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8. Ecological Design and Engineering

T. P. Chandra

Assistant Professor,
Department of Botany,
Govt. Pt. Madhav Rao Sapre College,
Gaurella Pendra Marwahi (C.G.).

Abstract:

Ecosystems are sophisticated systems hence the measurement and quantification of a process for necessary manipulation is a complex task for engineers. The solution seems inside the ecological modeling approach that offers a well-designed tool for the assessment of the linkage and interaction between biotic and abiotic components residing in the ecosystem. The damaged ecosystem needs ecological engineering tools to revitalize. Ecological engineering could be used to design novel ecological systems for urban society and also be used for the restoration of the damaged ecosystem. Engineering has integrated with environmental biology since the 1990s to solve the environmental issue by using the latest engineering tools and technologies. Ecological engineering is being grown up to design and construct sustainable ecosystems for a specific purpose using engineering methods besides traditional approaches. The present chapters deal with the comprehensive insight of ecological engineering and design perspective for the development of sustainable urban society and the conservation of ecosystem and biodiversity.

8.1 Introduction:

The concept of ecological design and engineering (EDE) emerged to apply advanced engineering to serve society by guarding the natural ecosystem for the betterment of the environment. Human life is solely depending upon nature to survive. The destruction of nature results in the eradication of the entire human society. The drastic increase in population leads to damage to the ecosystem. The present approach to revive the ecosystem is to input the engineering practices to shield the ecosystems and nature for prolonged support towards a healthy human society. Ecological design and engineering could potentially be used to develop a sustainable ecosystem. The study of ecological principles helps to make the balance between human society and natural resource utilization. The EDE starts with addressing specific issues. The team of well-trained engineers scientifically collected relevant data regarding the issue and used engineering tools with certain modifications to sort out the issue.

Renewable energy resources viz., bio-hydrogen, solar, hydrological, and wind energies are evidence of engineering towards suitable ecosystems. Preliminary, EDE requires the generation of refined ideology to solve the ecological issues. EDE ensures the integration of ecological science and environmental engineering principles to ensure healthy interaction between ecosystems and human society. The Scope of EDE is to design and develop energy-intensive ecosystems i.e., wetlands to treat wastewater efficiently and the restorative

damaged ecosystems by promoting eco-friendly urban development. The engineers have also worked to create models where the balance between the utilization of natural resources and conservation of natural resources could be done. The integration of society into ecosystems needs to follow eco-friendly urban planning. The concept of urban horticulture also needs engineering models for maximum output in less space. Thus, the EDE offers customized solutions for sustainable environmental practices.

Eco technology deals with the research and promotion of nature-friendly technologies on the earth. The term, eco technology is reflected in the use of engineering tools and techniques to mitigate environmental issues. Eco technology deals with the boosting economy by minimizing harm to the environment. As an example, environmental engineering provides efficient energy-intensive waste management processes. Eco technology enforced the concept of developing nature that works for society. Ecological engineering focused on the least energy-driven ecological processes. Ecological engineering is more sophisticated than environmental engineering. The modern forest management concept focused on the fulfillment of timber demand without harming the forest ecosystem, regeneration of the forest, clean water flows, mitigating habitat destruction, saving indigenous plants and animals, and maintaining biodiversity. The objective of ecological engineering is to integrate human society with its surrounding environment and ecosystem. Endemic ecosystems seem to be destroyed due to increasing human populations in particular regions. The green urban concept forced ecological and environmental model design among engineers working for EDE. The idea of implementing RRR viz., Reduce, Reuse and Recycle needs EDE.

