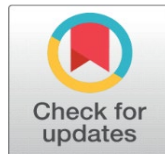


BRIDGING NATURE AND CITIES: HARNESSING ECOSYSTEM SERVICES FOR URBAN REGENERATION

Shaila Naaz ¹✉, Dr. Nirmita Mehrotra ²✉

¹ Research Scholar, Gautam Buddha University, Gautam Buddh Nagar, Uttar Pradesh, India

² Head, Department of Urban and Regional Planning, Gautam Buddha University, Gautam Buddh Nagar, Uttar Pradesh, India



Received 07 August 2025

Accepted 12 September 2025

Published 05 November 2025

Corresponding Author

Shaila Naaz, khanshailanaaz@gmail.com

DOI

[10.29121/granthaalayah.v13.i10.2025.6418](https://doi.org/10.29121/granthaalayah.v13.i10.2025.6418)

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Copyright: © 2025 The Author(s). This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).

With the license CC-BY, authors retain the copyright, allowing anyone to download, reuse, re-print, modify, distribute, and/or copy their contribution. The work must be properly attributed to its author.

ABSTRACT

This research paper tries to highlight the importance of the study and analysis of ecosystem services. This paper talks about knowledge of the ecosystem and its utilization for the regeneration of an urban system. These goals are going to be measurable and are based on real situations of the specific site. The system is going to be coined as an analysis of ecosystem Services. The study is crucial because due to rural-to-urban migration, exponential growth in population, and many more factors, the cities are getting huge populations to deal with. These growths have shown many negative impacts on the ecology and ecosystem of the urban areas. The dependency on the ecosystems for survival makes the ecosystem very prone to degradation in quality as well as quantity. Global warming, drastic climate changes, depletion of the ozone layer, and reduction of biodiversity make this topic incredibly significant to study so that we have tools to regenerate our urban areas. The focus of the study is not only to identify but also quantify them, with relevance to cities in India. It is exceedingly difficult to generalize this topic and to go ahead with a “one size fits all” approach. Every city in the world is different and reflects the importance of ecosystem services in a different manner. The ecosystem services and their significance vary from city to city. Cities are vastly different because of the factors that make a city. For example, sociologically the cities have hugely different demographics. They have socio-cultural differences, and the size and area of the cities vary from small cities to urban agglomerations. They have climatic and geographical differences. The paper is concluded with the identification of the ecosystem services and how to utilize them for the regeneration of an urban area.

Keywords: Urban, Ecosystem, Services, Environment, Ecology, Regeneration



1. INTRODUCTION

Rapid urbanization is happening in urban and semi-urban areas. It is expected that by 2035 India's urban population going to stand at 675 million. The percentage of people living in urban areas will be 43.2% of the total population by 2035. As more people are living in urban areas, the pressure is increasing on all the resources in cities. Cities are, dependent on the nearby semi-urban and peri-urban areas. The human system is a part of the ecological system. Everything in nature comprises four orders and human or knowledge order is one of them. The interconnectivity of all these orders helps the whole ecosystem to survive and revive. The mutual

fulfillment of these orders is the key to harmony in the ecosystem. The cities can be called the global network because all these orders interconnect with each other in this environment. If we compare the natural ecosystem in comparison with the man-made system, then due to the rapid growth of population and excessive degradation of natural resources the man-made ecosystem is less sufficient.

1.1. LITERATURE STUDY

The literature study explores the role of green infrastructure in urban regeneration and the potential it holds for improving ecosystem services. It examines the existing body of research, including scholarly articles, reports, and case studies, to analyze the impact of green infrastructure on urban regeneration and the associated ecosystem services. The study also investigates the underlying mechanisms and processes through which green infrastructure contributes to the regeneration of urban systems. The findings of this literature study demonstrate that green infrastructure plays a crucial role in enhancing urban regeneration by providing a multitude of ecosystem services. It highlights the positive effects of green spaces in mitigating urban heat island effects, reducing air pollution, and managing stormwater runoff. Moreover, green infrastructure promotes biodiversity conservation, facilitates ecological connectivity, and creates opportunities for recreational activities, thereby enhancing the overall quality of urban life. The study also identifies key challenges and barriers to the effective implementation of green infrastructure in urban regeneration projects, such as limited funding, lack of policy support, and competing land-use priorities. It emphasizes the need for integrated planning and collaboration among various stakeholders to overcome these challenges and maximize the benefits of green infrastructure for urban regeneration.

