ENVIRONMENTAL DESIGN CONTINUED

They are also a major source of the pollution that causes urban air quality problems and the pollutants that contribute to climate change. For example, they account for 49% of sulfur dioxide emissions, 25% of nitrous oxide emissions and 10% of particulate emissions, all of which damage urban air quality. Buildings, in general, produce 35% of the country's carbon dioxide emissions – the chief pollutant blamed for climate change.

In short, buildings have a tremendous impact on the environment both during their construction and through their operation. The term *green building* refers to buildings that make use of land, design and construction strategies in such a way as to reduce environmental impacts.

Let us now consider an example.

In the USA, there are more than 76 million residential buildings and nearly 5 million commercial buildings. These buildings together use one-third of all the energy consumed in the USA and two-thirds of all electricity. By the year 2010, it is estimated another 38 million buildings will be constructed. The challenge is to build them eco-smart in that they use a minimum of non-renewable energy, produce a minimum of pollution and cost a minimum of energy dollars, while increasing the level of comfort, health, and safety of the people who live and work in them. There are many opportunities to make buildings cleaner. For example, if only 10% of homes in the USA used solar water-heating systems, we would avoid about 8.4 million metric tonnes of carbon emissions each year.

What this means is that green building practices offer an opportunity to create environmentally sound and resource-efficient buildings by using an integrated approach to design. Green buildings promote resource conservation, including energy efficiency, renewable energy, and water conservation features; consider environmental impacts and waste minimisation; create a healthy and comfortable environment; reduce operation and maintenance costs and address issues such as historical preservation, access to public transportation and other community infrastructure systems. Green buildings consider the entire life-cycle of the building and its components as well as its economic and environmental impact and performance

What are the principles to be adopted when designing green buildings?

Principles of green building

The principles of a green building include the following

(i) **Energy efficiency and renewable energy resources:** Commercially available, cost-effective energy technologies could reduce the overall energy consumption, for example, in the United States by as much as one-third – worth some $343 billion. Strategies to achieve this include proper siting and airtight construction, as well as installing energy-efficient equipment and appliances and renewable energy systems.

(ii) **Environmental impact:** The built environment has a tremendous impact on the environment. However, your building can interact more positively with the environment, if you pay special attention to preserving the site's integrity and natural characteristics, appropriate landscaping and the selection of materials that have lower embodied energy and those that are produced locally.

(iii) **Resource conservation:** Conserving resources is a cornerstone of green building techniques. There are many ways to conserve resources during the building process. For example, selecting materials that have at least some recycled content can conserve natural resources and virgin materials. Minimising construction wastes can ease the impact on landfills and resources. Installing water- and energy-efficient products can conserve resources, while reducing operating costs. Choosing a green (plant-covered) roof can reduce energy use, cool urban heat islands and prevent storm water runoff as well as contributes to wildlife habitat and air quality.

(iv) **Indoor air quality:** Energy-efficient buildings are more airtight and therefore hold greater potential for indoor air quality problems, especially if not properly ventilated. Building products can contribute to poor air quality. But, by selecting the materials lower in chemicals and toxins and installing mechanical ventilation systems to ensure an adequate fresh air supply, we can reduce adverse environmental impacts.

(v) **Community issues:** Placing green building projects within easy access of public transportation, medical facilities, shopping areas and recreational facilities decreases the need for automobiles and encourages bicycling and walking. In addition, successful green buildings blend into the community, preserving natural and historical characteristics and will utilise existing infrastructure in order to reduce sprawl. Co-housing represents one approach to creating a community of green buildings.

ED strategies for building construction

Environmental considerations in building construction include selection of site, energy use, water use and selection of material for construction. By incorporating the following strategies in building planning and construction, we can make it environment friendly:

(i) **Building siting:** ED considerations in siting of a building include selecting a site well suited to take advantage of mass transit, protecting and retaining existing landscaping and natural features, selecting plants that have low water and pesticide needs, and generating minimum plant trimmings and using composts and mulches to save water and time.

(ii) **CO2 emission reduction:** Atmospheric levels of CO2 have increased steadily and are expected to increase more rapidly as the global economy grows. Hence there is need to regulate carbin dioxide emissions. During construction of building it is essential to consider carbon building print (i.e. carbon footprint). ED considerations in carbon dioxide emission reduction of building include the following:

a) **Energy efficiency: Improvements in the efficiency will lead to the conservation of energy or reduced requirement of energy. The strategy includes:**

- Selection of passive design strategies (i.e., shape and orientation, passive solar design and the use of natural lighting can dramatically affect building energy performance.)