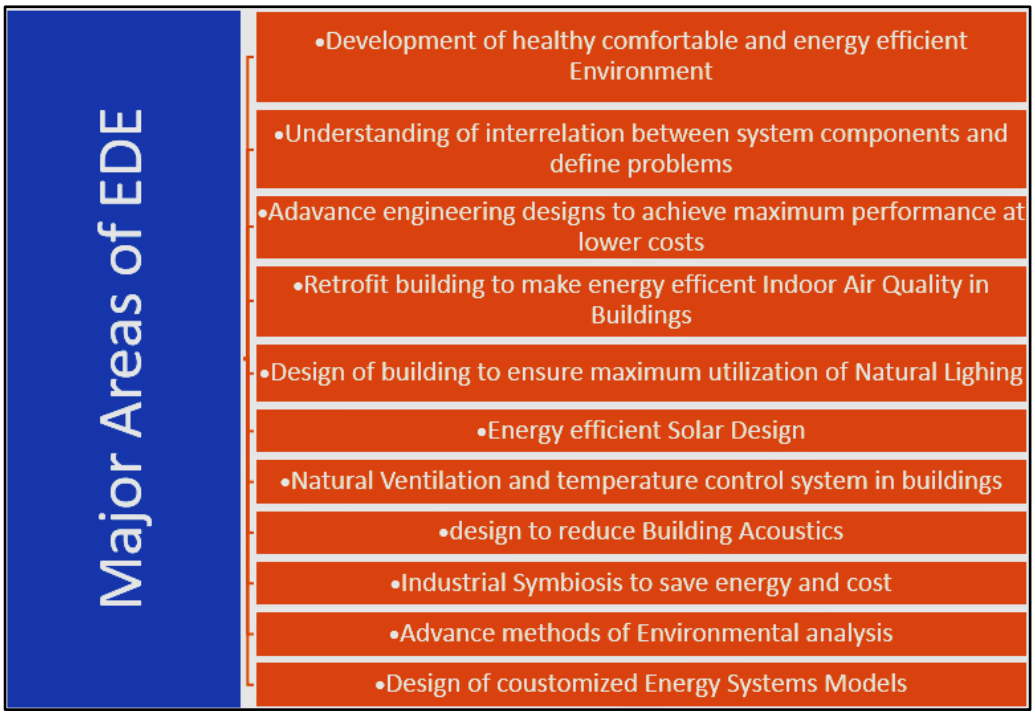
The EDE has two systems viz., active and passive systems. The active system directs the renewable= energy sources i.e., biomass, geothermal, solar, thermal, and wind energy. Solar power mitigates the consumption of petroleum and thereby reduces carbon dioxide emissions. The water recycling by rainwater harvesting setup to reuse water for multiple uses apart from dinking purposes is also a part of an active system. The passive system is most often used in the large civil constructions to make them nature friendly i.e., the natural daylighting, plant-based green roofing system, to regulate the temperature in summers. Ecological engineering has the following major challenge (a) reducing pollution, (b) ecosystem recovery, (c) cleaning and restoration of water streams, (d) implementation of organic agriculture practices, (e) development of low-cost renewable energy sources, and (f) work towards sustainability. The use of engineered microbial cells for waste treatment i.e., aerobic granular sludge technique, to remove organic and inorganic contaminants at a lower cost. Sometimes the aerobic process is integrated with anaerobic phases to make the process more effective. Microbial bioengineering for bioremediation have been on Bacteria viz., *Arthrobacter*, *Bacillus*, *Citrobacter*, *Cyanobacteria*, *Enterobacter*, *Pseudomonas,* and *Streptomyces*; Archea viz., *Phanerochaete*; Fungi *viz.*, *Aspergillus* and *Penicillium.*

8.2 Major Areas of Ecological Design and Engineering:

The EDE focused on a sustainable energy-efficient society that has healthy integration of the nearby ecosystem environment. Engineers are ensuring ecological well-being in buildings have the right mix of natural and mechanical ventilation systems along with solar systems to reduce external energy demand. The Godrej Green Business Centre (GGBC) is an awfully energy-efficient construction in India having a sophisticated solar panels

installation that produces approximately 100 units of electricity per day. Moreover, ITC Maurya hotel has secured the highest Leadership in Energy and Environment Decision (LEED). The US provides LEED certification to the commercial settings for excellence in energy and environmental friendliness.

