

Sustainable Engineering

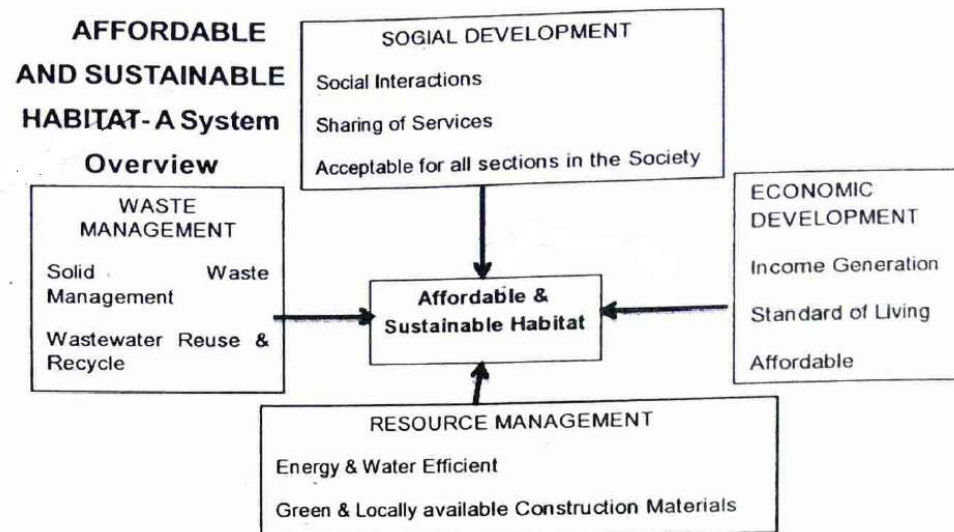
Module 5

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Basic Concepts of Sustainable Habitat

Basic concepts

- ❖ A “sustainable habitat” is an ecosystem that produces food and shelter for the inhabitants without much resource depletion in such a way that no external waste is produced.
- ❖ Population explosion and rapid urbanization led to the shortage of adequate facilities for habitat. Thus to attain sustainability, the basic needs of people, ie; food, clothing and shelter/housing should be fulfilled.
- ❖ Construction industry is considered to be one of the biggest in terms of consumption of natural resources. In this context, government of India has launched, “Sustainable Habitat Mission 2020”, to promote affordable and sustainable habitat.



GREEN BUILDINGS

- ❖ “**Green Building**” is defined as the building which can function using optimum amount of energy, consuming less water and other resources generating minimal waste and creating space for healthy and comfortable living as compare to conventional buildings.

Principles behind the concept of green buildings

- **Sustainable site design** :- Design is based on minimizing site disturbances thereby preserving valuable green space and blending with the aesthetics of the existing environment
- **Energy and environment** :- Providing natural ventilation and tapping renewable energy sources
- **Water and environment** :- Rain water harvesting and reuse of treated water in gardens can be followed for water conservation and waste water reuse
- **Indoor air quality** :- Low VOC emitting paints and adhesives (Volatile Organic Compounds emit carbon vapor), proper ventilation, effective control of acoustics etc; provides a healthy, comfortable and productive indoor environment for building equipment.
- **Less energy building materials** :-Use of locally available materials, recyclable building materials (such as timber) and resource efficient systems are preferred in the construction of green building
- **Waste reduction** :- Waste reduction should be aimed right from the planning phase, construction phase or even in the case of a building demolition case.

Green Materials for Building Construction

- ❖ Materials used for Green Building should be energy efficient, water efficient, non-toxic, have less CO₂ emission, low health risk, and are made from recycled materials and are themselves recyclable etc.

Examples of materials used for green buildings

- **Structural steel and bricks** obtained during building demolition activities can be reused
- Use of **LED** bulbs instead of incandescent lamps as well as CFLs
- **Crushed broken tiles** can be used as a partial replacement for gravels in making concrete.
- **Windows and doors from demolished buildings** can be reused in construction
- **Flyash** (ash produce by powdered coal or other materials carried into air) can be used as a partial substitute for Portland cement (cement manufactured from chalk and clay which hardens under water)
- **Wood chips** produced from timber waste can be used for construction of board
- **Triple glazed windows** can be used to reduce temperature
- Renewable materials like **bamboo and palm** can be extensively used for flooring
- **Low VCO emitting paints and adhesives** can be used to maintain high indoor air quality
- Usage of locally available materials such as **soil blocks (eg: Laterite stone blocks)** and bamboo in construction increase energy efficiency and also reduce cost.
- Air conditioner, fans, motor pumps etc. should be selected based on **energy efficiency ratings**.

