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UNIT V

SUSTAINABILITY PRACTICES

1. What is zero waste ? Explain its concept and principles.
2. What is R Concept ? Explain its advantages and disadvantages.
3. What is circular economy ? Explain various steps to achieve circular economy.
4. What is ISO 14000 series ? Explain its advantages and disadvantages.
5. What is life cycle assessment ? Explain its pros and cons.
6. Explain the various elements of EIA.
7. What is sustainable habitat ? Explain its objectives.
8. What is green building ? Explain its criteria and features.
9. With examples explain the green materials.
10. Explain the advantages and disadvantages of energy efficiency.
11. What is sustainable transport ? Explain its key elements.
12. What is sustainable energy ? Explain its different sources.
13. What is energy cycle ? Explain carbon cycle with neat diagram.
14. Explain carbon emission and carbon sequestration.
15. Explain the principle and goal of green engineering.
16. What is sustainable urbanisation ? Explain its rules and socio-economic changes.

1. ZERO WASTE:

Ref. Fig: 5.1

Definition:

It is the set of principles that focus on waste prevention. It encourages redesigning resource life cycles to reuse all the products.

Goal:

1. All the material should be reused up to the optimum level of consumption.
2. It provides guidelines to eliminate waste.
3. To avoid sending waste to lands and ocean.

Concept:

1. Conservation of all the resources.
2. It is done by responsible production, consumption, reuse and recovery of products.
3. Avoiding discharges to land, water and air.

Examples:

i) 1- way recyclable glass bottles
ii) 1- way milk bags.
iii) 1- way paper board cartons.

Principles of Zero waste:

Ref. Fig: 5.2

1. Refuse what you don't need:

It prevents unwanted items coming in to your home.

2. Reduce what you use:

It is equal to less waste at the end.

3. Regulate what is left over:

Food scraps, paper pieces, wooden or bamboo brushes can be Compost.

4. Reuse whatever you can
5. Recycle

Steps to achieve zero waste,

i) Buy ecofriendly products
ii) Support ecofriendly business.
iii) Substitute plastics with ecofriendly products.
iv) Compost put all your kitchen waste to good use.
v) Reuse, Recycle.
vi) Identify high waste areas in our lifestyle.
vii) Know where to apply the principles of zero waste.

Advantages:

i) It reduces climate impact.
ii) It conserves resources.
iii) It minimises pollution.
iv) It promotes social equity.
v) It supports and creates jobs.
vi) Zero waste businesses play a key role.

Disadvantages:

i) It is more expensive.
ii) It is time consuming.
iii) It can be misled.
iv) It is difficult for a large household.
v) Zero waste products are hard to find.
vi) It causes anxiety.

2. R CONCEPT:

Ref. Fig: 5.3

Definition:

The principle of reducing waste, reusing and recycling resources and products is called 3R's.

i) Reduce:

- It means reducing the amount of waste from the things used.
- Waste can be reduced by reducing the raw materials.

ii) Reuse:

- It involves repeated use of items.
- Refillable containers can be reused.
- Rubber rings can be made from discarded cycle tubes.

iii) Recycle:

- It means the use of waste itselves as a resource.
- It involves the production of new useful products from discarded materials.

Example:

1. Old aluminium cans and glass bottle are melted to produce new cans and bottles.
2. Preparation of cellulose insulation from paper.
3. The above process saves money, energy, raw materials and reduces pollution.

Concept of 3R:

i) It refers to reduce, reuse, recycle.
ii) It is mainly for production and consumption.

Principle:

i) To reduce the amount of waste generated.
ii) To improve overall waste management processes.

Importance:

i) Resources like water and energy can be saved.
ii) By reducing the solid waste the amount of garbage can be reduced.
iii) It is better to reduce and reuse rather than recycle.
iv) Recycling saves money and helps family.
v) Recycling reduces air and water pollution.
vi) Recycling reduces land fills.
vii) It prevents contamination of soil and water.

Advantages:

i) Saves energy ii) Saves money.
iii) Reduces green house gas emissions.
iv) Helps in sustainability.
v) Reduces the amount of waste.
vi) Prevents pollution.

Disadvantages:

i) It generates pollutants ii) Processing cost is high.
iii) Recycling sites are unhygienic, unsafe.
iv) Recycled products may not be durable.
v) Recycling might be expensive.
vi) Quality of final product is low.
vii) It is more energy consumption and pollutant.

