IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

The Pivotal Role Of Metropolitan Governance In Preserving Urban Reserve Forests: A Case Study Of Nanmangalam, Chennai

Ms. Pardita Ningthoujam[1] and Mr.T.G Thirumalai Bharathi [2]
Assistant Professors
Chennais Amirta International Institute of Aviation

ABSTRACT

Rapid urbanization presents a fundamental ecological paradox, particularly in developing metropolitan regions where infrastructure expansion often conflicts with environmental sustainability. This study examines the governance dynamics influencing biodiversity preservation within Nanmangalam Reserve Forest. Using a qualitative case study approach, the research integrates field observations, policy analysis, and stakeholder data collected from 80 long term residents across five suburban clusters.

The findings reveal that metropolitan systems function simultaneously as agents of ecological stress and potential enablers of conservation. While infrastructure projects such as metro rail expansion introduce acoustic, hydrological, and spatial pressures, strategic interventions such as quarry restoration, buffer enforcement and community engagement support biodiversity resilience. A key contribution of this study is the identification of "social capital driven conservation," where local stakeholders act as informal ecological stewards.

The paper proposes a governance framework emphasizing synchronization between infrastructure planning, ecological preservation, and community participation. The findings contribute to urban ecology and policy literature by demonstrating how fragmented forest systems can be sustainably integrated into rapidly expanding metropolitan regions.

Keywords: Urban forestry; metropolitan governance, biodiversity conservation, social capital, sustainable urbanization, Chennai

1. INTRODUCTION

1.1 Urbanization and Ecological Tension

Urbanization has become the dominant global trend of the twenty first century, with projections indicating that nearly 70% of the world's population will reside in cities by 2050. While metropolitan regions function as economic and social hubs, their expansion often results in the degradation of ecological systems. Urban and peri urban forests play a critical role in mitigating these effects by providing ecosystem services such as carbon sequestration, temperature regulation, stormwater

management, and biodiversity support. However, these ecosystems face increasing pressure from land use change, infrastructure development, and environmental fragmentation.

1.2 The Indian Metropolitan Context

Indian metropolitan regions, including Chennai, are characterized by rapid and often unplanned urban expansion. In such contexts, ecological preservation is frequently deprioritized in favor of infrastructure and housing demands. The concept of multi dimensional biodiversity extends beyond species count to include ecological stability, hydrological balance, and habitat connectivity. Urban expansion often disrupts these dimensions, leading to fragmented ecosystems and declining ecological resilience.

1.3 Urban Forests as Socio Ecological Assets

Urban forests function as critical public infrastructure rather than residual land parcels. They contribute to:

- Reduction of the Urban Heat Island (UHI) effect
- Groundwater recharge
- Air quality improvement
- Psychological well being of urban populations
- In high density cities, these benefits directly influence public health and economic productivity.

1.4 Study Context: Nanmangalam Landscape

Nanmangalam Reserve Forest represents a unique ecological system within Chennai's southern suburbs. Covering approximately 320 hectares, it is a remnant of the Tropical Dry Evergreen Forest (TDEF) ecosystem.

The site is notable for its transformation from a former granite quarry into a functioning ecological habitat, illustrating the adaptive capacity of post industrial landscapes.

1.5 Research Objectives

This study seeks to critically examine the role of metropolitan governance in shaping the ecological sustainability of urban reserve forests, with specific reference to Nanmangalam Reserve Forest. It aims to evaluate the effectiveness of existing institutional frameworks, planning policies, and regulatory mechanisms in safeguarding forest boundaries and mitigating the pressures arising from rapid urban expansion. In doing so, the research situates governance not merely as a regulatory function, but as a dynamic interface between infrastructure development and ecological preservation.

A second objective is to analyze the biodiversity dynamics within a post industrial ecological landscape. By focusing on the transformation of abandoned quarry sites into functional habitats, the study investigates how such "novel ecosystems" contribute to species diversity, habitat specialization, and overall ecological resilience within a metropolitan context.