Green Building Certification

- ❖ Green building certification is a system in which a building is certified to have achieved certain environmental performance with a pre-defined rating system (evaluation tool) called green building rating system. Some of them are listed below:

Examples of green building rating system

- BREEAM** (Building Research Establishment's Environmental Assessment Method). It is developed in UK.
- LEED** (Leadership in Energy and Environmental Design). Developed in United States. Later, Indian Green Building Council (IGBC) adapted the LEED system and launched LEED's India version
- CASBEE** (Comprehensive Assessment System for Building Environmental Efficiency). It is introduced by Japan

Indian green building rating systems

1. **GRIHA** (Green Rating For Integrated Habitat Assessment)

- It was developed by TERI (The Energy and Resources Institute), New Delhi, which was adopted as National Green Building Rating System by the Ministry of New and Renewable Energy, Government of India, in 2007.
- It is a three tier process, in which the rating evaluates the environmental performance during pre-construction stage, planning, construction, operation and maintenance.

- First step is submission of online application.
- Inspection from GRIHA. Rating system consists of 34 criteria. Some are mandatory and some are optional.
- Report submitted by GRIHA will be evaluated by evaluation committee and assign points.
- Maximum rating is 100 and shall be valid for a period of 5 years from the date of commissioning of building.
- GRIHA rated buildings in India :- Common Wealth Village, New Delhi, Fortis Hospital, New Delhi, Centre for Environmental Science and Engineering, Pune.

POINTS EARNED	RATING
50-60	One Star
61-70	Two Star
71-80	Three Star
81-90	Four Star
91-100	Five Star

GRIHA CRITERIA WITH POINTS

Sl.No	Description	Points	
Criterion 1	Site Selection	1	Partly mandatory
Criterion 2	Preserve and protect landscape during construction	5	Partly mandatory, if applicable
Criterion 3	Soil conservation (post construction)	2	
Criterion 4	Design to include existing site features	4	
Criterion 5	Reduce hard paving on site	2	Partly mandatory
Criterion 6	Enhance outdoor lighting system efficiency	3	
Criterion 7	Plan utilities efficiency and optimize on-site circulation efficiency	3	
Criterion 8	Provide, at least minimum level of sanitation/ safety facilities for construction workers	2	Mandatory
Criterion 9	Reduce air pollution during construction	2	Mandatory
Criterion 10	Reduce landscape water requirement	3	
Criterion 11	Reduce building water use	2	
Criterion 12	Efficient water use during construction	1	
Criterion 13	Optimise building design to reduce conventional energy demand	8	Mandatory
Criterion 14	Optimise energy performance of building within specified comfort limits	16	Partly mandatory
Criterion 15	Utilization of fly-ash in building structure	6	
Criterion 16	Reduce volume, weight, and time of construction by adopting efficient technology for example pre-cast systems, ready-mix concrete, and so on)	4	
Criterion 17	Use low-energy material in interiors	4	
Criterion 18	Renewable energy utilization	5	Partly mandatory
Criterion 19	Renewable energy based hot-water system	3	
Criterion 20	Waste water treatment	2	
Criterion 21	Water recycle and reuse (including rainwater)	5	
Criterion 22	Reduction in waste during construction	1	
Criterion 23	Efficient waste segregation	1	
Criterion 24	Storage and disposal of wastes	1	
Criterion 25	Resource recovery from waste	2	
Criterion 26	Use of low VOC paints/adhesives/sealants	3	
Criterion 27	Minimise ozone depleting substances	1	Mandatory
Criterion 28	Ensure water quality	2	Mandatory
Criterion 29	Acceptable outdoor and indoor noise levels	2	
Criterion 30	Tobacco and smoke control	1	Mandatory
Criterion 31	Universal accessibility	1	
Criterion 32	Energy audit and validation		Mandatory
Criterion 33	Operations and maintenance protocol for electrical and mechanical equipment	2	Mandatory
Criterion 34	Innovation (beyond 100)	4	
		100	