- Develop strategies to provide natural lighting. Studies have shown that it has a positive impact on productivity and well being.
- Install high-efficiency lighting systems with advanced lighting controls.
- Use a properly sized and energy-efficient heat/cooling system in conjunction with a thermally efficient building shell.
- Maximise light colours for roofing and wall finish materials; and use minimal glass on east and west exposures.
- Minimise the electric loads from lighting, equipment and appliances.

b) Use of **Renewable energy:** Renewable energy sources provide a great symbol of emerging technologies for the future. By integrating these sources it is possible to create zero emission building where energy consumption is self generating and non- polluting. It is also possible to construct energy plus buildings where excess energy can be sold to grids.

c) **Reforestation projects:** Carbon offsetting can be done by taking up planting and nurturing at the project site. Carbon footprint can be measured based on the direct and indirect carbon-dioxide and equivalent emissions that are related to:

(i) Consumption of grid delivered electricity

(ii) On site combustion of fossil fuels and

(iii) Fugitive refrigerant emissions

(iii) **Water efficiency:** ED considerations in improving water use efficiency through building design include the following:

- Design dual plumbing to use recycled water for toilet flushing or a gray water system that recovers rainwater or other non-potable water for site irrigation.
- Minimise wastewater by using ultra low-flush toilets, low-flow showerheads and other water conserving fixtures.
- Use recirculation systems for centralised hot water distribution.
- Install point-of-use hot water heating systems for more distant locations.
- Use a water budget approach that schedules irrigation using the California irrigation management information system data for landscaping.
- Meter the landscape separately from buildings. Use micro-irrigation (which excludes sprinklers and high-pressure sprayers) to supply water in non-turf areas.
- Use state-of-the-art irrigation controllers and self-closing nozzles on hoses.

(iv) **Materials efficiency:** ED considerations in improving material use efficiency through building design include the following:

- Select sustainable construction materials and products by evaluating several characteristics such as reused and recycled content, zero or low off gassing of harmful air emissions, zero or low toxicity, sustainably harvested materials, high recyclability, durability, longevity, and local production. These products promote resource conservation and efficiency. Using recycled-content products also helps develop markets for recycled materials.

- Use dimensional planning and other material efficiency strategies. These strategies reduce the amount of building materials needed and cut construction costs. For example, design rooms on 3-foot multiples to conform to standard-sized wallboard and plywood sheets.
- Reuse and recycle construction and demolition materials. For example, using inert demolition materials as a base course for a parking lot keeps materials out of landfills and costs less.
- Design with adequate space to facilitate recycling collection and to incorporate a solid waste management programme that prevents waste generation.

The Government of India has established a council for promotion of building material and technology

Leadership in Energy and Environmental Design (LEED)

LEED is internationally recognised green building certification system, providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across all concepts that include: energy savings, water efficiency, CO_2 emissions reduction, improved indoor air quality, and resource conservation and sensitivity to their impacts (i.e. material efficiency).

LEED has special rating systems that apply to all kinds of structures, including schools, retail and healthcare facilities. Rating systems are available for new construction and major renovations as well as existing buildings. The program is designed to inform and guide all kinds of professionals who work with structures to create or convert spaces to environmental sustainability, including architects, real estate professionals, facility managers, engineers, interior designers, landscape architects, construction managers, private sector executives and government officials.

LEED defines "a nationally accepted benchmark for the design, construction and operation of high-performance green buildings" and "provides building owners and operators with the tools they need to have an immediate and measurable impact on their buildings' performance".

LEED users include architects, real estate professionals, facility managers, engineers, interior designers, landscape architects, construction managers, lenders and government officials. LEED is being adopted to implement sustainability concepts in the built environment. State and local governments across the country are adopting LEED for public-owned and public-funded buildings; there are LEED initiatives in federal agencies, including the

Departments of Defence, Agriculture, Energy, and State; and LEED projects are in countries worldwide, including Canada, Brazil, Mexico and India.

Third-party certification through the independent Green Building Certification Institute (GBCI.org) assures that LEED buildings are constructed as intended. GBCI includes a network of ISO-compliant international certifying bodies, ensuring the consistency, capacity and integrity of the LEED certification process. An organization's participation in the voluntary and technically rigorous LEED process demonstrates leadership, innovation and environmental stewardship.

LEED is flexible enough to apply to all building types – commercial as well as residential. It works throughout the building lifecycle – design and construction, operations and maintenance, tenant fit out, and significant retrofit. LEED for Neighbourhood Development extends the benefits of LEED beyond the building footprint into the neighbourhood it serves.