In conclusion, this literature study underscores the importance of green infrastructure as a catalyst for urban regeneration and the provision of ecosystem services. It highlights the need for further research and empirical studies to quantify the specific benefits and cost-effectiveness of green infrastructure in different urban contexts. By understanding the role of green infrastructure and its potential to improve ecosystem services, policymakers, urban planners, and stakeholders can make informed decisions to foster sustainable and resilient urban systems.

1.2. WHAT IS AN URBAN ECOSYSTEM??

Urban ecosystems are the network of the connectivity and interaction of the biotic and abiotic components of an urban precinct. This interaction can be described as reinforcing factors of the ecosystem. Urban ecosystems act according to the diverse reinforcing forces, and they are very dynamic. The concept is that people and the associated activities have a greater impact on the ecosystem. Urban Ecology has been integrated with the services, and these services have been providing solutions to the problems of cities from ancient times. focus on solving the problems of cities. Urban ecosystems are influenced and impacted by the process of urbanization. The process of urbanization involves both population growth by the migration from rural to urban areas as well as the natural growth of the population in the cities. Nowadays, the process of urbanization is dictated by socio-economic changes associated with the exchanges in the nature of the job or the transition of sectors of the job. the rapid change in the field of technology and digitization of services has also impacted urbanization. The stratification of the market into different collar jobs such as blue-collar, white-collar, grey collar, etc., technological

advancements related to artificial intelligence, and sociocultural changes such as changes in family structure, demographics, and politics [Knox \(1991\)](#). Urban Sprawl is a process of rapid urbanizing process in many developed countries. In developing countries, both the rural-to-urban migration as well as the growth of slums and sprawl are responsible for haphazard growth in urban areas.

Figure 1

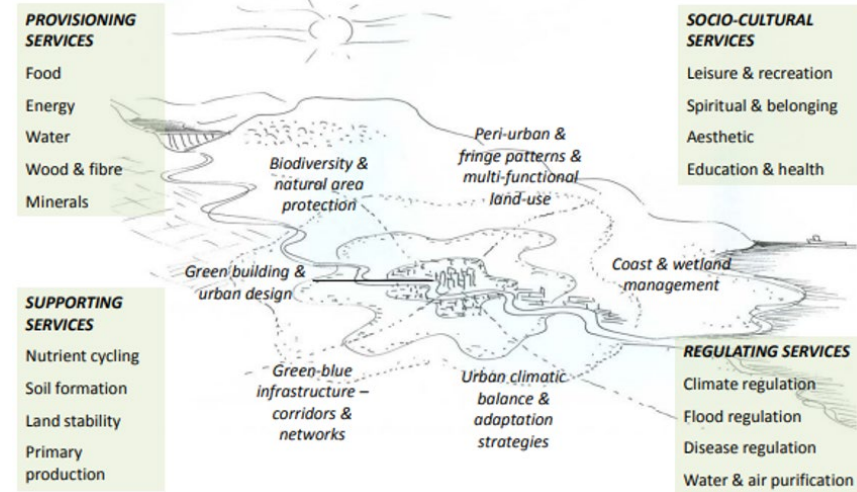


Figure 1 Urban Eco System Services

Source Millenium Ecosystem Assessment, 2005, [Ravetz and George \(2009\)](#)

