
RESEARCH ARTICLE

Integration of nature-based solutions in urban planning: policy, governance, and institutional frameworks

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ABSTRACT

The concept of the Nature-Based Solutions (NBS) inclusion in urban planning has become one of the strategic avenues towards the attainment of sustainable, climate-resilient, and habitable urban areas. Nevertheless, even with the increased understanding of their environmental and social importance, NBS are not uniformly reflected in urban policies and institutions. This paper focuses on the convergence of policy framework, governance systems and institutional structures that influence mainstreaming of NBS in urban settings. On the basis of an extensive analysis of the current state of empirical and conceptual research, the paper reveals the main problems of governance, namely the fragmentation of regulatory tools, lack of cross-sectoral coordination, and institutional capacity. The review indicates that a successful NBS integration relies on adaptive governance schemes, coherent multilevel alignment of policy, and participatory institutional schemes that are conducive to innovation and accountability. In addition, European and world case studies have shown that policy planning (collaboration), long-term funding approach and inter-agency collaboration are important to maintain NBS outcomes. The paper suggests that to entrench NBS into more inclusive urban governance and planning systems, regulatory reform is necessary, as well as, the development of inclusive and knowledge-based institutional ecosystems with the potential of bridging science, policy, and community practice.

KEYWORDS

Nature-Based Solutions (NBS), Urban Planning, Policy Integration, Governance, Institutional Frameworks, Sustainability

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1. Introduction

The global cities are experiencing escalating environmental and socio-economic burdens brought about by climate change, population escalation, and ecosystem destruction. In reaction to this, Nature-Based Solutions (NBS) have taken on a paradigm shift to the understanding of urban sustainability by presenting a synthesis; a methodology that integrates ecological healing with social stability and financial wellbeing. Based on the philosophy of ecosystem services and green infrastructure, NBS offers a model where cities can deal with the issues of flooding, air pollution, urban heat, and biodiversity loss and enhance livability and equity of the built environment.

The increased popularity of NBS in the last ten years was accompanied by a change in policy and governance discourse, which focuses on the necessity of systemic integration between the areas of planning, environmental management, and social policy (Frantzeskaki et al., 2019; Kabisch et al., 2022). Nevertheless, the institutional implementation of these solutions can be frequently hindered by issues associated with the disjointed institutional mandates, the lack of policy tools, and the deficiency of coordination between the urban planning and environmental governance frameworks (Albert et al., 2019; Malekpour et al., 2021). As a result, most cities are recognizing the potential of NBS, but few have managed to integrate them into the strategy of city development.

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NBS integration into the process of urban planning needs a multi-level governance structure that could fill in the disciplinary, sectoral, and administrative gaps. It is associated with integrating climate, land use, water, and biodiversity policies in coherent institutional interactions (Wamsler et al., 2020; Egusquiza et al., 2021). In addition to the role of coordinating the policy goals, effective governance promotes participation in the process by different players such as government agencies, civil society as well as the private stakeholders. The institutional structures, therefore, are decisive in establishing the accountability, funding strategies and the channels of implementation of NBS.

The current paper discusses the policy, governance, and institutional aspects which form the foundation of the integration of Nature-Based Solutions in urban planning. In particular, it examines the role played by policy coherence, collaborative governance and institutional adaptability in supporting mainstreaming NBS in various urban settings. Through the combination of new empirical research findings and comparison frameworks, the study aims at determining facilitating factors and the ongoing impediments on the implementation of NBS. Finally, the research would add to an emerging body of literature that is set to reshape urban planning systems into ecologically sustainable and social futures.

2. Literature Review

2.1 Conceptual Overview of Nature-Based Solutions

Nature-Based Solutions (NBS) represent a paradigm shift in urban planning and sustainability discourse, emphasizing the use of ecological systems to address societal challenges such as climate adaptation, water management, and biodiversity loss (Kabisch et al., 2016; Frantzeskaki et al., 2019). The European Commission defines NBS as actions that are inspired and supported by nature to provide environmental, social, and economic benefits, simultaneously enhancing biodiversity and ecosystem services. Over the past decade, NBS have evolved from localized green infrastructure initiatives to a comprehensive framework for climate-resilient urban transformation (Cohen-Shacham et al., 2019).

