Environmental Sustainability (DI02000051)

Summer 2025 Exam Solutions

Milav Dabgar

Lecturer, Dept of ECE
GP Palanpur

Date of Exam: 31-05-2025

Exam Overview

Exam Details

Subject: Environmental Sustainability
Code: DI02000051
Date: 31-05-2025
Time: 10:30 AM – 01:00 PM
Marks: 70

Topics at a Glance

Q.2 Pollution, BOD/COD, E-waste
Q.3 Energy sources, Solar, Wind, Biogas
Q.4 Climate change, Global warming
Q.5 Green building, Env. laws, 5R

Paper Structure

Q.1 14 MCQs (1 mark each = 14)
Q.2–5 (A) any 2 × 3 marks = 6 each
(B) any 2 × 4 marks = 8 each

Q.1 — MCQ Answers (1–7) [14 marks]

#	Key word	Ans	Option
1	Largest ecosystem on Earth	**B**	Oceans
2	Human role in food web	**C**	Primary & secondary consumer
3	Amazon O_2 percentage	**C**	20%
4	Primary consumer	**A**	Herbivore
5	Fungi and bacteria type	**C**	Decomposers
6	Nitrogen in atmosphere	**C**	78%
7	Key element in biotic life	**C**	Carbon

Quick Recall

- **Oceans** cover 71% of Earth; largest ecosystem
- Humans are **omnivores** — eat plants and animals
- Amazon = "lungs of Earth" — **20%** of O_2
- **Herbivore** eats only plants → primary consumer
- Fungi/bacteria = **decomposers** (break down organic matter)
- Atmosphere: **78%** N_2, 21% O_2, 1% Ar + others
- **Carbon** is the backbone of all organic molecules

Q.1 — MCQ Answers (8–14) [14 marks]

#	Key word	Ans	Option
8	Most damaging gas (factories)	**D**	Carbon dioxide
9	Which is NOT a greenhouse gas	**B**	O_2 (oxygen)
10	BOD stands for	**C**	Biochemical oxygen demand
11	Pollution from pesticides	**D**	All of the above
12	Energy for sustainable development	**B**	Renewable energy
13	Biomass energy source type	**C**	Renewable
14	Highest wind power capacity (state)	**A**	Tamil Nadu

Quick Recall

- **CO_2** from combustion is the main environmental pollutant
- **O_2** is essential for life — NOT a greenhouse gas
- BOD = **Biochemical** oxygen demand (microbe decomposition)
- Pesticides contaminate air, soil & water — **all three**
- **Renewable energy** (solar, wind) supports sustainability
- Biomass (biogas, firewood) is **renewable**
- **Tamil Nadu** leads India in installed wind capacity

Q.2(A)(1) — Pollution and Pollutant [3 marks]

Pollution

Pollution is the introduction of harmful substances (physical, chemical, or biological) into the environment that causes adverse changes to air, water, soil, or living organisms.

Types: Air, Water, Soil, Noise, Radiation, Thermal pollution.

Pollutant

A **pollutant** is any substance or energy that causes pollution when introduced into the environment at a concentration harmful to living beings.

Classification:

- **Biodegradable** — broken down by microbes (food waste, sewage)
- **Non-biodegradable** — persists for years (DDT, plastics, heavy metals)
- **Primary** — directly emitted (CO, SO_2)
- **Secondary** — formed by reactions (O_3, smog)

Q.2(A)(2) — Mist, Aerosol, Dust [3 marks]

Mist	Aerosol	Dust
Definition: Tiny water droplets (<10 μm) suspended in air, reducing visibility.	**Definition:** Solid or liquid particles dispersed in gas/air (size: 0.001–100 μm).	**Definition:** Solid particles (>1 μm) suspended or settled in air, from mechanical processes.
Formation: Cooling of moist air to dew point.	**Formation:** Combustion, sea spray, volcanic eruptions.	**Formation:** Crushing, grinding, construction, wind erosion.
Examples: Morning mist near rivers/forests; industrial steam.	**Examples:** Smog, spray cans, smoke.	**Examples:** Cement dust, coal dust, road dust.
Hazard: Can carry dissolved pollutants; reduces visibility causing accidents.	**Hazard:** Enter lungs; affect respiratory health; climate effects.	**Hazard:** Silicosis, asthma; reduces visibility and solar radiation.