The research further aims to assess the extent to which surrounding urbanization influences ecological stability. This includes examining the impacts of infrastructure development, land use change, and anthropogenic stressors such as noise, waste, and thermal variation on the structural and functional integrity of the forest ecosystem.

Finally, the study endeavors to develop an integrated urban forest governance framework that synthesizes ecological, infrastructural, and social dimensions. By incorporating stakeholder driven insights and emphasizing inter agency coordination, the proposed framework seeks to offer a scalable model for achieving sustainable coexistence between metropolitan growth and biodiversity conservation.

2. LITERATURE REVIEW

The evolution of urban ecology reflects a shift from viewing cities as "anti nature" to understanding them as socio ecological systems. Early planning ideas such as Ebenezer Howard's Garden City model emphasized separation between urban and natural spaces, whereas later work by Mark Benedict and Edward McMahon (2006) introduced Green Infrastructure (GI) as an integrated approach, positioning urban forests as essential systems. Research in landscape ecology by Richard T. T. Forman (2014) highlights how urban expansion leads to fragmentation, creating isolated habitats and increasing edge effects. The literature emphasizes ecological corridors as critical for maintaining biodiversity, particularly in rapidly urbanizing regions such as Chennai.

The valuation of ecosystem services, pioneered by Robert Costanza et al. (1997), underscores the economic and environmental importance of urban forests, especially in regulating the Urban Heat Island effect, as further explored by T. R. Oke (1982) and Mat Santamouris (2014). The theory of novel ecosystems by Richard J. Hobbs et al. (2006) reframes post industrial landscapes, such as quarry sites, as emerging ecological habitats, supported by studies like Jeremy Lundholm and David Richardson (2010). Regionally, research by N. Parthasarathy et al. (2008) highlights the ecological significance of Tropical Dry Evergreen Forests, though urban fragments such as Nanmangalam Reserve Forest remain underexplored. Governance studies by Harini Nagendra (2016) and Cecil Konijnendijk (2003) identify institutional fragmentation and emphasize integrated and participatory approaches, while technological contributions by P. S. Roy and S. Tomar (2000) highlight the role of GIS in monitoring ecosystems. Additionally, social perspectives from Richard Louv (2005) and Stephen Kaplan (1995) stress the public health importance of access to natural environments.

Research Gap:

Despite extensive scholarship, gaps remain in integrating governance, post industrial ecology, and urban forest management. Existing studies are largely ecological rather than managerial, with limited focus on synchronizing infrastructure development and conservation. This study addresses these gaps through a governance centered analysis of Nanmangalam Reserve Forest.

3. RESEARCH METHODOLOGY AND DATA ANALYSIS

3.1 Research Design

This study adopts a qualitative dominant single case study design, following the methodological framework proposed by Robert K. Yin (2018). This approach is particularly suitable for examining complex, real world interactions where the boundaries between urban systems and ecological processes are not clearly defined. The selection of Nanmangalam Reserve Forest as a critical case enables an in depth investigation of the interface between metropolitan infrastructure expansion and ecological sustainability. By focusing on a high pressure peri urban environment, the study aims to generate context sensitive insights into governance mechanisms influencing biodiversity outcomes.

3.2 Study Area

The study area is located on the southern periphery of Chennai, within the Medavakkam–Kovilambakkam–Tambaram corridor. Covering approximately 320 hectares, Nanmangalam represents a post industrial ecological system, characterized by the presence of abandoned granite quarries that have evolved into perennial water bodies and rocky habitats. This transformed landscape supports diverse flora and fauna, making it an example of a "novel ecosystem." Simultaneously, the forest is subjected to intense urban pressures due to its proximity to rapidly expanding residential and infrastructure corridors, thereby providing an appropriate setting to analyze metropolitan–ecological interactions.

3.3 Sampling Strategy and Data Collection

Primary data were collected using a purposive sampling strategy, targeting stakeholders with long term familiarity and direct dependence on the local environment. The sample consisted of 80 respondents, primarily landlords and long term residents aged between 35 and 60 years. This cohort was selected based on their prolonged residence (typically exceeding two decades) and their heightened sensitivity to environmental changes, including groundwater availability, temperature variations, and land use transformations.