2. LEED (Leadership in Energy and Environmental Design)

- Indian Green Building Council (IGBC) adapted the LEED system of United States and launched LEED's India version in 2014.
- The vision of IGBC is “ To enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025.
- LEED rating system is based on “5 elements” or “Panchabhutas” (Earth, Water Fire, Air and Space) , and consists of following criteria:-

Serial No.	Criterion	Points
	Pre requisites	8
1	Sustainable site selection, planning and design	13
2	Water conservation	6
3	Energy efficiency and atmosphere protection	17
4	Material and resource conservation	13
5	Indoor environmental quality	15
6	Innovation, integrated design and development	5
	Total	69

- LEED rated buildings in **India** :- Sorabji Godrej Green Business Center, Birla International School, Anna Centenary Library Building, Chennai, Larsen and Toubro Limited-Engineering and Design Centre (ERDC), etc.
- LEED rated buildings in **Kerala** :- Energy Management Center, Trivandrum, Kerala.

3. BEE (Bureau of Energy Efficiency)

- BEE is created in 2002, under the ministry of power.
- Its function is to develop programs which will increase the conservation of efficient use of energy in India.
- BEE has developed building rating system based on a 1 to 5 star scale.
- Performance of a building in terms of its specific energy usage in kilowatt hours per square meter per year is considered for rating.
- Reserve Bank of India buildings in Delhi and Bhubaneswar has received BEE 5 star rating.

Methods for Increasing Energy Efficiency of Buildings

- ❖ Being energy efficient means, using less energy for doing the same amount of work, while enjoying the same quality of life.
- ❖ It is estimated that one-third of global energy is consumed by buildings. Hence to increase energy efficiency, it is to be ensured that minimum resources are consumed during construction.
- ❖ Energy consumption in buildings can be categorized into two:-
 - i. **Direct energy consumption** (energy consumed during the useful life of building)
 - ii. **Energy consumed during the construction phase** (depend upon choice of building materials, transportation and building techniques)

Some energy efficient practices :-

- **Ventilation :-** Proper sizing, location of windows are important in ventilation. Opening at higher levels helps venting out hot air.
- **Walls :-** Light color walls reflects more light and heat. Also proper thermal insulation and air cavities in walls, reduce heat transmission into buildings.

- **Roof :-** Roof shading, light colored paints, vegetated roof etc. can reduce heat.
- **Building materials :-** Bamboo, recycled metal, non-toxic adhesives, reusable bricks, laterite stone blocks etc. should be selected for construction.
- **Building orientation :-** Orientation of building slightly east or south is favoured in cold climatic region to gain heat during day time.
- **Building form (Surface to Volume Ratio (S/V)) :-** For any given building volume, the more compact the shape, the less will be the heat loss, due to low S/V ratio.
- **Location of water bodies :-** Proximity of water bodies to buildings can significantly cool the climate of adjacent buildings.
- **Proper landscaping :-** It reduces direct heating from sun. Trees provide shade during summer and in winter these trees shed leaves and allow the sun to heat the buildings.
- **Reducing electricity consumption :-** Installing energy efficient appliances for cooking, heating lighting cooling etc. will reduce electricity consumption.
- **Water conservation :-** Installing “low flow” shower heads and taps will conserve water.
- **Use of Renewable energy systems :-** Use of photovoltaic system and solar water heater system will reduce the consumption of non-renewable energy sources.

Energy Efficiency in Kerala's Naalukettu : Kerala had developed its own housing concepts from time immemorial, wherein Naalukettu was the traditional style of homes designed for a number of families (Joint family) to live together. The traditional architecture is typically a rectangular structure, where four walls are joined together with a central courtyard (called Nadumuttam) open to the sky. The four halls on the sides are known as Vadakkini (Northern block), Padinjattini (Western block), Kizhakkini (Eastern block) and Thekkini (Southern block). Here every structure faces the sunlight and there is excellent ventilation. Temperatures even in the summer season, are comparatively lower within the Naalukettu. Sloping roofs, provided on all the four sides ensures the smooth passage of rain water as well. Another feature of Naalukettu is that the construction materials used are eco-friendly and locally available materials such as mud, wood, laterite blocks etc. The floors are well rammed and made smooth by means of cow dung and charcoal dust.