1.3. DEFINITION OF ECOSYSTEM SERVICES

Ecosystem services are the facilities that are provided to humans and work as an asset such as environmental assets, which include landforms, water bodies, flora, and fauna. These assets transform into the network and lay the base for ease of human activities. Since ancient times, humans have made changes in the natural ecosystems to prioritize those species that can be used for direct benefits (e.g., crops). They usually overlook the indirect but crucial ecosystem services (e.g., soil erosion, pollination, fertility of the soil, and pest control). These factors are very important and if they are lost, they are very difficult to replace sometimes irreplaceable. Some ecosystem services were very less visible such as climate change, percentage of nutrients in the soil, water cycle, carbon cycle nitrogen cycle until recent times. The disturbance to these vital systems has made a significant contribution to climate change, global warming, soil erosion, ozone depletion, and eutrophication. Ecosystems are interconnected networks of complex systems. We don't get to know the damage until it is at the edge of collapse. The supporting frame which makes the whole network sometimes gets eroded without obvious warning symptoms. Sometimes warnings are there but we tend to ignore them because of so many reasons. In the case of Australia, an established example is the case of fisheries, which may suddenly collapse even when there is no change in the amount of catching. [Australian et al. \(2005\)](#). Another evident example is in the landscape where foreign crops have replaced native/local vegetation. They have a different need for nutrients and water which is changing the whole water content of the soil. They require very less water in comparison to the native plants, so the excess water goes to the soil and groundwater 10 times faster approximately. Consequently, the groundwater level is slowly rising and dissolving the natural salt in the weathered soil. This salt can come to the land surfaces or streams in Australia in the upcoming 100 years or less [Australian State of the Environment Committee \(2001\)](#). It can have

many devastating impacts on biodiversity and production. Many ecosystem services have been ignored for so long and if nothing is going to be done in this regard the cost of these can be a significant burden to the whole society. It has become a priority to understand the value of ecosystem services and to incorporate them into economic guidelines and frameworks.

2. MATERIALS AND METHODS

The methodology for writings this paper is to first find out a problem statement and build a hypothesis. After that go through the literature study of the relevant topics to give out the research gap. The process of literature study is done through primary as well as secondary sources, such as books research papers publications, articles, journals

Chapters thesis, dissertation, and review papers. For the primary study, a case study has been chosen, and site visits and analysis have been done to know the site-specific conditions. The context study was also important to know the whole ecosystem. Ecosystem services are prevalent in the context of the site and how the whole network is working. After site study and analysis, the inference has been noted down. The hypothesis has been cross-checked that if it is correct or not. After that, the proceed framework is provided and the limitations of it is do discussed. The paper is finally concluded by providing the guidelines to be followed to establish ecosystem services for the regeneration of urban ecosystems.

3. RESULTS AND DISCUSSIONS

Ecosystem services analysis is a systematic approach to assessing and evaluating the benefits that ecosystems provide to human well-being. It involves identifying, quantifying, and valuing the various services and functions that ecosystems offer, as well as understanding the relationships and trade-offs among them. Ecosystem services analysis provides a comprehensive framework for understanding and valuing the benefits that ecosystems provide to society. It helps to integrate ecological and socio-economic considerations, enabling a more holistic approach to environmental management and decision-making. The key steps involved in ecosystem services analysis:

- 1) Identifying Ecosystem Services:** The first step is to identify and classify the different ecosystem services relevant to the study area or system. Common categories of ecosystem services include provisioning services (e.g., food, water, timber), regulating services (e.g., climate regulation, water purification), cultural services (e.g., recreation, spiritual value), and supporting services (e.g., nutrient cycling, soil formation). This step involves understanding the specific services provided by the ecosystem and their beneficiaries.
- 2) Assessing Service Supply:** Evaluate the capacity of the ecosystem to provide the identified services. This may involve measuring physical and ecological parameters, such as biomass, species composition, water quality, or habitat quality. Monitoring and data collection methods can vary depending on the specific service being analyzed.
- 3) Quantifying Service Flows:** Determine the actual flows of ecosystem services from the ecosystem to human beneficiaries. This step involves estimating the amount, frequency, and spatial distribution of service delivery. For example, in the case of water provisioning, the analysis may

involve measuring the volume of water available from a particular watershed or aquifer.