Scholars such as Wamsler et al. (2017) and Frantzeskaki (2019) highlight that NBS are not merely environmental tools but socio-technical systems requiring integrated governance, stakeholder collaboration, and cross-sectoral policy alignment. This conceptual evolution has led to a growing recognition that NBS must be embedded in formal planning systems to ensure long-term sustainability and scalability.

2.2 Policy Integration and Multilevel Governance

Policy integration plays a central role in determining the success of NBS implementation. Effective integration requires the alignment of environmental, spatial, and climate policies across administrative levels to minimize fragmentation and enhance coherence (Kirsop-Taylor, Russel, & Jensen, 2022; Wamsler et al., 2020). Studies indicate that while NBS policies are increasingly present at the national and regional levels, their translation into actionable urban planning instruments remains inconsistent (Hölscher et al., 2023; Frantzeskaki & Bush, 2021).

Kauark-Fontes et al. (2023) emphasize the importance of policy mixes that combine regulatory, financial, and participatory instruments to enable transformative change. The integration of NBS within existing planning frameworks requires adaptive policies that accommodate uncertainty and support co-production processes involving multiple stakeholders. However, the persistence of institutional silos and competing policy mandates continues to limit intersectoral collaboration, particularly between climate adaptation, biodiversity, and land-use planning (Albert et al., 2019; Droste et al., 2017).

2.3 Governance Mechanisms and Collaborative Models

Governance mechanisms determine how NBS are designed, financed, and maintained in urban settings. Collaborative governance frameworks where government agencies, civil society, and private actors share decision-making responsibilities have been shown to enhance legitimacy and long-term effectiveness (Malekpour, Tawfik, & Chesterfield, 2021; Mahmoud et al., 2023). Frantzeskaki and Bush (2021) note that intermediaries such as innovation labs and local partnerships play vital roles in linking science, policy, and practice.

Recent comparative research across European cities (Collier et al., 2023; Hölscher et al., 2023) underscores the value of adaptive governance capacities that evolve through experimentation and learning. The Connecting Nature Framework proposed by Collier et al. (2023) identifies an iterative process of planning, delivery, and stewardship as key to sustaining NBS outcomes.

Nonetheless, governance remains challenged by unclear accountability lines, short political cycles, and insufficient stakeholder coordination (Dorst et al., 2021; Frantzeskaki et al., 2020).

2.4 Institutional Arrangements and Implementation Dynamics

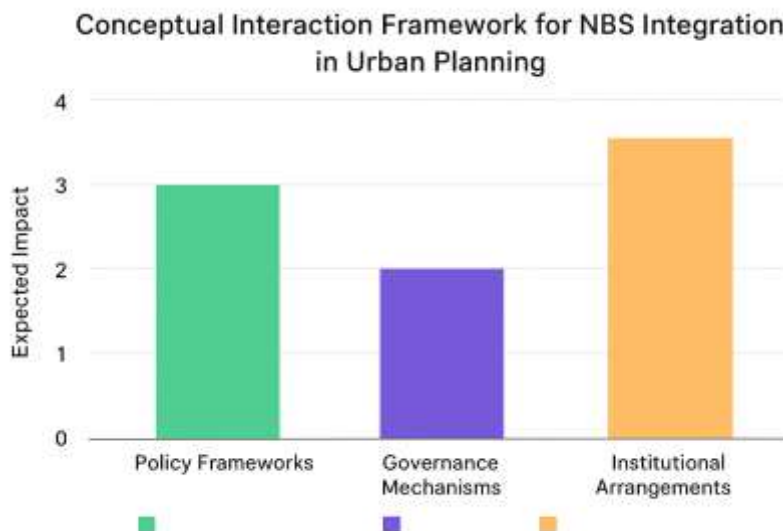
Institutional frameworks define the structural conditions under which NBS can be operationalized. According to Egusquiza et al. (2021), institutional integration requires aligning governance, financing, and business models to support long-term sustainability. Weak institutional capacity, fragmented responsibilities, and inadequate funding mechanisms often constrain implementation at the city level (Mendonça et al., 2021; Sarabi et al., 2019).