Assignment

1. Define "Green Engineering". Explain the 12 principles of Green Engineering?

SUSTAINABLE URBANIZATION

- ❖ People move to cities in search of jobs and for better quality of life. At the same time, the so called urban areas also contains poverty, social inequality and environmental degradation.
- ❖ Around 50% of the global population now live in cities and urban areas. But 33% of global urban population now live in slums.
- ❖ The reason for people move from rural to urban areas, can be classified in to two:-
 - **Push factors** :- Factors (negative reasons) that encourage people to leave rural areas
 - **Pull factors** :- Factors (positive reasons) that attract people to urban areas.
- ❖ Even though the world urban area occupy only 2% of Earth's land, the same urban area is responsible for 60 to 80% of global energy consumption and 75% of global carbon emissions, which makes it necessary to transform it towards sustainability path.

Push Factors	Pull Factors
1.Economic No Job No money Less choices	1.Economic More jobs Good money Low price
2. Social Poor education Poor health care Unemployment No social security	2.Social Good education Good health care Good facilities
3. Environmental Extreme weather Natural disasters Pollution	3. Environmental Fine weather Low natural disasters Nice environment Clean water
4.Political War Tyrannical corruption	4.Political Good government Less corruption

Principles to be practiced for attaining Sustainable Urbanization

- i. Minimization of material input which enter into production and consumption in urban areas.
- ii. Maximization of percentage of reused and recycled material in urban areas
- iii. Minimization of pollution and waste discharged from urban areas into nature

Measures to be taken for attaining Sustainable Urbanization

- ❖ Industries to be switched to clean and renewable energies as far as possible
- ❖ Develop urban infrastructure so as to provide water, sanitation & housing for residents
- ❖ Proper design/planning measures to be taken by local government bodies
- ❖ Monitoring and improving air quality
- ❖ Integration of four pillars of sustainability (Economic development, Social development, Environmental management and Urban governance)
- ❖ Construction of energy efficient and low carbon buildings

- ❖ Improved infrastructure between rural areas and urban area increases rural productivity, access to education, healthcare etc.
- ❖ Smart energy generation to renewable energy sources
- ❖ In social level, urban majority should be given prior attention.
- ❖ Huge investment is required
- ❖ City transport has to be planed properly to reduce carbon emission
- ❖ Practice sustainable water harvesting
- ❖ Robust engineering needed for sustainable cities in developing countries

SUSTAINABLE CITIES

- ❖ It is estimated that 70% of Indians would live in cities by 2050. World cities occupy just 2% of earth's land, but accounts for 60% to 80% of global energy consumption and 75% of global carbon emissions
- ❖ As a result cities are chocked with a number of problems such as increased use of natural resources, growing energy consumption, lack of adequate food and drinking water, air and water pollution, inadequate facilities for housing transport communication, healthcare sanitation etc.

Basic Features of a sustainable city

- i. A sustainable city needs proper design/planning to have a harmony with nature
- ii. Need more open spaces and ensure air quality
- iii. Predominant transport mode to be walking, cycling and public transport
- iv. Minimize the required inputs such as water, energy and other resources
- v. Conservation of existing water bodies and rain water harvesting to increase ground water recharge, waste water for gardening purpose and drip irrigation to reduce water demand.
- vi. Increase the usage of renewable energy sources.
- vii. Maintenance of law on order to reduce crime rate.
- viii. Create jobs for local population and reduce poverty
- ix. Implementation of improved waste management techniques.
- x. Maximize waste recycling
- xi. Energy efficient, low carbon buildings

Frame work for sustainable cities



SUSTAINABLE CITY – A CASE STUDY: TIANJIN ECO-CITY : The world's largest eco-city is a collaborative project between the Chinese and the Singaporean government **VISION:** To become a thriving city which is socially harmonious, environmental friendly and resource efficient