- 4) **Valuing Ecosystem Services:** Assign economic or non-monetary values to the ecosystem services being analyzed. This step helps to understand the contribution of ecosystem services to human well-being and can facilitate decision-making processes. Valuation methods can range from market-based approaches (e.g., estimating the market price of a service) to non-market valuation techniques (e.g., stated preference surveys, cost-based methods).
- 5) **Mapping and Spatial Analysis:** Utilize spatial data and mapping techniques to represent the spatial distribution of ecosystem services and their beneficiaries. Geographic Information Systems (GIS) can be used to overlay ecological data, socio-economic data, and ecosystem service values, providing a visual representation of the distribution and potential trade-offs among services.
- 6) **Trade-off and Synergy Analysis:** Investigate the trade-offs and synergies among different ecosystem services. This involves analyzing the relationships and dependencies between services and identifying situations where enhancing one service may come at the expense of another. Trade-off and synergy analysis can inform decision-making processes and help identify win-win opportunities for ecosystem management and conservation.
- 7) **Decision Support and Policy Integration:** Integrate the findings of the ecosystem services analysis into decision-making processes, policy development, and land management strategies. By understanding the values, trade-offs, and synergies associated with ecosystem services, policymakers, and stakeholders can make more informed and sustainable choices regarding ecosystem management and conservation.

Figure 2

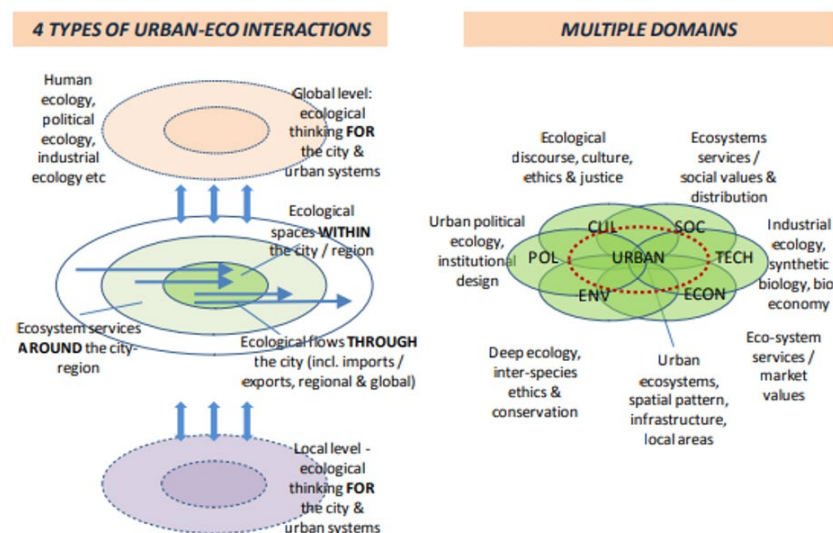


Figure 2 Urban Ecosystem Interactions

Source Source: Millenium Ecosystem Assessment, 2005; Ravetz and George (2009)

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. STEPS OF ECOSYSTEM SERVICES ANALYSIS IN URBAN DEVELOPMENT

Ecosystem services analysis (ESA) can be utilized by architects, urban planners, designers, city planners, ecologists, and policymakers at local as well as regional levels to incorporate it into the regenerative plans for any urban area.

It is going to be a stepwise process. Different stages are as follows:

Stage 1: Identification of a Healthy Existing Ecosystem

The initial step in Ecosystem Service Assessment (ESA) involves assessing the current state of the urban local scenario to determine if it can be studied. If not, specific design targets can be established as a foundation for further study. To evaluate the importance of different aspects of a site, measurable indicators can be utilized, such as rainfall, availability of fresh water, soil condition, and other site-specific studies. While conducting these assessments, gaps in our knowledge of ecosystem services may become apparent. In the field of ecology, each ecological system offers unique services that can inform the development of regenerative designs.

Stage 2: Determination of Optimal Environmental Performance

The design targets established in the previous stage will be used to ascertain the optimal environmental performance for the built environment on the site. These targets serve as benchmarks for evaluating the effectiveness of design interventions.

Stage 3: Analysis of Available Ecosystem Services on Site

An in-depth examination and analysis should be conducted to evaluate the current state of ecosystem service provision on the site. This assessment helps identify the ecosystem services that are currently present and their significance.

Stage 4: Comparative Analysis of Available and Optimal Rates

A comparative analysis is performed to compare the current rates of ecosystem services on the site with the optimal rates determined in the previous stage. This analysis allows for a clear understanding of the gaps between the existing conditions and the desired outcomes. The knowledge of ecosystem services is a theoretical concept that can guide long-term visions and goals. Design techniques and tools are utilized for implementing interventions on the site to align with these concepts. Integrating ecosystem services can also establish criteria to ensure that technologies and systems employed in various development processes consider their impact on multiple ecosystem services and facilitate sustainable development.