3. CIRCULAR ECONOMY:

Ref. Fig: 5.4

Definition:

- It is the new production and consumption model.
- It ensures sustainable growth over time.
- It reduces consumption of raw materials.
- It recovers waste by recycling
- It gives a second life as a new product.

Aim:

i) It applies reduce, reuse, recycle.
ii) It makes the most of material resources available to us.
iii) It extends the life cycle of products.

Benefits:

i) It protects environment. ii) It benefits local economy.
iii) It promotes resource independence.
iv) Necessary steps (7R's).

1. Redesigning:
- Redesigning consumes less raw materials and generates less wastes.
- It extends the life cycle.

2. Reduce:
- By reducing consumption, raw materials and waste generation, impact on the environment gets reduced.

3. Reuse:
Reusing the products extends the life cycle.

4. Repair:
- It avoids the use of raw materials
- It saves energy
- It does not generate environmental waste.

5. Renovate:
By updating old object they can be reused.

6. Recycle:
Waste product is used to manufacture new products.

7. Recover:
The discarded products can be recovered for new use.

Example:

i) Electrical devices are designed to repair easily.
ii) Products and raw materials are reused as much as possible.
iii) The products are designed to be reusable.

4. ISO 14000 SERIES:

Ref. Fig:5.5

- It is an international organisation on standardisation.
- It has representatives from various national standard organisation.
- It provides standards and guidelines for business and provides technical support.

- ISO 14000 Series:

i) It is related to environmental management and helps organisations
ii) Minimise their negative impacts to environment.
iii) obeys with applicable laws, regulations and other requirements.
iv) Continually improve with above.

Objectives:

To promote effective environmental management systems in organisations.

List of ISO 14000 Series:

Standard	Title	Applications
ISO 14001	Environmental Management System	Requirements with guidance for use.
ISO 14050	Environmental Management	Vocabulary, terms and definitions.
ISO 14062	Environmental Management	Product design and development

Core elements:

i) Environmental Policy
ii) Planning
ii) Implementation & operation
iv) Checking and Corrective action.
v) Management review
vi) Continuous improvement.

Advantages:

i) It identifies risks and oppurtunities.
ii) It prevents problems
iii) It boosts marketing and sales efforts.
iv) It improves employee performance.
v) It lowers your expenses like energy bills, tax bills.
vi) It helps to reduce waste and carbon footprint.
vii) It is recognised internationally.

Disadvantages:

i) It is extremely costly.
ii) It requires a lot of administrative work.
iii) organisations face a lot of challenges.
iv) No improvement in environmental performance.

5. MATERIAL LIFE CYCLE ASSESSMENT: [LCA]

Ref. Fig. 5.6

- It is the proves of evaluating the effects of a material on the environment in the entire period of its life.
- It is refferred as cradle-to-grave analysis.

Steps:

1. Raw materials extraction
2. Manufacturing
3. Transportation
4. Distribution
5. Usage and retail
6. Waste disposal.

Benefits:

i) It supports sustainable development.
ii) It identifies hotspots in environmental impact.
iii) It is based on internationally accepted standards.
iv) It provides the holistic view on the environmental impacts.
v) Its a tool to access the environmental impacts of a product in its entire life span.
vi) It allows the decision makers to compare two products.

Limitations:

i) It requires large amount of data.
ii) If data collection is poor, conclusions cannot be made.
iii) The approaches and result may confuse the non experts.
iv) It is not easy to communicate the results of LCA
v) The scope and assumptions may vary which leads to different results.

6. ENVIRONMENTAL IMPACT ASSESSMENT [EIA]:

i) It is a formal process.
ii) It predicts the environmental consequences of development projects.
iii) It identifies the environmental, social and economic impacts of the project prior to decision making.

Aim of EIA:

To determine the potential environmental, social and health effects of a developmental project.

Objectives of EIA:

i) To identify the main issues of parties.

ii) To identify who is the party.
iii) To identify what are the problems of the parties.
iv) To identify why the problem arise.

Benefits:

i) Cost and time of the project is reduced.
ii) Biodiversity is maintained.
iii) Human health is improved.
iv) Performance of the project is improved.
v) Usages of resources are decreased.
vi) Waste treatment and cleaning expenses are minimised.
vii) It helps in preventing earthquake, cyclone etc.,

Key elements of EIA:

i) **Scoping:**
- It is used to identify the key issues at an early stage.
- It helps in site selection.
- It also identifies any possible alternatives.

ii) **Screening:**
- It decides if EIA is required based on the informations collected.

iii) **Identifying and evaluating alternatives:**
- It knows the alternative sites and alternative techniques and their impacts.

iv) **Mitigating measures dealing with uncertainty:**
- It reviews the action taken to prevent the adverse effects of the project.

v) **Environmental statements:**
- It is the final stage of the EIA process and reports the findings of EIA.