Q.2(A)(3) — BOD vs COD [3 marks]

Property	BOD (Biochemical O_2 Demand)	COD (Chemical O_2 Demand)
Full form	Biochemical Oxygen Demand	Chemical Oxygen Demand
Definition	O_2 (mg/L) needed by microorganisms to decompose organic matter at 20°C over 5 days	O_2 needed to chemically oxidize all (organic + inorganic) matter using $K_2Cr_2O_7$
Process	Biological (microbes)	Chemical oxidation
Time	5 days (BOD_5)	1–3 hours
Scope	Only biodegradable organics	All oxidizable matter (broader)
Relation	COD $\geq$ BOD always	COD $\geq$ BOD always
Application	Sewage treatment efficiency	Industrial effluent strength

Higher BOD/COD = more polluted water. Standards: BOD $\leq$ 30 mg/L, COD $\leq$ 250 mg/L for discharge.

Q.2(B)(1) — Gravity Settling Chamber [4 marks]

Principle & Construction

The simplest and oldest **particulate control device**. A large rectangular chamber through which particle-laden gas flows at **low velocity**.

Principle: When gas velocity is reduced, gravitational force exceeds drag force, causing particles to **settle to the floor**.

Construction:

- Long rectangular chamber ($L \gg H$)
- Inlet baffle to spread gas flow
- Dust collection hopper at base
- Outlet for clean gas at far end

Performance

Particle size:	>50 µm (coarse)
Efficiency:	40–60%
Pressure drop:	Low
Cost:	Very low

Advantages & Disadvantages

Advantages:

- Low cost, simple construction
- No moving parts; low maintenance
- Can handle hot and abrasive gases

Disadvantages:

- Large space required
- Only removes coarse particles
- Low efficiency (<60%)

Q.2(B)(2) — Effects of Noise Pollution [4 marks]

Health Effects (Human)

1. **Hearing damage** — permanent hearing loss at >85 dB prolonged exposure; immediate damage at >140 dB
2. **Cardiovascular** — hypertension, increased heart rate, risk of heart disease
3. **Sleep disturbance** — insomnia, fatigue, reduced productivity
4. **Psychological** — stress, anxiety, irritability, elevated cortisol
5. **Cognitive** — impaired concentration, learning difficulties in children
6. **Communication** — speech interference, social isolation

Effects on Animals & Environment

1. **Wildlife disruption** — disturbs feeding, mating, and communication of birds and marine mammals
2. **Sonar interference** — underwater noise disrupts whale/dolphin navigation
3. **Habitat abandonment** — animals flee noisy areas; biodiversity loss
4. **Crop/plant impact** — vibrations from heavy machinery reduce plant growth

Indian standards: 55 dB (residential/day), 45 dB (residential/night)

Q.2(B)(3) — E-Waste: Impact on Environment & Health [4 marks]

Environmental Impact

1. **Soil contamination** — Pb, Cd, Hg leach into soil from landfills; harm soil organisms
2. **Water pollution** — toxic metals leach into groundwater and surface water; kill aquatic life
3. **Air pollution** — burning e-waste releases dioxins, furans, and toxic fumes (SO_2, HCl)
4. **Bioaccumulation** — heavy metals accumulate in food chain (fish $\rightarrow$ humans)
5. **Long persistence** — electronic materials take decades to decompose

Health Impact

1. **Nervous system** — Pb and Hg damage brain/nerves; developmental issues in children
2. **Cancer** — BFRs (flame retardants) and dioxins are carcinogenic
3. **Respiratory** — toxic fumes from informal burning cause lung disease
4. **Reproductive** — Cd, BFRs disrupt hormones; affect fertility
5. **Kidney/liver** — Pb, Cd cause kidney damage and liver toxicity

Q.3(A)(1) — Conventional vs Non-Conventional Energy [3 marks]

Property	Conventional Energy	Non-Conventional Energy
Source	Fossil fuels (coal, oil, nat. gas), nuclear	Solar, wind, hydro, biomass, geothermal, tidal
Availability	Finite; depleting reserves	Inexhaustible; continuously available
Pollution	High CO_2, SO_2, NOx emissions	Minimal/zero pollution during use
Cost	Low capital, rising fuel cost	High capital, negligible running cost
Reliability	Reliable; available 24/7	Intermittent (solar/wind depend on weather)
Technology	Well-established, mature	Developing rapidly; efficiency improving
Examples	Thermal power, diesel generator	Solar PV, wind turbine, biogas plant