Features of Tianjin Eco-city : ■ This city is being built on a polluted area. (it took almost 3 years for the clean up) ■ This city aims to house 350,000 people by the year 2020 ■ Planned parking and green spaces (green community) ■ All the city's building to be green (water saving sanitary fittings, insulated walls, double glazed windows) ■ Every where is walkable or cycleable ■ Tap water is drinkable (clean water) ■ Pneumatic municipal waste collection system (this eliminates need for trucks) ■ Next generation driverless EN-V (Electric Networked – Vehicle) (Green Transportation) ■ All the buildings with smart control (Automatic raising and lowering of window to regulate light and temperature in the room) ■ All the wastewater goes to an anaerobic biogas digester from where methane is emitted which is used to produce energy (Effective waste management and recycling) ■ Reed beds being created to attract birds which also filter the water ■ Wind turbines and solar powered lighting system (Clean Energy) ■ To maintain social harmony, one fifth of the house will be subsidized for low wage workers and family to convey the message " being green isn't a luxury it is an affordable necessity"

When the Tianjin Eco-city is ready, it will create a new lifestyle for its future residents, the first-of-its-kind sustainable lifestyle in China.

SUSTAINABLE TRANSPORT

- ❖ Population explosion, urbanization, exponential growth of vehicular traffic, slow expanding road network and lack of proper planning and management in the road transportation sector has accelerated traffic related issues.
- ❖ According to World Health Organization (WHO), yearly around 2 lakhs people get killed in road accidents in Indian roads.
- ❖ The harmful impact of transportation on sustainability is categorized as shown below :

ENVIRONMENTAL DIMENSION	ECONOMIC DIMENSION	SOCIAL DIMENSION
Air and Water pollution	Traffic Congestion	Inequity of impacts
Noise pollution	Mobility barriers	Mobility disadvantaged
Climate Change	Accidents (Crash damages)	Human health impacts
Habitat loss	Transportation facility costs	Community interaction
Depletion of non-renewable resources	Consumer transportation costs	Aesthetics

Environmental Dimension

- i. **Air and water pollution** :- In vehicles, pollution is caused by unburnt hydrocarbons during combustion of fossil fuels. Waste water disposal from automobile service stations and garages into water bodies decreases the dissolved oxygen levels in water and decrease the aesthetics of water bodies.
- ii. **Noise pollution** :- It results in irritation, loss of concentration, sleep disturbances and loss of hearing. Ear damage occurs when noise level become greater than 90 decibels.
- iii. **Climate change** :- Greenhouse gas emissions results in global warming and climate change.
- iv. **Habitat loss** :- Expansion of transportation infrastructure such as, laying rail networks and expanding roads, involves deforestation and destruction of hill-rocks, results in loss of habitats of other species.
- v. **Depletion of non-renewable resources** :- Current transportation systems mainly depends on non-renewable energy sources such as petroleum fuels. If this trend continues, renewable energy sources may not last beyond 2050.