Stage 5: Recommendations and verification of Suggested recommendations

The final objective of the ecological urban performance improvement by the ESA (Ecological Site Assessment) is to ensure that the optimal solution is derived without causing any negative impacts on other ecosystem services. It is essential to evaluate the suitability of each specific project to determine whether it is appropriate to implement the ESA. This evaluation is crucial because certain green building technologies may initially appear to enhance environmental performance but can actually lead to adverse ecological outcomes in the long run.

For instance, the utilization of green walls or facade technologies may be suitable in certain locations. However, factors such as the composition of the systems, the source of water and plant selection, the distance these technologies or systems need to travel, and the climate context must be taken into account. This

thorough assessment is necessary because their implementation may unintentionally increase the overall ecological footprint of the development rather than decrease it [Gerhardt and Vale \(2010\)](#).

4.2. RECOMMENDATIONS

- **Integrate Nature into Urban Planning:** Incorporate green infrastructure and nature-based solutions as integral components of urban development plans. Prioritize the establishment of parks, green corridors, and urban forests to enhance biodiversity, improve air and water quality, and provide spaces for recreation and community engagement.
- **Create Incentives for Nature-Based Approaches:** Develop financial incentives, subsidies, and tax breaks for developers and communities that adopt nature-based solutions. These incentives can encourage the implementation of green roofs, permeable pavements, and other sustainable practices that enhance ecosystem services.
- **Foster Collaboration and Knowledge Sharing:** Facilitate collaboration between researchers, practitioners, and policymakers to share best practices and lessons learned from successful urban regeneration projects. Establish platforms for regular knowledge exchange to accelerate the adoption of effective strategies.
- **Invest in Research and Monitoring:** Allocate resources for ongoing research to quantify the benefits of ecosystem services in urban environments. Long-term monitoring of these projects can provide valuable data on their effectiveness and inform future decision-making.
- **Engage Communities:** Involve local communities in the planning and design of urban regeneration projects. Engaged citizens are more likely to take ownership of and care for the natural assets in their neighborhoods, contributing to the long-term sustainability of ecosystem services.
- **Educate and Raise Awareness:** Launch public awareness campaigns to educate residents about the importance of ecosystem services and their role in enhancing urban quality of life. Cultivate a sense of stewardship among citizens to ensure the preservation and maintenance of these natural assets.
- **Implement Adaptive Management:** Recognize that urban regeneration is an ongoing process, and factors like climate change and population dynamics can impact the effectiveness of ecosystem services over time. Implement adaptive management strategies that allow for flexible adjustments as conditions evolve.
- **Leverage Technology:** Embrace technological advancements such as Geographic Information Systems (GIS) and remote sensing to assess the distribution and impact of ecosystem services within urban areas. This data-driven approach can inform evidence-based decision-making.
- **Promote Policy Integration:** Foster coordination between environmental, urban planning, and public health departments to ensure that policies align and complement each other. Integrated policies can generate synergistic benefits across different sectors.

- **Support Capacity Building:** Invest in training programs and workshops for urban planners, architects, and other professionals to enhance their understanding of ecosystem services and their integration into urban design and development.

4.3. CONCLUSION

The study delves into the critical relationship between nature and cities, highlighting the potential of harnessing ecosystem services for urban regeneration. The findings underscore the significance of integrating nature-based solutions into urban planning and development strategies to address the multifaceted challenges faced by modern cities.

Through a comprehensive review of literature and case studies, this research paper has illuminated the myriad benefits that ecosystem services offer to urban environments. From improved air and water quality to enhanced biodiversity and mental well-being, these services have the potential to create sustainable, resilient, and vibrant urban spaces. The success stories presented in various cities emphasize the feasibility and positive outcomes of incorporating green infrastructure and ecological principles into urban renewal efforts.

However, the implementation of nature-based solutions requires a concerted effort from policymakers, city planners, communities, and various stakeholders. Adequate policies, incentives, and regulations are imperative to ensure the effective integration of ecosystem services into urban development projects. Furthermore, fostering community engagement and education plays a crucial role in building a sense of ownership and stewardship towards these natural assets.