Data collection was conducted across five spatial clusters to ensure geographical representation and spatial triangulation:

Medavakkam Junction (n = 20) Vijayanagaram (n = 15) Vellakal (n = 15) Kovilambakkam (n = 15) Santhosapuram (n = 15)

These clusters were selected to capture varying degrees of exposure to infrastructure development, particularly metro rail construction. Data sources included semi structured interviews, field observations, and secondary institutional reports.

3.4 Data Analysis

The collected data were analyzed using thematic analysis, enabling the identification of recurring patterns related to environmental perception, infrastructure impacts, and governance effectiveness. Key analytical themes included:

Infrastructure induced ecological stress Hydrological dependency and groundwater concerns Thermal and microclimatic changes
Stakeholder perceptions and community response

Triangulation across respondent narratives, observational data, and policy documents enhanced the validity of findings.

3.5 Empirical Findings: Infrastructure–Ecology Interface

The analysis reveals a significant interaction between metropolitan infrastructure expansion and ecological stability, particularly in relation to projects implemented by Chennai Metro Rail Limited.

Acoustic and Vibrational Impacts:

A majority of respondents (92%) in Medavakkam and Kovilambakkam reported increased noise and vibration levels due to construction activities. These disturbances were perceived to affect local biodiversity, particularly avian species inhabiting quarry cliffs.

Edge Degradation and Waste Encroachment:

In Vellakal, 95% of respondents identified construction debris dumping as a major issue, indicating weak enforcement of environmental safeguards along forest boundaries.

Hydrological Concerns:

In Santhosapuram, 88.4% of respondents associated the forest with groundwater stability. Additionally, 77% expressed concerns regarding deep piling activities potentially affecting subsurface aquifers, highlighting a gap in communication and environmental transparency.

Thermal Effects:

Approximately 80% of respondents in Medavakkam reported increased indoor temperatures and energy consumption following roadside tree removal, indicating a decline in microclimatic regulation.

3.6 Spatial Variation in Stakeholder Perceptions

The findings indicate spatial variation in environmental stress and stakeholder concerns across the five clusters. Areas directly affected by construction activities reported higher levels of ecological disturbance and public anxiety, while buffer zones exhibited concerns related to water security and thermal comfort. This spatial differentiation underscores the uneven distribution of urbanization impacts within peri urban ecosystems.

3.7 Conceptual Insight: The “Vested Interest” Model

A key outcome of the analysis is the identification of a “Vested Interest” model of conservation, wherein local stakeholders function as informal ecological stewards. Property owners demonstrate heightened environmental awareness due to their dependence on ecosystem services such as groundwater and temperature regulation. This alignment between economic interest and ecological preservation suggests the potential for integrating community participation into formal governance frameworks.

3.8 Limitations

The study is subject to certain limitations, including reliance on perception based data and the absence of quantitative ecological measurements. Additionally, the focus on a specific stakeholder group may introduce sampling bias. Future research could incorporate geospatial analysis and ecological field data to complement qualitative findings.

4. RESULTS AND DISCUSSION

4.1 Governance Gap and the Role of Social Capital

The findings reveal a significant policy gap in metropolitan governance, characterized by a predominantly top down approach in which institutional actors operate in isolation. While regulatory bodies focus on boundary protection and infrastructure expansion, there is minimal engagement with local stakeholders residing around Nanmangalam Reserve Forest. Evidence from the 80 respondents indicates that these communities possess valuable situated knowledge—including awareness of ecological changes, illegal dumping zones, and species behavior—which remains largely unutilized within formal governance frameworks.

A key outcome of the study is the identification of social capital as an effective management resource. In areas such as Santhosapuram, conservation outcomes are influenced not solely by state enforcement but by stakeholder dependence on ecosystem services, particularly groundwater availability. This creates a "vested interest" dynamic, where residents actively monitor and protect the forest. The findings suggest that transitioning from exclusionary governance toward inclusive stewardship models, such as community managed buffer zones or citizen forest committees, could significantly enhance conservation effectiveness.