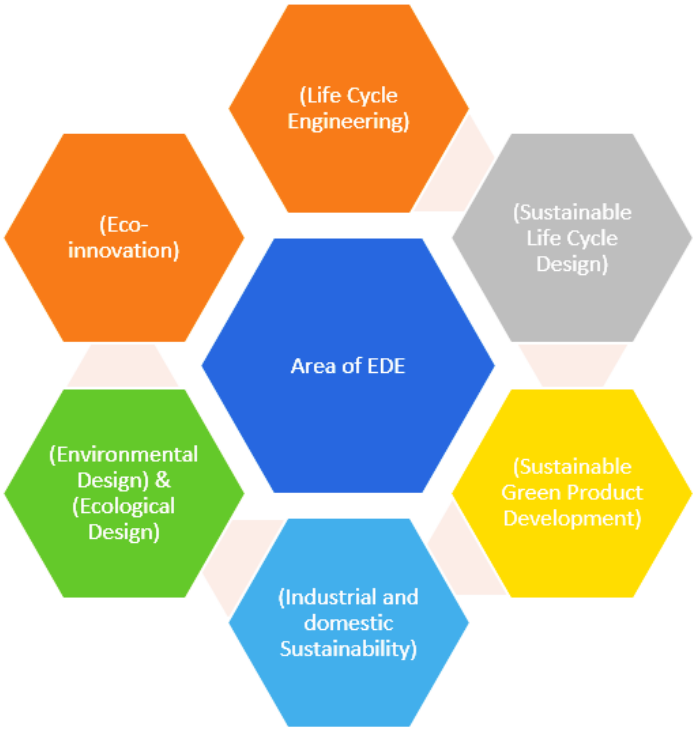
The environmental and ecosystem analysis consisted of thorough observation, scientific experiments, and customized engineered modeling to solve a specific issue. Modern simulation methods are used to forecast the efficacy of working models. Energy systems models like microbial fuel cells are now used at the pilot scale. Retrofitting's now being trendy to make old infrastructure energy efficient. Engineers are seeking sustainable domestic and commercial housing plans for their customers so they are deeply working on the optimization of multi-objective designs or models. Presently air quality is also the prime concern of human society. The concept of industrial symbiosis focused on the recycling of wastes where the waste and by-products of one industrial setup become the raw component for another industrial setup.



8.2.1 The Following Major Practices Approached by EDE:

- Renewable energy is arisen from natural resources and will naturally replenish. Biomass, geothermal, hydropower, solar, and wind energy are an example of renewable energy. The term clean energy is used to represent the zero-CO2 emission. Renewable energy itself is recognized as clean energy. The EDE ensures easy access to renewable energy sources for all.
- The energy-efficient buildings (commercial and domestic) help to reduce the harmful impact on the ecosystem.

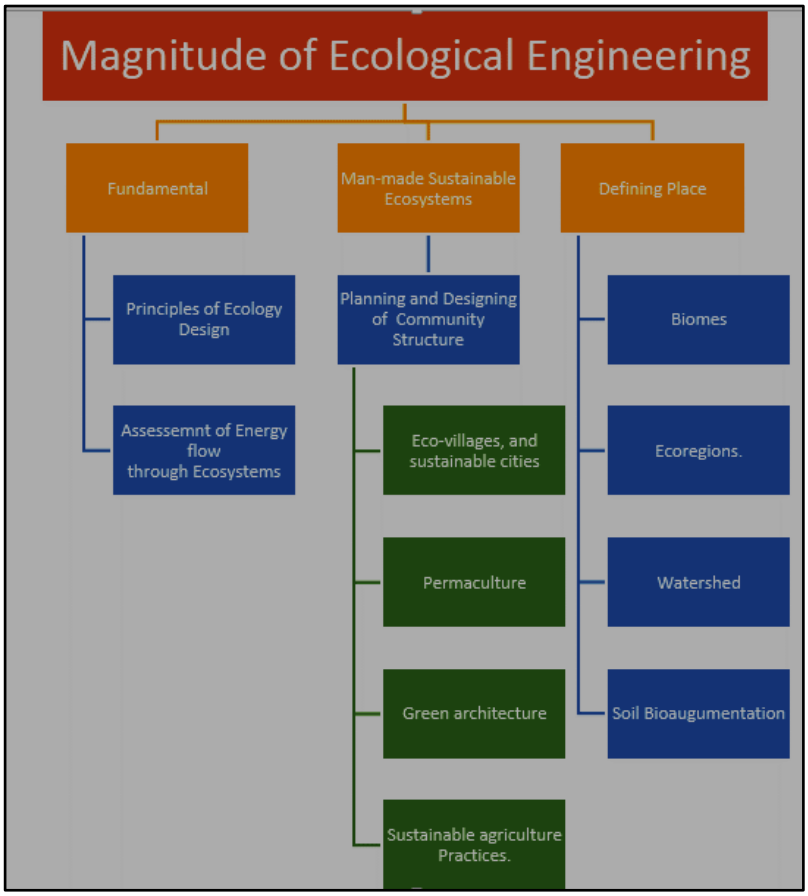
- Water recycling and conservation along with restoration of water streams are the major area of concern to maintain a healthy ecosystem.
- Sustainable urban societies and green buildings with an efficient waste management system.
- Forest renovation and biodiversity conservation is an important aspects of ecological restoration
- Sustainable agriculture practices are crucial to mitigate the harmful biocide chemicals used in agriculture that damage the terrestrial soil ecosystem and aquatic ecosystem. The microbial agriculture principle needs to be implemented along with crop diversification.
- Air pollution is another area of concern thereby the clean air demand is increased in Mero cities like Delhi.