ED FOR DEVELOPMENTAL PLANNING

Throughout history, millions of people have migrated from rural areas to urban areas in search of places to work and livelihood. However, the experience has been that the employment generation in the secondary and tertiary sectors of the economy in the urban areas are not enough to effectively absorb the surplus labour from the rural areas. But, the migrations result in heavy stress on urban infrastructure thereby reducing overall quality of life. As urban areas enjoy better connectivity, both transport and communication, a vicious circle starts. The process of migration continues till the city expands in size and congestion. However, at a certain stage, the expansion becomes financially, environmentally and humanely unsustainable.

Historically, the concept of *carrying capacity* (CC) has been developed out of descriptions of growth and dynamics of natural populations, and as such has been used as a basis for range and forest management practices. Carrying capacity is defined as maximum population that can be supported in a given habitat without permanently impairing the productivity of ecosystem(s) upon which that population subsists. For human society, carrying capacity can be defined as the maximum rate of resource consumption and waste discharge that can be sustained indefinitely in a defined planning region without progressively impairing the bio-productivity and ecological integrity. Ecosystem carrying capacity provides the physical limits to economic development.

The goal of planning, therefore, is to provide a desired array of quality of life elements through physical and social design of the human environment. In accomplishing this goal, the planner traditionally works within the limits of what is technologically and economically feasible and what is socially, politically and legally acceptable.

Present planning process, however, is restricted to the allocation of monetary resources to various economic sectors to increase the production levels. Increase in production is believed to enhance the quality of life, which is defined narrowly as the availability of per capita income. Neither the perspective plan nor the five-year or annual plan delineates, in quantitative terms, the impact on the state of ecological resources as a result of envisaged planning process. Thus, the present planning process overlooks the basic requirement of availability of natural resources as also human and institutional resources that form building blocks in the developmental process.

The validation of the mechanics involved in developmental environmental planning, based on carrying capacity, is desirable, though challenging. Its success largely depends on the participation of planners as also the beneficiary community.

A framework

The evolution of human society can be attributed to the continuous process of development in every sphere of human activity. The process of development requires growth in flow rates of materials and energies. This places an ever-increasing demand on the production and assimilation capabilities of resources in the natural environment. The capacity of natural and human environments to accommodate or absorb change without experiencing conditions of instability and attendant degradation is a significant concern in view of current trends of urban growth and development.

Recognising that the quantity, productivity and regenerative capacity of resources are limited, a strong motivation exists for a conceptualisation of environmental CC as a basis for regional planning and environmental management. Scarce resources must be managed in the context of many competing demands, and the natural and human environments must withstand perturbations caused by changes in our social and economic activities.

Researchers have used the idea of a limit or upper boundary on population density as a conceptual tool in the management of natural communities. Many of the difficult problems of environmental management arise, however, in the urban-regional context. Since urban systems interface with natural systems, the concept of carrying capacity in this setting needs enrichment in definition and interpretation. Rather than a single fixed number being rigorously established as a population carrying capacity, it suggests that planners should be concerned about the resource limits and environmental factors that may act as constraints or damping forces in the dynamic interaction of population growth, related socio-economic activities, the resource base, the environmental quality and quality of life.

Thus, the basic elements involved in assessing the carrying capacity hinge on the interrelation between resources and processes, which convert these resources to desired outputs and waste products and residuals, which must be assimilated back into the resource base with future effects on quantity and quality.

Carrying capacity may then be seen as the ability to produce desired outputs (i.e., goods and services) from a limited resource base (i.e., inputs or resources) while at the same time maintaining desired quality levels in this resource base. For an open system, the definition allows for import of resources, goods, services and the export of production and residuals.

The four dimensions that are relevant to the estimation of carrying capacity are:

(i) The stock of available resources to sustain rates of resource use in production.

(ii) The capacity of the environmental media to assimilate wastes and residuals from production and consumption.

(iii) The capacity of infrastructure resources (e.g., distribution and delivery systems) to handle the flow of goods and services and resources used in production.

(iv) The effect of both resource use and production outputs on quality of life.

Based on these dimensions, human carrying capacity may be considered as the level of human activity (including population dynamics and economic activity), which a region can sustain (including consideration of import and export of resources and waste residuals) at an acceptable quality or life levels in perpetuity. It also follows that carrying capacity must be assessed and properly identified with dimensioned domains. The domains of key concern are space and time.

Spatial domain

Regional delineation for analysis of carrying capacity must be based on consideration of the functional elements of three general types of regional space: the ecological space, the economic space, and the policy space. The study area for analysis within these three regional dimensions should fulfil the following criteria:

- The study area should be relatively easy to identify and separate from other units.
- The study area should be capable of being manipulated separately with a minimal effect on other units.
- The boundaries of the study area should remain within, or resemble as close as possible, the less discrete boundaries of the ecosystem so that broad management practices are applicable throughout the study area.

- The movement of materials across boundaries can be measured.