4.2 Infrastructure–Ecology Interface

The expansion of metro infrastructure by Chennai Metro Rail Limited emerges as a critical point of friction between development and ecological stability. The study identifies this as an issue of institutional misalignment, where infrastructure planning does not adequately integrate ecological considerations.

One of the most prominent impacts is acoustic and vibrational disturbance, which has implications for biodiversity. The observed decline in sightings of species such as the Indian Eagle Owl indicates that ecological integrity is influenced not only by physical habitat loss but also by sensory disruption. This highlights a limitation in conventional conservation metrics that prioritize green cover while neglecting factors such as noise and light pollution. The findings underscore the need for mitigation strategies, including acoustic barriers and coordinated planning mechanisms, to align infrastructure development with ecological preservation.

4.3 Post Industrial Ecology and the Quarry Landscape

The study further identifies the abandoned quarry zones within Nanmangalam as central to its ecological functioning. These areas have evolved into multi functional habitats, supporting biodiversity and acting as hydrological reservoirs. Rather than representing degraded land, the quarries function as critical ecological assets within the broader forest system.

However, ongoing infrastructure activities pose potential risks to these systems, particularly through deep piling operations that may disrupt subsurface hydrological structures. The findings suggest that such areas should be formally designated as Special Management Zones (SMZs), with targeted conservation strategies that recognize their ecological and hydrological significance.

Synthesis

Overall, the results demonstrate that effective urban forest conservation in metropolitan contexts requires a shift toward integrated governance, where infrastructure planning, ecological management and community participation are aligned. The case of Nanmangalam Reserve Forest illustrates that sustainable outcomes are achievable when local knowledge, institutional coordination, and ecological sensitivity are collectively incorporated into urban development processes.

5. CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Key Findings

This study demonstrates that the interaction between metropolitan infrastructure development and urban ecological systems is not inherently contradictory, but is currently characterized by a lack of institutional synchronization. In the case of Nanmangalam Reserve Forest, rapid infrastructure expansion associated with Chennai Metro Rail Limited has generated measurable ecological stress, particularly in the form of acoustic disturbance, vibrational impact, and habitat fragmentation. These pressures have led to observable biodiversity responses, including the displacement of sensitive indicator species such as the Indian Eagle Owl, signaling early stage ecological degradation.

A second major finding is the existence of a strong but underutilized layer of informal environmental governance. The study identifies local landlords and long term residents as critical “de facto ecological stewards,” whose environmental awareness is shaped by direct dependence on ecosystem services such as groundwater stability and thermal comfort. This reveals a structural gap in current governance systems, where high value local knowledge is not systematically integrated into formal planning or environmental decision making.

Additionally, the study highlights the ecological significance of post industrial landscapes, particularly abandoned quarry systems, which function as hydrological reservoirs and biodiversity niches. These areas represent essential components of the forest’s ecological resilience but remain vulnerable to infrastructure related disturbances due to inadequate zoning and protection mechanisms.

5.2 Conclusion

The findings of this research confirm that urban forest conservation in rapidly growing metropolitan regions is fundamentally a governance challenge rather than solely an ecological one. The central conclusion is that sustainability in such contexts depends on the alignment of three systems: infrastructure development, ecological integrity, and community based stewardship.

The current governance model is characterized by fragmentation across institutions and limited coordination between planning authorities, transport agencies, and environmental departments. This “unsynchronized governance” results in unintended ecological consequences, even when infrastructure projects are framed as environmentally progressive. Therefore, the long term survival of urban forests depends on transitioning from sectoral planning to integrated metropolitan ecological governance.

5.3 Policy Recommendations

To ensure the long term ecological stability and functional sustainability of urban forests such as Nanmangalam Reserve Forest, the following strategic interventions are proposed:

1. Integrated Eco Infrastructure Governance Framework
A permanent multi agency coordination body should be established, integrating urban planners, environmental authorities, and representatives of local stakeholders. This mechanism would enable continuous environmental impact assessment and ensure that infrastructure development aligns with ecological thresholds rather than operating independently of them.