8.2.2 Magnitude of Ecological Design and Engineering

The EDE is extended into three major steps.

a. Gathering Fundamental knowledge about ecological design and understanding of the energy flow in the ecosystem.
b. The most crucial portion is to deal with Man-made Sustainable Ecosystems. It consisted of planning and designing community structures i.e., Eco-villages, Green architecture in the metro cities, and sustainable agriculture practices.
c. The EDE also deals with the designing of large ecosystems i.e., Biomes, Eco-regions, and Watersheds.



Research and Development Centres for Ecological Design and Engineering

8.2.3 TERI:

The Energy and Resource Institute (TERI), New Delhi, is an independent organization that works for a sustainable future. They provide research and consultancy for ideology and help to implement the idea. The service is provided towards climate change, energy, and sustainability models, to protect natural habitats and conversations of nature. The major areas of concern are the development of sustainable practices and mitigation of anthropological impact on the environment and climate. The TERI has a team of eminent scientists and engineers for action-oriented quality research. They are working for a clean and sustainable future through energy-efficient innovative eco-friendly ideologies.

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8.2.4 CSE:

The Centre for Science and Environment (CSE) delivers comprehensive evidence and a database of environmental problems and also provides information regarding natural resource management (NRM).

8.2.5 BNHS:

Bombay Natural History Society (BNHS) actively participates in research practices in the conservation of nature along with their research publications and newsletters that help in EDE.

8.2.6 NEERI:

The National Environmental Engineering Research Institute offers an innovative solution to environmental problems.

Some organizations i.e., Environmental Information System (ENVIS), Indian Council of Forestry Research and Education, (ICFRE), Indian Renewable Energy Development Agency (IREDA) and National Afforestation and Eco-Development Board (NAEB) is also working on environmental issues and the conservation of nature and biodiversity.

8.3 Conclusion:

Ecological design and engineering work for the betterment of human society without damaging the ecosystem. Human life was solely dependent upon the nearby ecosystem. As the growing population damaged the ecosystems, ecological restoration and conservation seem to be challenging. The EDE has worked to build sustainable human society models that have the least harmful impact on the nearby ecosystem and also on ecological restoration and conservation. EDE focused on the reduction of pollution, minimization of waste generation, implementation of reuse and recycle approach, ecological reclamation, and restoration, sustainable agricultural practices to reduce the biocidal impact on the ecosystem, development of renewable energy resources, bioremediation using genetically engineered microbial strains, sustainable ecology design and modeling, energy-efficient eco-buildings and water management.

8.4 Further Readings:

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8. Sustainable Ecosystem Modeling Lab – https://www.egr.msu.edu/ceco/sem/