

## Subject Name & Code:

ENVIRONMENTAL SCIENCE, SUSTAINABILITY AND RENEWABLE ENERGY- BE04000101

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### Assignment 3: Sustainability (CO4)

#### A. Sustainable development & Circular economy (CO4)

##### 1. Define Sustainability. *(Short)*

- **Sustainability:** Meeting the **needs of the present** without compromising the ability of **future generations** to meet their own needs. It rests on three pillars: **Environmental protection, Social equity, and Economic viability** (People, Planet, Profit).

##### 2. Why is sustainable development so often associated with protecting the environment? *(Medium)*

- Because **the environment provides the foundation** for both society and the economy.
- **Reasoning:**
  - **Resource base:** The economy depends on natural resources (wood, water, minerals). Environmental degradation destroys this base.
  - **Life support:** A clean environment (air, water, stable climate) is essential for human health and survival.
  - **Intergenerational link:** Environmental damage (e.g., species extinction, climate change) is often **irreversible** or takes centuries to repair. A company can go bankrupt and recover; an extinct species cannot.
  - **Carrying capacity:** The environment has a finite capacity to absorb pollution. Sustainable development focuses on staying within these planetary boundaries.
- **Conclusion:** While social and economic sustainability are important, **environmental sustainability is the prerequisite** for the other two.

##### 3. Enlist at least five Sustainable Development Goals (SDGs). *(Short)*

The 17 SDGs (2015-2030) adopted by the UN. Any five:

1. **SDG 1:** No Poverty
2. **SDG 2:** Zero Hunger
3. **SDG 3:** Good Health and Well-being
4. **SDG 4:** Quality Education
5. **SDG 5:** Gender Equality
6. **SDG 6:** Clean Water and Sanitation
7. **SDG 7:** Affordable and Clean Energy

8. **SDG 11:** Sustainable Cities and Communities
  9. **SDG 12:** Responsible Consumption and Production
  10. **SDG 13:** Climate Action
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## **B. Basic concept of Green Building (CO4)**

### **1. Explain in brief "Green Building". (Medium)**

- **Definition:** A **Green Building** (or sustainable building) is a structure that is designed, constructed, operated, and maintained in an **environmentally responsible and resource-efficient** manner throughout its life cycle.
- **Key focus areas:**
  - **Water efficiency** (low-flow fixtures, rainwater harvesting).
  - **Energy efficiency** (solar panels, LED lighting, insulation).
  - **Material efficiency** (recycled content, locally sourced, low-VOC paints).
  - **Indoor environmental quality** (daylight, natural ventilation, non-toxic materials).
  - **Site selection** (protect natural habitat, reduce heat island effect).
- **Goal:** Minimize environmental impact while providing healthy, comfortable spaces for occupants.

### **2. What are the objectives of green building? (Medium)**

- **Environmental Objectives:**
  - Reduce **carbon footprint** (lower energy use).
  - Conserve **water** and **natural resources**.
  - Minimize **construction waste** (recycle debris).
  - Protect local **biodiversity**.
- **Economic Objectives:**
  - Lower **operating costs** (30-50% less energy/water bills).
  - Higher **property value** and rental income.
  - Reduced maintenance costs.
- **Social/Health Objectives:**
  - Improve **indoor air quality** (reduces sick building syndrome).
  - Enhance **occupant comfort** (thermal, acoustic, visual).
  - Promote **well-being** (access to nature, daylight).

### **3. Explain the various fundamental principles of green building. (Long)**

- **Principle 1: Sustainable Site Design**

- Choose brownfield (contaminated land) or infill sites to avoid disturbing greenfields.
- Preserve existing trees and topsoil.
- Reduce heat island effect with light-colored roofs and pavement.
- **Principle 2: Water Conservation**
  - Rainwater harvesting (collect roof runoff for landscaping).
  - Low-flow fixtures (faucets, showerheads, dual-flush toilets).
  - Greywater recycling (reuse sink/shower water for flushing).
- **Principle 3: Energy Efficiency (Most important)**
  - Passive solar design (orientation to maximize winter sun, block summer sun).
  - High-performance envelope (insulation, double-glazed windows, air sealing).
  - Energy-efficient appliances (5-star BEE rating).
  - On-site renewable energy (solar PV panels, wind turbines).
- **Principle 4: Materials Selection**
  - Use **recycled content** (e.g., fly ash in concrete, recycled steel).
  - Use **rapidly renewable** materials (bamboo flooring, cork).
  - Use **locally sourced** materials (reduce transport emissions).
  - Avoid materials with **VOCs** (volatile organic compounds) and formaldehyde.
- **Principle 5: Indoor Environmental Quality (IEQ)**
  - Maximize **daylighting** (windows, skylights) and views.
  - Provide **operable windows** for natural ventilation.
  - Use **low-VOC paints**, adhesives, sealants.
  - Control moisture to prevent mold.
- **Principle 6: Waste Reduction**
  - Design for **deconstruction** (easy to disassemble, reuse materials).
  - Divert construction waste from landfill (recycle concrete, wood, metal).