7. SUSTAINABLE HABITAT:

It means the maintenance of our natural home.

Definition:

It is an ecosystem that produces food and shelter for people and other organisms without resource depletion (ie) No external waste is produced.

Characteristics:

i) Proper waste management
ii) Affordable housing.
iii) Wastewater treatment
iv) Green transportation.

Objectives:

i) To reduce energy demand. It is done by
   a) Promoting alternative technologies.
   b) Energy Conservation practices.
   c) In residential and commercial areas.
ii) Better urban planning. (Ex)
   a) Disaster management
   b) Less use of private transport
   c) More use of public transport.
iii) Encourage community involvement and participation
iv) Conservation of natural resources.
v) Facilitate the growth of small and medium cities.
vi) No elements to be considered as a waste product by engineers and architects.

How to maintain sustainable habitat:

i) Promote energy efficiency
ii) Promote public transport
iii) Promote eco friendly fuels
iv) Manage municipal solid waste.

8. GREEN BUILDINGS:

- It is an efficient method of Construction.
- It produces healthier buildings.
- It has less impact on environment and climate.
- It requires less cost to maintain.

Criteria:

i) The building should be on previously developed land rather than developing new land.
ii) The building is to be near existing infrastructure like bus route, market, library.
iii) The building site should be smaller.
iv) The sites must be sustainably landscaped.
v) It should not suffer from soil erosion (or) light pollution.
vi) The building should have low-flow toilets, grey water systems to reduce usage of water.
vii) The buildings should use clean energy like solar, wind and geothermal.
viii) It reduces material usage and prefer natural, renewable sources.
ix) It uses low emitting materials and products to improve human health and environment.

Features:

i) Efficient use of energy, water and other resources.
ii) Use of renewable energies.
iii) Pollution and waste reduction measures.
iv) Good indoor environmental air quality.
v) Use of non toxic, ethical and sustainable materials.

Principles:

i) Livable communities ii) Energy efficiency

iii) Indoor air quality iv) Resource Conservation.
v) Water Conservation

Components:

i) Energy efficient windows ii) Green roof.
iii) Solar power iv) Water conservation.
v) Recycling vi) Landscaping.
vii) Aluminium weather resistant insulated access panel.

Advantages:

i) Water efficient devices ii) Reduction in waste.
iii) Less air pollution iv) High market value
v) Energy efficient vi) Eco friendly materials.
vii) Less green house gas emission viii) Protect natural resources.
ix) Indoor air quality x) Renewable energies.
xi) Day lighting is best used xii) Rain water collection.
xiii) over all health improvements.

Disadvantages:

i) High initial cost.
ii) Maintenance is difficult.
iii) Technology problem is more
iv) Funding problems.
v) Availability of green construction materials.
vi) Not suitable for all locations.
vii) Experienced workers are rare
viii) Energy supply varies with weather conditions.

9. GREEN MATERIALS:

i) They are ecofriendly materials.
ii) They are building construction materials.
iii) They have low impact on the environment.
iv) Ex: Wood, Ceramics, Glass, clay, sand and stone.

Criteria:

i) Local availability of materials
ii) Rapidly renewable materials
iii) Recyclability of materials
iv) Durability.
v) Environmental impact
vi) Energy efficiency.
vii) Percentage of waste materials used
viii) Include energy of materials

Characteristics:

i) They are energy efficient products
ii) It uses less energy
iii) It lowers energy cost
iv) Lessen pollution.
v) Mostly renewable
vi) Recyclable.
vii) Non-toxic
viii) Cost effective.
ix) Durable and no need to upgrade
x) Locally available.

Important green building materials:

i) Stone: Low maintenance and durable
ii) Cob: Cheap and energy efficient.
iii) Bamboo: Durable and light weight
iv) Cork: Thermal insulator and mould resistant.
v) Adobe brick: Natural noise protection.
vi) Straw Bale: Easily renewable and cheap.
vii) Cord wood: Affordable and thermal efficiency.
viii) Earth bags: Natural insulation
ix) Mushroom roots: Strong and light weight.

