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Landscape Urbanism and Green Infrastructure in Bhopal: Integrating Ecological Resilience into Urban Design

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Abstract - One of the effects of urbanization in India is the high rate of ecological devastation; this is most justifiable in urban centers such as the city of Bhopal. The paper situates emergent ways of addressing these anomalies first from Urban Landscape Urbanism and then from Green Infrastructure, thus enabling the incorporation of ecological resilience into the design of cities. The research is based on a study of Bhopal's botany, history, and sociocultural circumstances as connected to aspects of sustainable urban design potential that would reduce environmental stress as they enhance livability. Some of the treated subjects are the processes by which ecosystems can be reestablished into green infrastructure possibilities and strategic frameworks for constructing Bhopal (Benedict & McMahon, 2002).

Keywords: *Urbanism, landscape, green infrastructure, resilience.*

1.INTRODUCTION

The Urbanization Challenge

Overall, urbanization in India has taken a heavy toll on the environment; this results in destruction of habitats, change in air and water quality and threatened biodiversity. The "City of Lakes" of India, Bhopal has gradually viewed increased environmental destruction due to rapid urbanization and industrial growth. The encroachment encroached the water bodies and green space areas which amputated the city's ecological footprint. Moreover, chaotic urban planning has increased people's dependence on grey infrastructure, thereby exacerbating the ecological situation (Bhopal Municipal Corporation, 2020).

The Role of Landscape Urbanism

Landscape urbanism shifts the focus of urban design from individual buildings to large landscapes and the areas developing according to this philosophy. It seeks to integrate ecological processes into the city, making it more resilient to problems like climate change, flooding, and loss of biodiversity. This approach emphasizes the multi-functional character of landscapes, combining environmental, social, and economic objectives to enhance the quality of urban life (Waldheim, 2006).

Importance of Green Infrastructure

Green infrastructure refers to a series of interlinked green spaces and natural systems that aim for ecological, social, and economic benefit. Its application in urban design results in management of stormwater, improvement in air quality, cooling of the urban climate, and improvements in community health. Besides environmental benefits, the creation of socially equitable public open spaces fosters quality life in diverse urban population groups (Tzoulas et al., 2007).

Relevance to Bhopal

The historical importance of Bhopal, being a city planned with natural water bodies and green spaces, presents a unique opportunity to reinvigorate its ecological legacy. The amalgamation of landscape urbanism combined with green infrastructure may enable the regeneration of its status as an ecologically sustainable city center, appropriately responding to current challenges while safeguarding its natural assets (Government of India, 2021).

2.LITERATURE REVIEW

Landscape Urbanism- Mr. Waldheim (2006) concludes that landscape urbanism supports the incorporation of natural systems as the heart of organizing in urban design. This perspective takes landscape not merely as an aesthetic element but instead as the backbone for resilient environments in cities. Focusing on ecological functions helps maximize the adaptation and sustainability abilities of urban environments.

Green Infrastructure

According to Benedict and McMahon (2002), green infrastructure is deliberately designed systems of natural and semi-natural spaces that support ecosystem services. Examples include urban forests, bioswales, wetlands, and green roofs. Such systems provide environmental, social, and economic benefits through the reduction of urban heat islands, enhancement of biodiversity, and optimization of stormwater management.

Ecological Resilience

Holling (1973) established the concept of resilience, emphasizing an ecosystem's potential to retrieve from disturbances. In urban planning, this idea translates to the design of interconnected systems proficient of modifying to

environmental stressors. Resilient cities stable development with conservation to support long-term ecological well-being.

Case Study: Bhopal

Ecological Context

The remarkable waterscape, forested areas, and hilly topographies define Bhopal. About over a thousand years old, the Upper and Lower Lakes form the backbone of the city's ecological system. In addition to these lakes, sites like Van Vihar National Park support biodiversity and provide vital ecosystem services, including groundwater replenishment and thermal regulation. However, unregulated urban development has had devastating effects on these natural systems (Bhopal Municipal Corporation, 2020).