Q.3(A)(2) — Applications of Renewable Energy [3 marks]

Solar Energy Applications

- **Solar PV** — grid electricity, rooftop power, solar parks
- **Solar water heater** — domestic/industrial hot water
- **Solar cooker** — cooking in rural/remote areas
- **Solar pump** — irrigation for agriculture
- **Solar street lights** — off-grid lighting

Wind Energy Applications

- Grid-scale power generation (wind farms)
- Small turbines for remote/rural areas
- Offshore wind farms

Other RE Applications

Hydro	Dams, micro-hydro for mountains
Biogas	Cooking, electricity, CNG for vehicles
Biomass	Fuel for industries, briquettes
Geothermal	Space heating, electricity
Tidal	Coastal power generation

India target: 500 GW RE capacity by 2030. Current installed: 200+ GW.

Q.3(A)(3) — Geothermal Energy [3 marks]

Definition & Principle

Geothermal energy is heat energy stored within the Earth's crust, generated by **radioactive decay** of minerals and residual heat from planetary formation.

Temperature gradient: Earth's temperature increases by $\approx 30^{\circ}$C per km depth.

Types of resources:

- Hydrothermal (steam/hot water)
- Geo-pressured brines
- Hot dry rock (HDR)
- Magma resources

Working

1. Wells drilled deep into earth
2. Hot water/steam extracted
3. Steam drives turbine $\rightarrow$ electricity
4. Used water re-injected into reservoir

Applications

Electricity: Iceland, USA, Philippines
Space heating: Direct use in buildings
Agriculture: Greenhouse heating
India: Potential at Manikaran (HP), Puga (Ladakh)

Q.3(B)(1) — National Solar Mission [4 marks]

Overview

The **Jawaharlal Nehru National Solar Mission (JNNSM)** was launched by the Government of India in **January 2010** as part of the National Action Plan on Climate Change (NAPCC).

Vision: Make India a global leader in solar energy by using solar power to meet energy needs in an eco-friendly manner.

Key Objectives

1. Deploy 100 GW of solar power capacity
2. Reduce solar energy cost to grid parity
3. Develop domestic solar manufacturing
4. Create skilled workforce in solar sector
5. Promote off-grid solar for rural areas

Revised Target (2022)

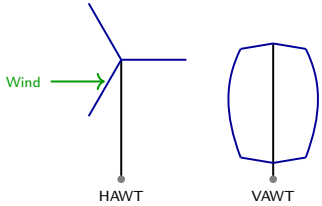
100 GW solar capacity by 2022:
40 GW rooftop solar + 60 GW utility-scale

Achievement

India now has >70 GW solar installed (2024). Among top 5 solar nations globally. Solar tariff reduced from Rs.15/unit (2010) to Rs.2.5/unit (2024).

Q.3(B)(2) — Types of Wind Turbines [4 marks]

Property	HAWT	VAWT
Axis	Horizontal	Vertical
Wind dir.	Must face wind; yaw needed	Works from any direction
Efficiency	40–45% (higher)	30–35% (lower)
Height	60–120 m (tall)	Short, near ground
Maintenance	Hard (at height)	Easy (generator at base)
Noise	Moderate	Lower
Use	Large wind farms	Urban/small-scale
Examples	3-blade propeller (most common)	Darrieus, Savonius



India's wind capacity: ∼45 GW (2024). Tamil Nadu leads; Gujarat second.

Q.3(B)(3) — Biogas Plant: Construction [4 marks]

Components (KVIC Fixed Dome Design)

Inlet pipe:	Slurry (dung+water 1:1) feed
Digester tank:	Brick/concrete underground cylindrical; airtight
Dome:	Fixed/floating on gas; collects biogas
Outlet pipe:	Spent slurry exits as bio-fertilizer
Gas outlet:	Pipe to kitchen/generator
Mixing chamber:	Prepares slurry before feeding

Working Process

1. Cattle dung + water (1:1 ratio) mixed in mixing tank
2. Slurry fed into airtight digester
3. Anaerobic bacteria decompose organics → CH_4 (55–60%) + CO_2 (35–40%)
4. Biogas collects in dome → piped for cooking/electricity
5. Spent slurry (effluent) exits as high-quality fertilizer

Retention time: 30–50 days. 1 cow $\approx$ 5 kg dung/day $\rightarrow$ 0.5 m^3 biogas/day.