Examples of green materials:

i) Bamboo floorings
ii) LED lightings
iii) Solar panels
iv) Recycled steel
v) Cork
vi) Reclaimed wood
vii) Energy efficient appliances
viii) High efficiency glass windows.

10. ENERGY EFFICIENCY:

Ref. Fig: 5.7

It is the use of less energy to perform the same task and produce the same result.

Methods to achieve energy efficiency:

i) Alternative waste treatment.
ii) Capture and combustion of landfill gas.

Calculation:

$$\text{Energy efficiency} = \frac{\text{energy output}}{\text{energy input}} \times 100\%$$

$$\eta = \frac{W_{out}}{W_{in}} \times 100\%$$

Advantages:

i) It decreases water use.
ii) Lowers individual utility bills.
iii) It creates jobs.
iv) It helps to stabilize electricity prices.
v) Lowers green house gases and other pollutants
vi) It is the fastest and effective way to save money.
vii) It lowers overall electricity demand.
viii) It reduces the need to invest in new electricity generation.

Example: Energy efficient LED light bulbs use 75-80% less electricity.

Disadvantage:

i) Building materials are not always available.
ii) Additional cost is required to build and plan energy efficient constructions.
iii) It causes unfavourable effects on human health.
iv) Indoor air is 3 to 7 times more polluted than outdoor air.

(11) SUSTAINABLE TRANSPORT:

Ref. Fig: 5.8

It is any means of transport that is "Green" and has low impact on the environment.

Examples:

i) Walking ii) Cycling iii) Transit iv) Car sharing
v) Green vehicles vi) Car pooling.

Importance:

i) To reduce the negative impacts on the environment.
ii) To reduce atmospheric pollution and improve air quality.

Key elements:

i) Fuel economy:

- Fuel economy leads to lower emission in same mileage. It is achieved by,
  a) Making engines more efficient
  b) Lighter vehicles and bodies are more aerodynamic

ii) Occupancy:

Stick more people in the vehicle leads to lower the carbon intensity.

iii) Electrification:

It is the important pathway to lower carbon transport.

iv) Pedal power:

Bicycle reduces the carbon emissions.

v) Urbanisation:

It reduces the distance travelled and carbon intensity.

Steps for promoting sustainable transport:

i) Enhancing public transportation.
ii) Encouraging carpooling.
iii) Encouraging bicycle use
iv) Teleworking.
v) Improving the parking experience.

Advantages:

i) It creates job.
ii) Provides safer transportation.
iii) Emits less pollution.
iv) Promotes health.
v) Saves energy.
vi) Saves money.
vii) Decreases Congestion.
viii) Conserves land.

Disadvantages:

i) Modifications to handling and transport facilities.
ii) The initial purchase of reusable Containers
iii) Additional cost of the tracking system.

12. SUSTAINABLE ENERGY:

It is the energy which meets the needs of the present without compromising the needs of the future.

Sources:

i) Wind Energy ii) Solar Energy iii) Ocean Energy
iv) Hydropower v) Geothermal energy.

Advantages:

i) Improves public health:
Sustainable energy emits no air (or) water pollutants and eliminates all the health problems and improves public health.

ii) Creates local jobs:
Its infrastructure is built locally thereby helps in creating jobs.

iii) Decrease your carbon footprint:
It creates zero carbon emission.

iv) Cost saving:
It is easily available and cost effective.

v) Energy security:
It helps in conserving the planets' natural resources.

Disadvantages:

i) Not available round the clock.
ii) Initial Cost is high.
iii) Energy sites needs a lot of space.
iv) Energy devices need recycling.

SOLAR ENERGY:

Ref. Fig: 5.9 & 5.10

The energy directly got from the sun.

Methods of harvesting:

1. Solar cells:

i) It consists of p and n-type semiconductors

each other.

iii) When solar rays fall on the top electrons gets promoted from p-type to n-type through p-n junction.

iv) This produces electric current.

Uses: Calculators, watches, street lights, water pumps

Solar batteries:

The connection of large number of solar cells in series.

2. Solar heat collectors:

i) Consists of materials like glass, stones and bricks.

ii) Absorbs heat at day and release at night.

Uses:

In cold places to keep the houses hot.

3. Solar water heater: Ref. Fig: 5.11

i) It consist of an insulated box painted with black paint

ii) It is closed with glass lid.

iii) It has a black painted copper coil.

iv) When cold water flows in it gets heated up and flows to storage tank.