Current Challenges

• Urban Sprawl: The unregulated growth of the urban areas led to the green areas being developed, and increased surface runoff along with reducing ecological connectivity.

•Water Management Issues: Encroachment of water bodies and lack of stormwater management has increased water scarcity and flooding.

•Loss of Biodiversity: It has caused habitats to be destroyed, resulting in reduced populations of native flora and fauna, disturbing the ecological balance.

•Climate Change: Increased temperatures and fluctuations in rainfall increase the risks of a city's vulnerability, like heat stress and water shortage. Holling, 1973).

•Social Inequalities: Poor communities lack access to open spaces because they have lesser ability to deal with environmental and social stress.

3.METHODOLOGY

Mixed-Methods Approach

This study employs a combination of spatial analysis, stakeholder engagement, and case studies to explore sustainable solutions:

• Spatial Analysis: Mapping of gaps using GIS determines which areas of the city lack development in green infrastructure while measuring ecological connectivity.

• Stakeholder Engagement: Interviews of urban planners, ecologists, and local residents will give information about the challenges and opportunities to incorporate green infrastructure.

•Case Studies: Strategies used in other Indian cities for green belts by Chandigarh and river restoration by Pune shall inform the approach of Bhopal.

4.RESULTS AND DISCUSSION

Integrating Landscape Urbanism in Bhopal

- Reconnecting Urban and Natural Systems
  Green corridors can link fragmented habitats and encourage biodiversity while improving human-nature interaction.
  Example: A green belt around the Upper and Lower Lakes would protect the water quality, serve as a buffer against encroachment, and protect natural resources (Sharma & Joshi, 2020).

- Water-Sensitive Urban Design
  Bioswales, rain gardens, and permeable pavements can assist in stormwater management and control urban flooding.
  Example: Neighborhood-scale rainwater harvesting system development to enhance groundwater recharge and resilience (Government of India, 2021).

- Public Spaces
  Unused or underutilized space can be transformed into multi-functional green space that provides ecological, recreational, and social value.
  Example: Repurposed abandoned industrial sites into urban parks with native plants and community facilities (Benedict & McMahon, 2002).

Implementing Green Infrastructure

- The Restoration of Lakes is an endeavor that utilizes natural filtration systems, riparian buffers and community-led initiatives to rejuvenate Bhopal's lakes. For instance, citizen-driven clean-up efforts, part of the “Bhoj Wetland Conservation” project, effectively illustrate the potential of community involvement in ecological restoration (Bhopal Municipal Corporation, 2020).
- Urban Forests play a crucial role in environmental health; planting native species in degraded areas can sequester carbon, mitigate urban heat islands and support diverse wildlife. One noteworthy approach is the Miyawaki method, which focuses on creating dense, fast-growing urban forests (Miyawaki, 1999).
- Green Roofs and Vertical Gardens on buildings can significantly reduce energy consumption, improve air quality and enhance aesthetic appeal. This is particularly evident through the introduction of government incentives, such as tax rebates, for adopting green roof technology (Tzoulas et al., 2007).

However, these initiatives often face challenges in implementation; although there are clear benefits, community engagement is essential for long-term success.

Challenges and Solutions

- Policy and Governance

Fragmented governance hinders coordinated green infrastructure efforts. A city-wide green infrastructure strategy will help provide clear guidelines and encourage collaboration among stakeholders.

- Community Engagement

Local communities must be involved in planning and maintaining green infrastructure to ensure long-term success.

This would involve conducting participatory workshops and awareness campaigns for informing the public on the benefits of green infrastructure.

- Funding

Big ecological projects usually lose due to financial constraints. Funding large-scale projects can be obtained through public-private partnerships, government grants, and innovative funding instruments such as green bonds.

5.CONCLUSION

Land-scape urbanism and green infrastructures can be incorporated into Bhopal to attain ecological protection, increase resilience, and quality of life. This requires a joint effort by the policymakers, urban designers, and the local communities so that the system can be designed to promote development and conservation simultaneously. More advanced technologies, including environmental monitoring using IoT-enabled devices, can be included for further implementation of green infrastructures.

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