Q.4(A)(1) — Effects of Climate Change [3 marks]

Physical Effects

1. **Rising temperatures** — avg. global temp. up 1.1°C since pre-industrial times
2. **Sea level rise** — 3.3 mm/yr; projected +1 m by 2100 (thermal expansion + melting ice)
3. **Extreme weather** — more frequent hurricanes, droughts, floods, heatwaves
4. **Glacier retreat** — Himalayan glaciers shrinking rapidly; drinking water threat

Ecological & Social Effects

1. **Biodiversity loss** — habitat destruction, species extinction (coral bleaching)
2. **Food security** — reduced crop yields due to erratic rainfall and heat
3. **Ocean acidification** — CO_2 dissolves in sea $\rightarrow$ kills coral, shellfish
4. **Human displacement** — coastal flooding forces climate migration
5. **Disease spread** — expansion of malaria, dengue zones

Q.4(A)(2) — Global Agreements on Climate Change [3 marks]

Year	Agreement	Key Feature
1972	Stockholm Conference	First major UN environment conference; founded UNEP
1987	Montreal Protocol	Phase-out of CFCs to protect ozone layer
1992	Earth Summit (Rio)	UNFCCC framework; biodiversity convention
1997	Kyoto Protocol	Legally binding GHG reduction targets for developed nations (first commitment period: 2008–2012)
2009	Copenhagen Accord	Non-binding; $<2°C$ warming target introduced
2015	**Paris Agreement**	**Landmark deal** — limit warming to 1.5°C; NDC mechanism; 195 countries; legally binding
2021	COP26 (Glasgow)	Accelerate phase-out of coal; cut methane 30% by 2030

Q.4(A)(3) — Steps to Control Global Warming [3 marks]

Energy Transition

1. **Switch to renewable energy** — solar, wind, hydro to replace coal/oil
2. **Energy efficiency** — LED lighting, insulation, efficient appliances
3. **Electric vehicles** — replace ICE vehicles; reduce transport emissions
4. **Green hydrogen** — decarbonize heavy industry and shipping

Other Mitigation Steps

1. **Afforestation** — plant trees to absorb CO_2; protect existing forests
2. **Sustainable agriculture** — reduce CH_4 from livestock, rice paddies
3. **Carbon capture (CCS)** — capture and store industrial CO_2 underground
4. **Circular economy** — reduce waste; recycle materials
5. **Policy and cooperation** — carbon tax, international agreements (Paris)

Q.4(B)(1) — Greenhouse Gases [4 marks]

Definition

Greenhouse gases (GHGs) are atmospheric gases that **absorb and re-emit infrared radiation**, trapping heat and warming the Earth's surface (greenhouse effect).

Without GHGs, Earth's avg temp would be -18C instead of $+15$C.

Gas	Sources	GWP
CO_2	Fossil fuels, deforestation	1
CH_4	Livestock, landfills	28
N_2O	Fertilizers, soil	265
CFCs	Refrigerants, AC	4750+

Effects of GHGs

1. **Global warming** — avg temp rise of 1.1°C since industrialization
2. **Sea level rise** — melting ice and thermal expansion
3. **Extreme weather** — more intense storms, droughts
4. **Ocean acidification** — CO_2 dissolves in ocean
5. **Ecosystem disruption** — coral bleaching, species extinction

CO_2 concentration: 280 ppm (pre-industrial) $\rightarrow$ 420+ ppm (2024).

Q.4(B)(2) — Global Warming: Detail [4 marks]

Definition & Mechanism

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

Mechanism:

1. Burning fossil fuels releases CO_2, CH_4
2. GHGs accumulate in atmosphere
3. More IR radiation trapped $\rightarrow$ temp. rises
4. Feedback loops amplify warming (e.g., melting ice reduces albedo)

Consequences

- Rise of 1.1°C since 1880; 3–5°C projected by 2100
- Arctic warming 4$\times$ faster than global average
- Ice sheet and glacier loss accelerating
- Coral reef bleaching at 1.5°C warming
- More frequent wildfires (Australia, Amazon)
- Food/water insecurity for billions

Paris Agreement target: limit to 1.5°C above pre-industrial levels. Current trajectory: 2.5–3°C.