Significance:

i) Noise and pollution free.

ii) It requires no fuel.

iii) It can be used in forest, hilly regions and remote places.

WIND ENERGY: Ref. Fig: 5.12

- Moving air is called wind.
- Energy from wind is called wind energy.
- It is harvested by wind mills and wind farms.

1. Wind mills:

i) When the blowing wind strikes the blade it starts to rotate.

ii) This rotation produces electricity which is used to run water pump, flour mills etc.,

2. Wind Farms:

The large number of windmills joined together in a definite pattern to produce a large amount of electricity.

Condition: The speed of wind must be 15 km/hour.

Advantages:

i) No air pollution.

ii) Very cheap.

OCEAN ENERGY:

Energy derived from ocean.

1. TIDAL ENERGY or Tidal Power: Ref. Fig: 5.13

i) There are two types of tides, high tides and low tides.

ii) Rise of water is high tide and fall of water is low tide.

iii) The energy is taken by a tidal barrage.

iv) During high tide sea water flow in to the barrage and rotates the turbine to produce electricity.

v) During low tide the sea water flows into the sea from barrage and rotates turbine to produce electricity.

2. Ocean thermal energy [OTE]:

i) The energy taken from the difference in temperature of water between the surface level and deeper level of oceans.

Condition: The temperature difference should be $\geq 20^{\circ}c$.

3. Geothermal energy:

Ref. Fig: 5.14

i) The energy taken from the high temperature present inside the earth.
ii) The temperature increases by 20-75°C per Km. down the earth surface.
iii) It is taken by
   a) Natural geysers.
   b) Artificial geysers.

BIOMASS ENERGY:

Ref. Fig: 5.15

- It is the organic matter produced by plants and animals.

Types: Biogas, Biofuel, Hydrogen fuel.

1. Biogas:

i) It is obtained by anaerobic fermentation of animal dung in the presence of water
ii) It consists of about 65% of methane

2. Biofuels:

i) It is obtained by fermentation of biomass.

Examples:
a) Ethanol: It is produced from sugarcane.
b) Methanol: It is obtained from ethanol.
c) Gasohol: It is a mixture of gasoline + ethanol.

3. Hydrogen fuel:

i) It is produced by electrolysis of water.
ii) It has high calorific value.
iii) The combustion product is water.

$$2H_2 + O_2 \longrightarrow 2H_2O + 150\ KJ.$$

13. ENERGY CYCLES:

Ref. Fig: 5.16

It is the interactions between energy sources within the earth's environment

CARBON CYCLE:

It is the movement of carbon (or) carbon compounds continuously from the atmosphere to the earth and then back into the atmosphere.

Carbon is present in the form of carbon dioxide.

Sources of CO_2:

i) Combustion of fuels.
ii) Volcanic eruptions.
iii) Respiration of plants and animals.

Various steps involved in carbon cycle:

Ref. Fig: 5.13

i) Plants absorb CO_2 by photosynthesis [Producers]

$$CO_2 + H_2O + \text{Energy} \longrightarrow (CH_2O)_n + O_2.$$

ii) Animals consume these plants [Consumers]
iii) Decomposers eat the dead organisms of these plants and animals and return the carbon back to the atmosphere [Decomposers]

$$(CH_2O)_n + O_2 \longrightarrow CO_2 + H_2O + \text{Energy}$$

iv) The unreleased carbon becomes fossil fuels.
v) These fossil fuels when used pump more carbon back to the atmosphere.

Importance:

i) It is important for survival of life on earth.
ii) It is the building block of life.
iii) It balances the energy and traps long wave radiations to avoid global warming.

14. CARBON EMISSION AND CARBON SEQUESTRATION:

CARBON EMISSION:

It is the release of green house gases in to the atmosphere over a specified area and period of time.

Types:

1. Scope 1 emissions (or) Direct emission:

It is the direct emission from company. There are 4 categories.

a. Stationary combustion: All fuels
b. Mobile combustion : All vehicles, burning fuel.
c. Fugitive emission : Refrigeration, air-Conditioners.
d. Process emission : Cement and chemical manufacturing.

2. Scope 2 emissions (or) Indirect emissions:

It is the indirect emission from the generation of purchased energy.

Sources (or) causes of carbon emissions:

i) Natural sources:

a) Respiration b) Ocean release c) Carbonate rocks.
d) Decomposition of matter e) Animals exhale CO_2 as a waste product

ii) Human sources:

a) Burning of fossil fuels b) Deforestation.
c) Industrial activities d) Transportation.