Economic Dimension

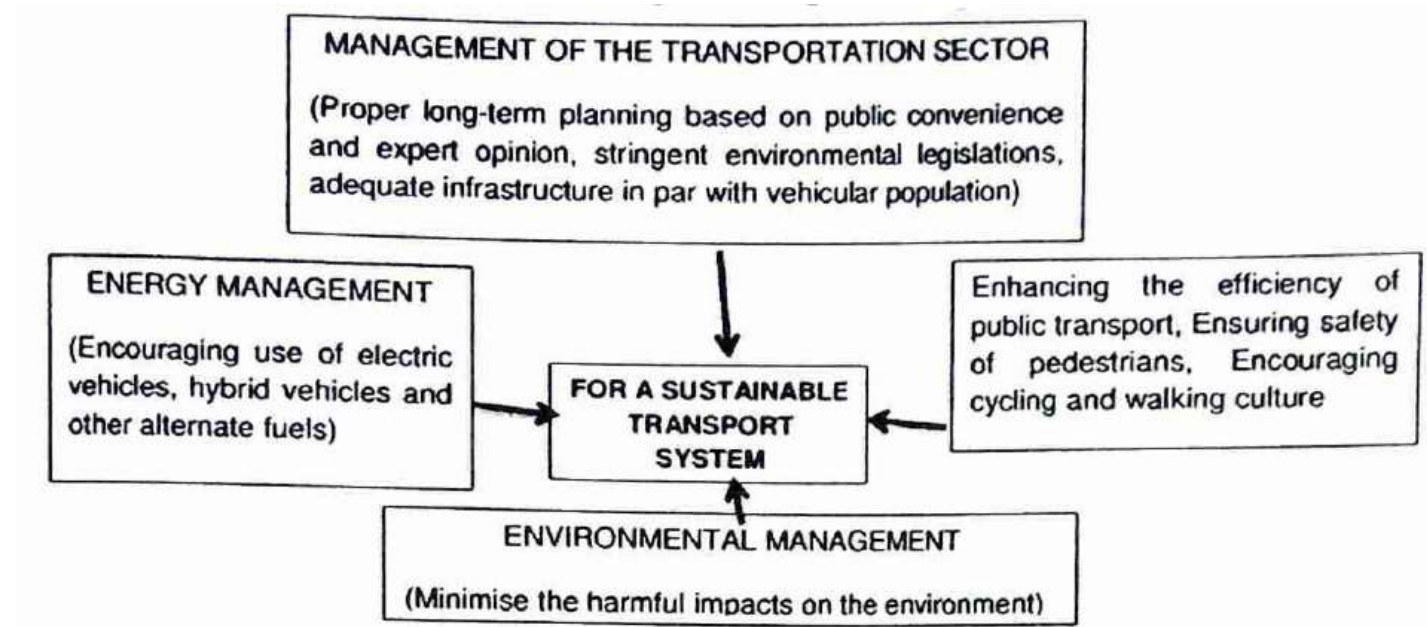
- i. **Traffic congestion** :- Traffic congestion decreases speed of vehicles, resulting in increased fuel usage and increased emission. Metro rail services is an alternative to reduce traffic congestion.
- ii. **Mobility barriers (Obstacles for travelling)** :- Rallies or meetings conducted by political parties, poor road conditions and accidents occur as barriers to smooth traffic mobility.
- iii. **Accidents** :- According to World Health Organization (WHO), it is estimated that nearly 200000 people get killed in traffic accidents on Indian roads every year, out of which 80% accidents are due to the fault of the driver.
- iv. **Cost of transportation facility** :- Cost of transportation increases with cost of fuel. Also, more the distance covered per day, by the travelers also increases the cost of transportation.
- v. **Consumer transportation costs** :- Everyday destinations such as shopping, hospitals, employment, recreation etc. should be closer to the consumer to reduce the cost of consumer transportation.

Social Dimension

- i. **Inequality of impacts** :- Impacts from transportation sector such as, health impacts, price hike of fuels, land acquisition for transport infrastructure, paying tolls etc; affects poor people badly than the rich.
- ii. **Mobility disadvantaged** :- A railway track causes mobility disadvantage to the people residing on either side of the track, as they would have to travel a long distance for crossing the railway track.
- iii. **Human health impacts** :- Air pollution due to increased traffic causes eye, nose and throat irritation and finally lead to chronic bronchitis.
- iv. **Community interaction** :- Lack of well developed road networks, inefficient public transport system and not ensuring safety for pedestrians can lower the quality of life and create unrest in community and reduces interrelation between people in that community.
- v. **Aesthetics** :- Lack of proper land usage planning, while implementing transportation projects, will harm the aesthetics of local environment.

STRATEGIES FOR SUSTAINABLE TRANSPORT SYSTEM

- ❖ A sustainable transport system is defined as, that transport system which meets current mobility needs with less impact on environment and health, without compromising the ability of future generations to meet these needs.
- ❖ The various components of a sustainable transport system is shown in a flow chart below :



Strategies for achieving sustainable transportation

- i. Encourage cycling and walking culture
- ii. Encourage public transportation
- iii. Use of green vehicles (eg: vehicles running on electricity, biodiesel, hydrogen etc.)
- iv. Encouraging “carpooling” system
- v. Developing efficient infrastructure for sustainable transport system
- vi. Encourage hybrid vehicle (vehicles that run on petrol and electric)
- vii. Depend more on rail and water transport
- viii. Developing a long term strategic vision and planning of a sustainable transport policy
- ix. Periodic services and maintenance of vehicles, adopting latest green-engineering technologies.
- x. Implementation of stringent rules and regulations by government bodies.

*As per the data available with the National Crime Records Bureau, around 4149 lives were lost in 39329 accidents in Kerala in the year 2016. In most cases young people are the victims. **3Es for reducing road accidents – Education for road users, Engineering for roads, Enforcement of traffic rules***