As urbanization continues to accelerate, the urgency of adopting holistic approaches that balance urban growth with environmental conservation becomes even more evident. The research highlights the need for interdisciplinary collaboration between ecologists, urban planners, architects, economists, and sociologists to design and implement innovative strategies that seamlessly blend the built environment with nature.

In essence, this paper underscores the significance of recognizing nature not as an isolated entity but as an integral component of urban life. By embracing the potential of ecosystem services, cities can mitigate the impacts of climate change, enhance resilience, and create more livable, sustainable, and harmonious urban landscapes. As we move forward, it is imperative that city leaders and policymakers prioritize the integration of nature into their vision for urban regeneration, ultimately fostering a future where nature and cities coexist synergistically for the benefit of both residents and the environment.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

REFERENCES

Basnou, C., Pino, J., & Terradas, J. (2015). Ecosystem Services Provided by Green Infrastructure in the Urban Environment. *CAB Reviews: Perspectives in*

- Agriculture, Veterinary Science, Nutrition and Natural Resources, 10, 10.1079/PAVSNNR201510004. <https://doi.org/10.1079/PAVSNNR201510004>
- Das, S., Sharma, S., Sannigrahi, S., & Chakraborti, S. (2022). Effect of Urbanization on the Dynamics of Ecosystem Services: An Analysis for Decision Making in Kolkata Urban Agglomeration. *Urban Ecosystems*, 25. <https://doi.org/10.1007/s11252-022-01246-3>
- Deng, J., Wang, Y., Zhang, Y., & Liu, Y. (2019). Ecosystem Services Dynamics Response to Tremendous Reclamation in a Coastal Island City. *Ecosystem Health and Sustainability*, 5, 155–168. <https://doi.org/10.1080/20964129.2019.1646103>
- Haase, D., & Wolff, M. (2022). Enabling Ecosystem Services at the Neighborhood Scale While Allowing for Urban Regrowth: The Case of Halle, Germany. *Ecology and Society*, 27(1), 22. <https://doi.org/10.5751/ES-12988-270122>
- Hawken, S., Sharma, S., & Sannigrahi, S. (2021). The SDGs, Ecosystem Services and Cities: A Network Analysis of Current Research Innovation for Implementing Urban Sustainability. *Sustainability*, 13, 14057. <https://doi.org/10.3390/su132414057>
- Luederitz, C., Brink, E., Gralla, F., Hermelingmeier, V., Meyer, M., Niven, L., Panzer, L., & Lang, D. J. (2015). A Review of Urban Ecosystem Services: Six Key Challenges for Future Research. *Ecosystem Services*, 14, 98–112. <https://doi.org/10.1016/j.ecoser.2015.05.001>
- Pedersen Zari, M. (2018). Regenerative urban design and ecosystem biomimicry. Routledge. <https://doi.org/10.4324/9781315114330>
- Sannigrahi, S., Chakraborti, S., & Das, S. (2019). Ecosystem Service Value Assessment of a Natural Reserve Region for Strengthening Protection and Conservation. *Journal of Environmental Management*, 244, 208–227. <https://doi.org/10.1016/j.jenvman.2019.04.095>
- Semeraro, T., Aretano, R., Pomes, A., & Leone, A. (2017). Green Infrastructure to Improve Ecosystem Services in the Landscape Urban Regeneration. *IOP Conference Series: Materials Science and Engineering*, 245, 082044. <https://doi.org/10.1088/1757-899X/245/8/082044>
- Sharma, S., Sannigrahi, S., Das, S., & Chakraborti, S. (2020). A Long-Term and Comprehensive Assessment of Urbanization-Induced Impacts on Ecosystem Services in the Capital City of India. *City and Environment Interactions*, 7, 100047. <https://doi.org/10.1016/j.cacint.2020.100047>
- Tomscha, S., Gergel, S. E., & Mistry, J. (2019). Uncovering the Ecosystem Service Legacies of Wetland Loss Using High-Resolution Models. *Ecosphere*, 10, e02888. <https://doi.org/10.1002/ecs2.2888>