Harmful effects:

i) It causes global warming
ii) It affects climate change.
iii) It affects the entire planet.

Methods of reduction:

a) Fuel switching
b) Energy efficiency.
c) use of renewable energy
d) Plant more trees
e) Recycling of materials
f) reduce air travel.
g) Drive more efficient
h) Combined heat and power.

CARBON SEQUESTRATION:

- It is the process of capturing and storing atmospheric CO_2.
- The main goal is to reduce global climate change.

Concept (or) Aim:

- It is to stabilize carbon in solid and dissolved forms.
- To reduce human carbon footprint.

Methods:

i) Biological carbon sequestration:

It is done by grassland, forests, soils and oceans.

ii) Geological carbon sequestration:

It is done by underground geological formations (or) rocks.

iii) Technological carbon sequestration:

- It is done by graphenes.
- Graphenes are used in screens of smart phones which absorb CO_2.

Advantages:

a) It prevents climate change.
b) It lower carbon emission. by 85%.
c) It can be liquified and transmitted through pipelines.

Disadvantages:

a) No enough geological resources.
b) Capturing CO_2 from power plants need more electric power

c) Injecting CO_2 to the oceans damage aquatic life.
d) Cost of energy increases by 5% in sequestration in power plants.
e) In planting trees, it requires more time for the trees to mature.

15. GREEN ENGINEERING:

It is the design, commercialisation and use of processes and products that minimises pollution, promotes sustainability and human health.

Examples:
i) Biodegradable cups and straws.
ii) Waste water treatment.
iii) Radiant floors.
iv) Plant-based cooling.
v) Industrial emission filters.

Goals:
i) Decrease of pollution.
ii) Minimising human population.
iii) Improving energy use
iv) Maintaining economic efficiency.
v) Reducing energy and water consumption.
vi) Reducing carbon footprint.
vii) Improving business efficiency.

Principles:
i) Making all materials and energy non-hazardous.
ii) Prevent waste.
iii) Minimising energy and material use.

iv) Mass, energy, space and time efficiency should be maximized.
v) All products should be designed to have a "after life".
vi) All material and energy inputs should be renewable.
vii) The design of products should have a choice of recycle and reuse.

Benefits:

i) It enhances business practices.
ii) Improves company's reputation.
iii) Minimises energy waste.
iv) Provides tax incentives
v) Reduces air, water and soil pollution.
vi) Provides new business oppurtunities.

Disadvantages:

i) Job losses.
ii) R & D and production costs are high.
iii) Implementation will take many years.
iv) The technology is immature.

16. SUSTAINABLE URBANIZATION:

It is the movement of human population from rural areas to urban areas for need of education, communication, health, employment etc.,

Rules:

i) Sustainable transportation
ii) Sustainable urban development.
iii) Applying ecological design.
iv) Improving water efficiency.
v) Increasing energy efficiency.
vi) Using low impact materials

Pillars of Sustainable Urbanisation: Ref. Fig: 5.18

i) It is based on three functional areas.
ii) They are social, environmental and financial.
iii) They are interconnected and must be considered together.
iv) The goal of sustainability is the place where all these meet and are balanced.

Advantages:

i) Provides better education.
ii) Provides better social life.
iii) More entertainment options.
iv) More tourist attractions.
v) More security and police availability.
vi) More places to shop.
vii) Provides better health care services.
viii) Better housing.

Disadvantages:

i) Over crowding.
ii) No privacy.
iii) More pollution.
iv) Cost of living is higher.
v) Too much crime.
vi) Unemployment problem.
vii) Decline in rural area
viii) Buying a house becomes challenge.

Socio - Economical change:

i) Rapid housing leads to over crowding.
ii) Leads to high crime rates and pollution.
iii) People compete for limited resources.

iv) Leads to inequality.
v) Environmental degradation.
vi) ~~Technological change~~.

Technological change:

It involves the introduction of new idea, method on a device

i) Technological innovation has changed the effectiveness.
ii) Upgradation of industries improve sustainable urbanisation.
iii) Digital technology has empowered a city to be more sustainable.