#### 4. Which are different Green Building rating systems? Explain any one in detail. (Long)

- **Major Rating Systems:**
  1. **LEED** (Leadership in Energy and Environmental Design) – USGBC (Global).
  2. **GRIHA** (Green Rating for Integrated Habitat Assessment) – India (TERI & MNRE).
  3. **IGBC** (Indian Green Building Council) – India (CII).
  4. **BREEAM** (Building Research Establishment Environmental Assessment Method) – UK.
  5. **Green Star** – Australia.

- **Detailed Explanation: LEED (v4 or v5)**
  - **Sections (Categories):**
    1. **Integrative Process**
    2. **Location & Transportation** (e.g., proximity to transit).
    3. **Sustainable Sites** (e.g., erosion control).
    4. **Water Efficiency** (e.g., 30% reduction).
    5. **Energy & Atmosphere** (e.g., 20% energy savings, on-site renewables).
    6. **Materials & Resources** (e.g., 30% recycled content).
    7. **Indoor Environmental Quality** (e.g., low-VOC paints).
    8. **Innovation** (e.g., exceptional performance).
    9. **Regional Priority** (local environmental issues).
  - **Scoring:** Certified (40-49 pts), Silver (50-59), Gold (60-79), Platinum (80+).
  - **Process:** Register project → Submit documentation → Review by GBCI → Certification awarded.

#### 5. Give the full form of: LEED, IGBC, GRIHA, TERI (*Short*)

- **LEED:** Leadership in Energy and Environmental Design
- **IGBC:** Indian Green Building Council
- **GRIHA:** Green Rating for Integrated Habitat Assessment
- **TERI:** The Energy and Resources Institute (New Delhi)

#### 6. Define smart city. Discuss the concept of smart city. (*Medium*)

- **Definition (Smart City):** An urban area that uses **information and communication technology (ICT)** and Internet of Things (IoT) sensors to efficiently manage assets, resources, and services, improving quality of life for citizens.
- **Concept (Core features):**
  - **Smart Infrastructure:** Sensors on water pipes (detect leaks), electricity grids (smart meters), traffic lights (adaptive control).
  - **Smart Mobility:** Real-time public transit info, integrated ticketing, EV charging networks, traffic congestion management.
  - **Smart Environment:** Air quality monitoring stations, automated waste bins (signal when full), smart streetlights (dim when no one around).
  - **Smart Governance:** Online portal for paying bills, applying for permits, reporting potholes (grievance redressal).
  - **Smart Living:** Telemedicine, Wi-Fi in public spaces, home automation.
- **Indian Context (Smart Cities Mission - 2015):** 100 cities selected (e.g., Gandhinagar, Surat, Pune). Focus on **area-based development** (retrofitting, redevelopment, greenfield).

### 7. What are the core infrastructure elements of smart city? (*Medium*)

The Ministry of Housing and Urban Affairs (India) lists these core elements:

1. **Adequate Water Supply:** 24x7 pressurized water with smart meters.
  2. **Assured Electricity Supply:** Reliable power, solar rooftops, smart grid.
  3. **Sanitation & Solid Waste Management:** Underground bins, sewerage network, waste-to-energy plants.
  4. **Efficient Urban Mobility & Public Transport:** Metro, bus rapid transit (BRT), bike-sharing.
  5. **Affordable Housing:** Especially for poor (in-situ slum redevelopment).
  6. **Robust IT Connectivity & Digitalization:** Fiber optic network, city Wi-Fi, data centers.
  7. **Safety & Security:** CCTV surveillance, emergency response system (panic buttons).
  8. **Health & Education:** Telemedicine, smart classrooms, e-hospitals.
  9. **Sustainable Environment:** Rainwater harvesting, green buildings, parks.
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### C. Concept of 4R'S (CO4)

#### 1. What are the principles of 4Rs? (*Short*)

The 4Rs form a **waste management hierarchy** from most to least preferred:

1. **Reduce:** Minimize the amount of waste generated at the source.
2. **Reuse:** Use an item again, either for the same purpose or a different one, without processing.
3. **Recycle:** Convert waste materials into new products (requires processing).
4. **Recover (or Rot for organic):** Extract energy from waste (e.g., incineration with energy recovery, anaerobic digestion).