Temporal domain

In the human environment, the temporal, i.e., time-frame, perspective (time-frame) is an important aspect of carrying capacity study. Economic mechanisms stimulate technological advances that lead to increases in carrying capacity over time (e.g., development of internal combustion engines generating lower emission levels per RPM will allow greater traffic volumes).

An important aspect of carrying capacity assessment is the problem of measuring the outputs of production processes. Production outputs may be divided into two classes: goods and services and wastes and residuals. Measurements for the former, known as social indicators, may be used to gauge the relative change in human needs and satisfaction levels. Measurements for the latter, known as environmental indicators, allow managers and decision-makers to determine how production activity affects the quality and assimilative and future productive capacity of the receiving environment.

Several indicators may be integrated into a single index for more complex conditions or components (e.g., air quality index). Indices at an intermediate level of aggregation may, in turn, be integrated into still more general indices (e.g., quality of life). In these contexts, the term *index* represents a measurement of some environmental or social component for which there is more than one indicator. This provides a basis for evaluating the performance of development plans in terms of the changes in carrying capacity indices. In developing environmental management strategies for the urban region, planners and decision-makers must continually assess the social and environmental implications of various proposals. Recognising and establishing the limits of economic activity could provide decision-makers with a workable approach to assessing the environmental viability of developmental proposals.

To reiterate, planning for development within the limits of carrying capacity recognises that humankind is dependent on the productive capacity of ecosystems, and therefore, a minimal level of ecosystem integrity is essential for human survival. Planning for sustainable development calls for trade-offs between the desired production-consumption levels through the exploitation of *supportive capacity* within its regenerative capacity and environmental quality within the *assimilative capacity* of regional ecosystem. The utilisation of carrying capacity, thus, requires a series of adjustments to reconcile competing operations in the developmental process through participation of various stakeholders.

The supportive capacity of a region is the capacity of the ecosystems to provide resources for various anthropogenic activities, i.e., human settlements/industries. The resource base of a region could be categorised into ecological and economic resources, transformational resources, infrastructure and distributive resources and socio-cultural and amenity resources. Pragmatic utilisation of these resources warrants the establishment of functional relationships between the resources and their present level of usages. The carrying capacity of an ecosystem is greatly influenced by the availability of resources and the manner in which they are utilised. The availability of resources at any particular time is the result of the interactions amongst the physical occurrence of the resource, and the quantum of requirement, as also the technological and managerial means of their exploitation.

Assimilative capacity is the maximum amount of waste discharge that can be allowed in an environment without violating the designated use. In operational terms, assimilative capacity can be defined as ratio of observed level of pollutant and the environmental standard stipulated by the concerned authorities. Assimilative capacity is governed by dilution, dispersion, phase transformation, deposition and absorption phenomena. These phenomena are relatively local in nature. Assimilative capacity, therefore, needs to be worked out for a defined geographical area. What the foregoing discussion suggests is that the major elements of work in carrying capacity study include the following aspects:

- Estimation of supportive capacity.
- Estimation of assimilative capacity.
- Assessment of present quality of life, developmental aspirations, developmental plans and policies.
- Development of alternate scenarios and strategies for improving quality of life within the limits imposed by the carrying capacity.

The overall scope of work for estimating carrying capacity, thus, involves:

- Delineation of boundaries of the study region, taking into account the location of anthropogenic activities likely to affect estuarine ecology, boundaries of *talukas* and watersheds.
- Assessment of stock and demand for land, water, minerals, transformational (e.g., power generation and manufacturing), infrastructure (e.g., water supply and sanitation, health and education, transport and communication and socio-cultural resources).

- Assessment of environmental quality vis-à-vis standards for air, noise, water (both surface and ground), land, biology (both aquatic and terrestrial) components based on secondary data (including time-series, if available) supported by primary data.
- Assessment of residual assimilative capacity.
- Assessment of quality of life through questionnaire survey.
- Assessment of present activity levels in various sectors of economy, viz., forestry, fishery, agriculture, manufacturing, trade and commerce, transport, waste management, etc.
- Identification and quantification of sources of pollution.
- Short-listing of environmental and developmental concerns.
- Review of existing developmental plans prepared by concerned authorities.
- Prediction of business-as-usual scenario in terms of impact of developmental plans on demand for supportive capacity and determination of environmental quality.
- Identification of limiting resources.
- Assessment of developmental potential of the region.
- Recommendation of short-term and long-term policy/planning/technology interventions for enhancing carrying capacity.

SUMMARY

In this Unit, we discussed the concept of environmental design (ED) or design for the environment. We began the Unit by giving an overview of the principles underlying ED and the benefits of adopting ED. We then discussed ED for manufactured products, construction and developmental planning. In this context, we introduced concepts such as eco-labelling, green building and carrying capacity.