Fig. 5.1 Logo for zero waste

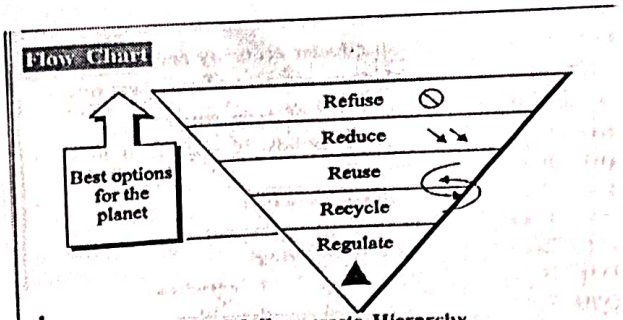

Fig. 5.2 Zero waste Hierarchy

Fig. 5.3 3R Concept

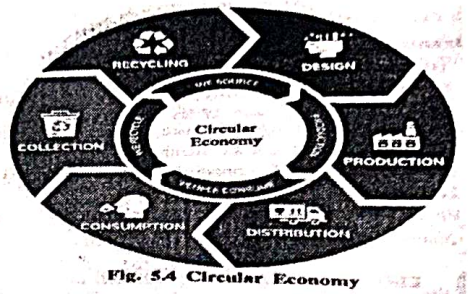

Fig. 5.4 Circular Economy

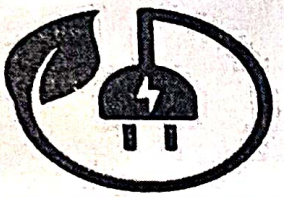

Fig. 5.7 Energy efficiency logo

Fig. 5.8 Sustainable transport

1. Solar cells (or) photovoltaic cells (or) PV cells

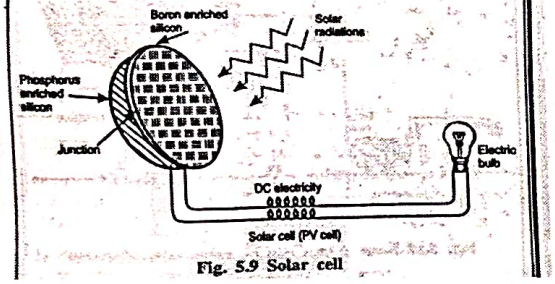

Fig. 5.9 Solar cell

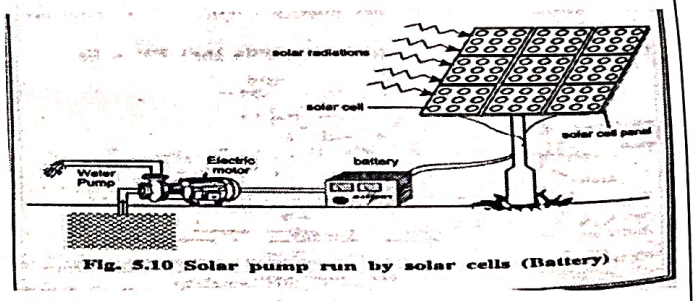

Fig. 5.10 Solar pump run by solar cells (Battery)