Q.4(B)(3) — Reasons for Climate Change [4 marks]

Human (Anthropogenic) Causes

1. **Burning fossil fuels** — coal, oil, gas release massive CO_2 and CH_4; largest contributor (75% of GHG)
2. **Deforestation** — trees that absorbed CO_2 are destroyed; Brazil, Indonesia worst hit
3. **Agriculture** — livestock (CH_4), rice paddies, fertilizers (N_2O)
4. **Industrial processes** — cement, steel, chemicals release CO_2/N_2O
5. **Refrigerants/AC** — CFCs and HFCs with very high GWP

Natural Causes

1. **Volcanic eruptions** — release CO_2, SO_2; can cause short-term cooling (aerosols)
2. **Solar variation** — changes in sun's output (Milankovitch cycles)
3. **Ocean circulation** — El Niño/La Niña affect global temperatures
4. **Methane hydrates** — natural release from ocean floor

Key fact: Human activities cause ≈97% of observed warming since 1950.

Q.5(A)(1) — Goals of Green Building [3 marks]

Definition

A **green building** is designed, constructed, and operated to minimize environmental impact, conserve resources, and provide a healthy and comfortable indoor environment.

Primary Goals

1. **Energy efficiency** — reduce energy consumption by 30–50% through insulation, daylight, efficient HVAC, solar panels
2. **Water conservation** — rainwater harvesting, low-flow fixtures, greywater recycling; reduce water use by 30–40%
3. **Waste reduction** — minimize construction waste; promote recycling and composting

Additional Goals

4. **Healthy indoor air** — use low-VOC materials; good ventilation; natural lighting
5. **Sustainable materials** — use recycled/local/certified materials (FSC timber, fly-ash bricks)
6. **Land use** — minimize site disruption; protect biodiversity; green roofs
7. **Carbon footprint** — achieve net-zero or even net-positive buildings

Q.5(A)(2) — Environmental Laws in India [3 marks]

Year	Law	Purpose
1972	Wildlife Protection Act	Protect wildlife; ban poaching and trade of endangered species
1974	Water (Prevention & Control of Pollution) Act	Regulate water pollution; establish PCBs
1980	Forest Conservation Act	Restrict diversion of forest land for non-forest use
1981	Air (Prevention & Control of Pollution) Act	Control air pollution; set emission standards
1986	**Environment Protection Act**	**Umbrella law** — empowers govt. to take all environmental measures
1991	Coastal Regulation Zone Notification	Protect coastal ecosystems from construction
2010	National Green Tribunal Act	Fast-track environmental dispute resolution (NGT)

Q.5(A)(3) — Rainwater Harvesting [3 marks]

Definition & Methods

Rainwater harvesting (RWH) is the collection, storage, and use of rainwater from rooftops, land, or other surfaces.

Methods:

- **Rooftop RWH** — gutters → downpipe → storage tank; filtered and used
- **Surface runoff** — check dams, ponds, percolation tanks
- **Recharge wells** — direct percolation to groundwater
- **Contour trenches** — on hillslopes to slow runoff

Advantages

1. **Groundwater recharge** — replenishes depleted aquifers
2. **Reduces water scarcity** — especially in dry seasons
3. **Reduces flood risk** — diverts runoff from urban areas
4. **Low cost** — simple, low-maintenance technology
5. **Good water quality** — soft water, low TDS
6. **Reduces dependence** on municipal supply
7. **Erosion control** — reduces surface runoff velocity

Q.5(B)(1) — Life Cycle Analysis (LCA) [4 marks]

Definition

Life Cycle Analysis (LCA) is a systematic methodology to assess the **environmental impacts** of a product, process, or service throughout its **entire life cycle** — from raw material extraction to disposal ("cradle to grave").

Standardized by **ISO 14040** and ISO 14044.