#### 2. How the concept of reduction of waste at source helps in waste management? (*Medium*)

- **Definition:** Reduction (or "source reduction") means preventing waste from being created in the first place.
- **How it helps:**
  - **Lower volume:** Less waste generated means less to collect, transport, and dispose of. This saves money (fuel, labor, landfill fees).
  - **Reduced toxicity:** Avoiding hazardous materials (e.g., using water-based paints instead of solvent-based) makes the waste safer.
  - **Conserves resources:** Using less paper means fewer trees cut; using less plastic means less petroleum consumed.
  - **Energy savings:** Manufacturing a product takes energy. Not making it (because we don't need it) saves that energy.
  - **Examples:** Buying bulk items (less packaging), refusing single-use plastic bags/straws, printing double-sided.

- **Hierarchy position:** Reduce is **the most effective R** because it eliminates the problem entirely rather than managing it later.
- 3. Explain the concept reuse the material to reduce the amount of solid waste. (Medium)**
- **Definition:** Using an item **again** without major reprocessing or recycling. It extends the life of the product.
  - **How it reduces waste:**
    - Keeps items out of the landfill for longer.
    - Requires little to no energy (unlike recycling which needs melting/repulping).
    - Saves the resources needed to manufacture a new item.
  - **Examples of Reuse:**
    - **Direct reuse:** Refilling a water bottle instead of buying a new plastic one; using cloth bags instead of plastic; repairing a phone instead of discarding it.
    - **Creative reuse (Upcycling):** Turning old tires into planters; glass jars into storage containers; old t-shirts into cleaning rags.
    - **Platform-based reuse:** Donating old clothes to charity; selling used books/furniture (OLX, Facebook Marketplace); sharing tools (library of things).
  - **Conclusion:** Reuse bridges the gap between Reduce (best) and Recycle (requires energy).
- 4. What are the possible ways of recycling the materials? (Medium)**
- **Recycling:** Processing waste materials into new, raw materials or products.
  - **Two main types:**
    - **Closed-loop recycling:** Waste product is recycled into the **same product** (e.g., aluminum can → aluminum can; glass bottle → glass bottle). Highly efficient.
    - **Open-loop recycling (Downcycling):** Waste is recycled into a **lower-quality product** (e.g., plastic bottle → plastic park bench; paper → cardboard). Eventually, it still goes to landfill.
  - **Possible ways/methods by material:**
    - **Paper/Cardboard:** Pulped (mixed with water), cleaned, de-inked, pressed into new paper.
    - **Plastics (PET, HDPE, etc.):** Sorted by type (1-7), shredded, melted, extruded into pellets → new bottles, fibers (fleece jackets), or lumber.
    - **Glass:** Crushed (cullet), melted, molded into new bottles/jars (infinite recyclable).
    - **Metals (Aluminum, Steel):** Shredded, melted, purified, cast into ingots → new cans, cars, beams. Aluminum saves 95% energy vs virgin.
    - **Electronics (E-waste):** Shredded, separated by magnets/eddy currents, smelted to recover copper, gold, silver.
    - **Organic waste:** Composting (aerobic) or anaerobic digestion.

## 5. How concept of 4R can be used for developing an effective solid waste management system. (Long)

- A 4R-based SWM system prioritizes actions in a hierarchy:
- **Step 1: Reduce (Top Priority)**
  - **Implementation:**
    - Government: Ban single-use plastics (e.g., India's ban on straws, cutlery).
    - Producer: Design products with minimal packaging (e.g., shampoo bars, refillable containers).
    - Consumer: Buy only what is needed; avoid over-packaged goods; carry own bag/bottle.
  - *Result:* Waste never enters the system.
- **Step 2: Reuse**
  - **Implementation:**
    - Deposit-refund system for glass bottles (return bottle get money back).
    - Community repair cafes (fix broken electronics, clothes).
    - Encouraging donation of used goods (clothes, books, furniture).
  - *Result:* Items circulate longer; landfill load reduced.
- **Step 3: Recycle**
  - **Implementation:**
    - **Mandatory segregation** at source (wet, dry, hazardous) in every household.
    - **Door-to-door collection** of segregated dry waste (plastic, paper, glass, metal).
    - **Material Recovery Facility (MRF):** Automated sorting of recyclables.
    - **Market linkages:** Ensure recyclers buy the material (e.g., plastic waste to cement plants as fuel).
  - *Result:* Materials re-enter economy; less mining/virgin resource extraction.
- **Step 4: Recover (Energy)**
  - **Implementation:**
    - **Waste-to-Energy (WtE) incineration** for non-recyclable, combustible waste (after R1-R3).
    - **Biogas plants** for organic (wet) waste from markets, restaurants.
    - **Landfill gas capture** from old dumpsites.
  - *Result:* Generate electricity or heat; reduce landfill volume.
- **Step 5: Disposal (Last resort)**

- Only inert waste (ash, construction debris) goes to sanitary landfill.
  - *Result:* Minimal land use; no environmental contamination.
  - **Conclusion:** A system built on 4Rs is **circular** (resources stay in use) rather than linear (take-make-dispose).
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