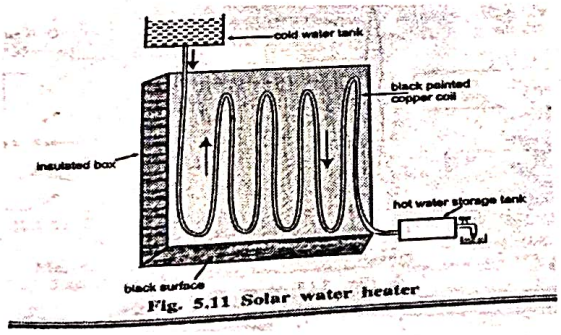

Fig. 5.11 Solar water heater

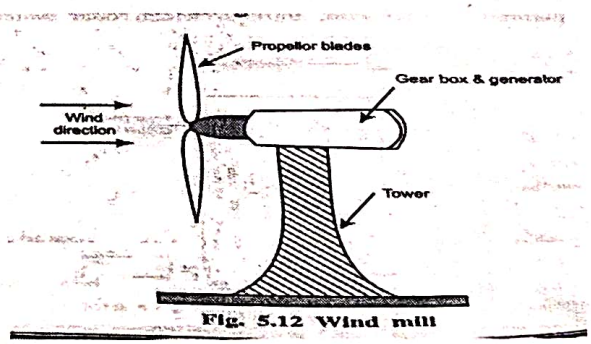

Fig. 5.12 Wind mill

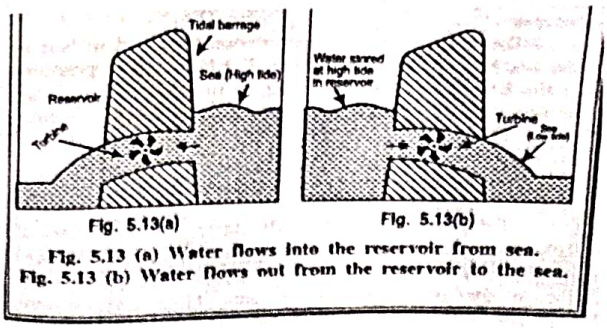

Fig. 5.13(a) Fig. 5.13(b)

Fig. 5.13 (a) Water flows into the reservoir from sea.
Fig. 5.13 (b) Water flows out from the reservoir to the sea.

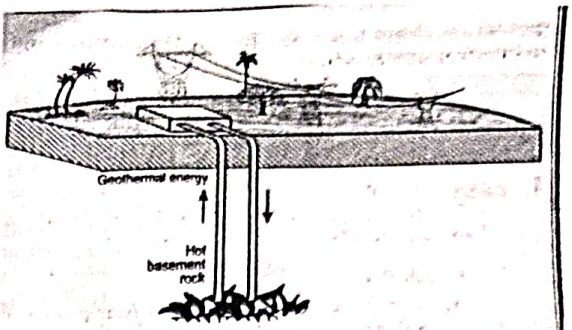

Fig. 5.14 Geo-thermal Energy

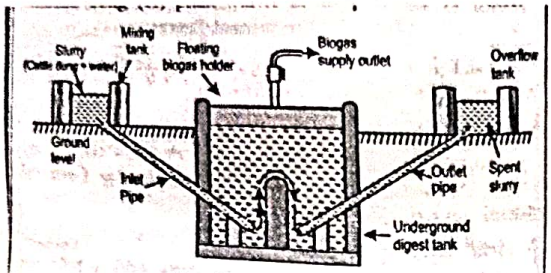

Fig. 5.15 Biogas Plant

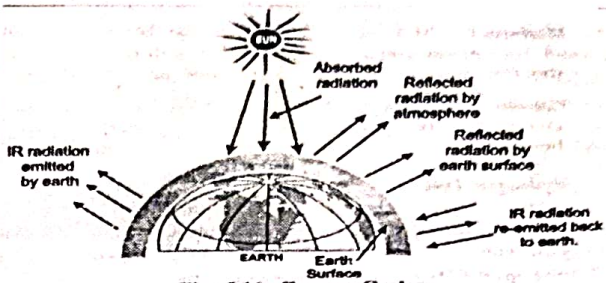

Fig. 5.16: Energy Cycles

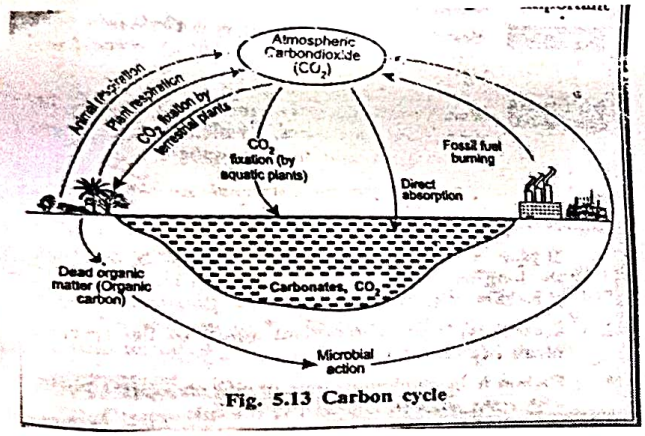

Fig. 5.13 Carbon cycle

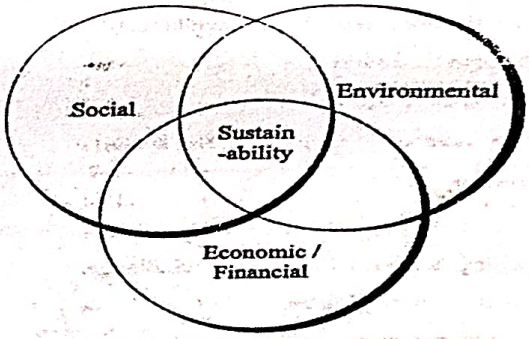

Fig. 5.18 Functional areas of urban sustainability