2. Sensory and Habitat Protection Measures
Infrastructure projects near sensitive ecological zones must incorporate mandatory mitigation systems, including acoustic barriers, vibration dampening technologies, and controlled lighting systems. These interventions are essential to preserve habitat integrity, particularly for nocturnal and disturbance sensitive species.

3. Transparent Hydrological Monitoring Systems
Comprehensive and publicly accessible aquifer and groundwater impact assessments should be conducted prior to and during major infrastructure development. Such transparency is critical to maintaining both ecological resilience and public trust in urban development processes.

4. Digital Ecological Monitoring and Enforcement Systems
The deployment of GIS based boundary monitoring, GPS tracked waste management systems, and real time ecological surveillance should be institutionalized. These technologies would enable proactive detection of encroachment, illegal dumping, and boundary violations, particularly in vulnerable buffer zones.

5. Community Based Stewardship Integration
Local residents should be formally integrated into conservation governance structures through citizen forest committees or participatory monitoring networks. This approach leverages existing social capital, transforming informal ecological awareness into structured environmental stewardship.

WORKS CITED

1. Benedict, Mark A., and Edward T. McMahon. Green Infrastructure: Smart Conservation for the 21st Century. Island Press, 2006.

2. Costanza, Robert, et al. “The Value of the World’s Ecosystem Services and Natural Capital.” Nature, vol. 387, no. 6630, 1997, pp. 253–260

3. Forman, Richard T. Urban Ecology: Science of Cities. Cambridge UP, 2014.

4. Hobbs, Richard J., et al. “Novel Ecosystems: Theoretical and Management Aspects of the New Ecological World Order.” Global Ecology and Biogeography, vol. 15, no. 1, 2006,
pp. 1–7,

5. Jim, C. Y., and Wendy Y. Chen. “Ecosystem Services and Management of Social Ecological Systems in Asian Cities.” Applied Geography, vol. 29, no. 2, 2009, pp. 131–139.

6. Konijnendijk, Cecil C. “A Decade of Urban Forestry in Europe.” Forest Policy and Economics, vol. 5, no. 2, 2003, pp. 173–186.

7. Nagendra, Harini. Nature in the City: Bengaluru in the Past, Present, and Future. Oxford UP, 2016.

8. Oke, Timothy R. “The Energetic Basis of the Urban Heat Island.” Quarterly Journal of the Royal Meteorological Society, vol. 108, no. 455, 1982, pp. 1–24.

9. Parthasarathy, N., M. A. Selwyn, and M. Udayakumar. “Tropical Dry Evergreen Forests of Peninsular India: Ecology and Conservation Status.” Tropical Conservation Science, vol. 1, no. 3, 2008, pp. 191–210.

10. Ramanujam, M. E. “On the Prey of the Indian Eagle Owl (Bubo bengalensis) in and Around Pondicherry, Southern India.” Zoos’ Print Journal, vol. 21, no. 5, 2006, pp. 2231–2240.

11. Yin, Robert K. Case Study Research and Applications: Design and Methods. 6th ed., SAGE Publications, 2018.

TAMIL NADU GOVERNMENT & STATUTORY SOURCES

1. Chennai Metropolitan Development Authority. Second Master Plan for Chennai Metropolitan Area 2026, vol. 2, Government of Tamil Nadu, 2008,

2. Chennai Metro Rail Limited. Environmental Impact Assessment (EIA) for Phase II – Corridor 5 (Madhavaram to Sholinganallur), Government of Tamil Nadu, 2020.

3. Environment, Climate Change and Forests Department. G.O. (Ms) No. 135: Formation of Tamil Nadu Green Climate Company (TNGCC), Government of Tamil Nadu, 2021.

4. Policy Note 2023–2024: Green Tamil Nadu Mission, Government of Tamil Nadu, 2023,

5. Tamil Nadu State Biodiversity Board. Tamil Nadu Biodiversity Rules, 2017, Government of Tamil Nadu, 2017.

6. State Biodiversity Strategy and Action Plan (TN SBSAP), Government of Tamil Nadu, 2020.