Avoid products that create waste	Say no to plastic bags, disposable items
<b>2.</b> <b>Reduce</b>	Minimize consumption	Use less of resources	Buy only needed items, choose durable products
<b>3.</b> <b>Reuse</b>	Use items multiple times	Extend product lifespan	Repurpose containers, donate old clothes
<b>4.</b> <b>Repurpose</b>	Creative alternative uses	Transform waste into useful items	Convert bottles to planters, tires to swings
<b>5. Recycle</b>	Process waste into new products	Material recovery and reprocessing	Paper, plastic, metal recycling

### Detailed Explanation:

#### 1. Refuse:

- **Concept:** First line of defense against waste
- **Implementation:** Consumer choice and awareness
- **Impact:** Prevents waste generation at source
- **Examples:** Refusing single-use plastics, unnecessary packaging

#### 2. Reduce:

- **Concept:** Minimize resource consumption and waste generation
- **Strategies:** Efficient use, durability focus, sharing economy
- **Benefits:** Lower environmental footprint, cost savings
- **Applications:** Energy efficiency, water conservation, minimal packaging

#### 3. Reuse:

- **Concept:** Extend product life without reprocessing
- **Methods:** Direct reuse, repair and maintenance, redistribution
- **Advantages:** Energy savings, economic benefits, creativity
- **Examples:** Glass jars for storage, furniture restoration

#### 4. Repurpose:

- **Concept:** Creative transformation for different functions
- **Innovation:** Design thinking and creativity
- **Community aspect:** Maker spaces, DIY culture
- **Environmental benefit:** Waste diversion from landfills

#### 5. Recycle:

- **Concept:** Material recovery and reprocessing
- **Types:** Mechanical, chemical, biological recycling
- **Infrastructure:** Collection, sorting, processing facilities
- **Markets:** End-use applications for recycled materials

### Implementation Framework:

Table 36: 5R Implementation Levels

Level	Stakeholders	Actions	Outcomes
<b>Individual</b>	Consumers, households	Conscious choices, lifestyle changes	Reduced personal footprint
<b>Community</b>	Neighborhoods, schools	Local programs, awareness campaigns	Community engagement
<b>Business</b>	Companies, industries	Circular economy, sustainable design	Resource efficiency
<b>Government</b>	Policy makers, regulators	Regulations, incentives, infrastructure	System-wide change

#### Benefits of 5R Approach:

- **Environmental:** Reduced pollution, resource conservation, climate protection
- **Economic:** Cost savings, job creation, new business opportunities
- **Social:** Community engagement, education, behavioral change
- **Resource security:** Reduced dependence on virgin materials

#### Challenges:

- **Consumer behavior:** Changing established habits and preferences
- **Infrastructure:** Adequate collection and processing facilities
- **Economics:** Market viability of recycled products
- **Policy support:** Regulatory framework and incentives

#### Success Factors:

- **Education:** Awareness and capacity building programs
- **Infrastructure:** Adequate waste management systems
- **Policy:** Supportive regulations and economic instruments
- **Technology:** Innovation in waste processing and product design
- **Collaboration:** Multi-stakeholder partnerships

**Circular Economy Connection:** The 5R concept forms the foundation of circular economy principles, where waste becomes input for new production cycles, minimizing resource extraction and environmental impact.

#### Measurement and Monitoring:

- **Waste reduction metrics:** Quantity diverted from disposal
- **Material recovery rates:** Percentage of waste recycled/reused
- **Environmental indicators:** Carbon footprint, resource consumption
- **Economic metrics:** Cost savings, job creation, revenue generation

#### Global Examples:

- **Zero Waste Cities:** San Francisco, Ljubljana, Kamikatsu
- **Extended Producer Responsibility:** EU packaging regulations
- **Deposit Systems:** Bottle return programs in Germany, Canada
- **Sharing Economy:** Tool libraries, clothing swaps, repair cafes

#### Future Directions:

- **Digital platforms:** Apps for waste reduction and sharing
- **Advanced recycling:** Chemical recycling, AI-powered sorting
- **Bioplastics:** Biodegradable alternatives to conventional plastics
- **Policy evolution:** Right to repair, extended producer responsibility

#### Mnemonic

“R5-POWER” - Refuse, Reduce, Reuse, Repurpose, Recycle - Protect Our World’s Environmental Resources