Phases of LCA

1. **Goal & Scope** — define purpose, system boundary
2. **Inventory (LCI)** — collect data on inputs/outputs (energy, materials, emissions)
3. **Impact Assessment (LCIA)** — evaluate environmental impacts (GWP, acidification

Applications

- **Product design** — compare eco-profiles of alternatives (plastic vs glass bottle)
- **Eco-labelling** — justify environmental claims (carbon footprint labels)
- **Policy making** — guide regulations on materials, energy, waste
- **Green procurement** — choose suppliers with lower environmental impact
- **Building sector** — compare materials (concrete vs timber)

Example: LCA of Li-ion battery shows mining phase has highest impact, not use phase.

Q.5(B)(2) — GRIHA [4 marks]

Overview

GRIHA (Green Rating for Integrated Habitat Assessment) is India's national green building rating system developed by **TERI** (The Energy and Resources Institute) in partnership with the **Ministry of New & Renewable Energy (MNRE)**.

It evaluates buildings on **34 criteria** across 6 categories and awards **1 to 5 stars** (5 stars = highest).

Evaluation Criteria

Site planning	Land use, biodiversity
Construction	Resource-efficient practices
Energy	Demand reduction, RE use
Water	Conservation, recycling
Waste	Solid waste management
Occupant	Indoor air quality, comfort

Key Benefits

1. **Energy savings** — 30–40% less than conventional buildings
2. **Water savings** — 20–30% reduction through efficient fixtures and RWH
3. **Lower carbon footprint** — reduces operational GHG emissions
4. **Better occupant health** — improved indoor air quality and natural light
5. **Market value** — GRIHA-rated buildings command premium rents

Over 1000 projects registered under GRIHA across India. Mandatory for govt. buildings >5000 m^2.

Q.5(B)(3) — Concept of 5R [4 marks]

What is 5R?

The **5R framework** is a waste management hierarchy that prioritizes actions to reduce environmental impact — in order from most to least preferred.

The 5R Hierarchy

1. **Refuse** — avoid buying/using items you don't need; say no to single-use plastics
2. **Reduce** — use less; buy in bulk; choose products with less packaging
3. **Reuse** — use items multiple times; repair instead of discarding; borrow/share
4. **Repurpose** — give items a new function (upcycling); creativity over disposal
5. **Recycle** — process waste into new raw materials; glass, metal, paper, plastic

Examples in Practice

Refuse:	Carry cloth bag; decline plastic straw
Reduce:	Fix leaky taps; use less paper
Reuse:	Refillable bottles; old clothes as rags
Repurpose:	Jars as storage; tyres as planters
Recycle:	Segregate waste; use recycled paper

Extended versions include **6R** (Recover) or **7R** (Rethink) but 5R is the standard framework.

Summary — Summer 2025 Solutions

Q	Topic	Marks
Q.1 (1–14)	MCQ + Fill in the Blanks	14
Q.2(A)(1)	Pollution and Pollutant	3
Q.2(A)(2)	Mist, Aerosol, Dust	3
Q.2(A)(3)	BOD vs COD	3
Q.2(B)(1)	Gravity Settling Chamber	4
Q.2(B)(2)	Effects of Noise Pollution	4
Q.2(B)(3)	E-Waste Impact	4
Q.3(A)(1)	Conventional vs Non-Conv. Energy	3
Q.3(A)(2)	Applications of RE	3
Q.3(A)(3)	Geothermal Energy	3
Q.3(B)(1)	National Solar Mission	4
Q.3(B)(2)	Types of Wind Turbines	4
Q.3(B)(3)	Biogas Plant Construction	4

Q	Topic	Marks
Q.4(A)(1)	Effects of Climate Change	3
Q.4(A)(2)	Global Climate Agreements	3
Q.4(A)(3)	Steps to Control Global Warming	3
Q.4(B)(1)	Greenhouse Gases	4
Q.4(B)(2)	Global Warming in Detail	4
Q.4(B)(3)	Reasons for Climate Change	4
Q.5(A)(1)	Goals of Green Building	3
Q.5(A)(2)	Environmental Laws in India	3
Q.5(A)(3)	Rainwater Harvesting	3
Q.5(B)(1)	Life Cycle Analysis (LCA)	4
Q.5(B)(2)	GRIHA	4
Q.5(B)(3)	Concept of 5R	4
	Total	**70**