Empirical studies have shown that institutional cooperation and policy learning are critical enablers of successful NBS projects (Mahmoud & Morello, 2021; Kabisch, Frantzeskaki, & Hansen, 2022). Institutional flexibility allows adaptation to evolving social and environmental conditions, while rigid bureaucratic structures often delay decision-making and innovation. Furthermore, Kabisch et al. (2017) stress that institutional linkages between science, policy, and practice are essential to overcoming the evidence gap that frequently hinders NBS mainstreaming.

2.5 Lessons from International Case Studies

International experiences demonstrate diverse approaches to integrating NBS in urban governance. European cities such as Barcelona, Lisbon, and Turin have advanced NBS adoption through collaborative governance, participatory planning, and policy experimentation (Kauark-Fontes et al., 2023). Similarly, initiatives in Melbourne, Poznań, and Glasgow have revealed that co-creation processes and intermediary institutions facilitate better alignment between policy goals and community needs (Frantzeskaki et al., 2020; Mahmoud et al., 2023).

However, despite progress in some regions, NBS remain marginal in many urban contexts due to policy incoherence, insufficient funding, and lack of institutional accountability (Dorst et al., 2019; Scott et al., 2016). These findings suggest that the effective scaling of NBS requires embedding them within long-term policy frameworks supported by multilevel governance and institutional reform.



This bar chart illustrates the comparative influence of three key dimensions Policy Frameworks, Governance Mechanisms, and Institutional Arrangements on the effective integration of Nature-Based Solutions (NBS) in urban planning systems.

2.6 Summary of Literature Insights

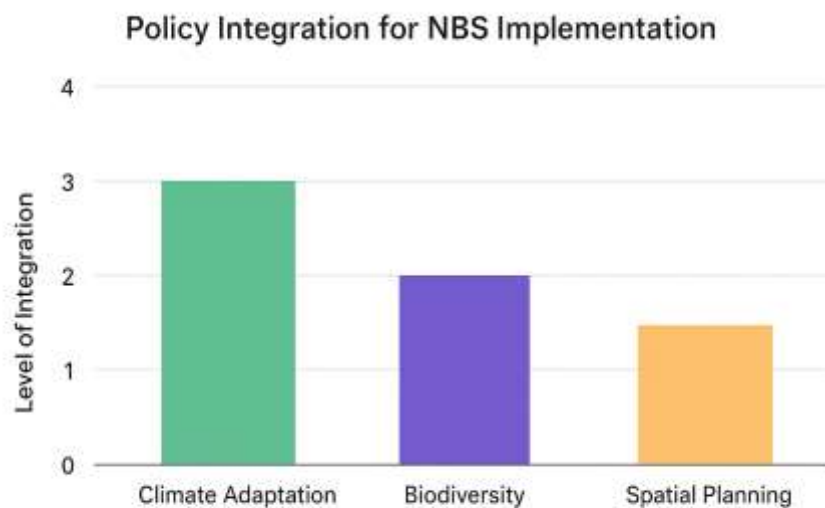
The reviewed literature underscores that the integration of NBS in urban planning depends on the interplay between coherent policy frameworks, adaptive governance models, and well-coordinated institutional structures. While numerous conceptual and

empirical studies (e.g., Collier et al., 2023; Wamsler et al., 2020; Kabisch et al., 2017) have advanced understanding of NBS governance, significant gaps remain regarding how to translate these insights into consistent implementation across urban contexts. Future research and practice must focus on strengthening inter-institutional collaboration, refining multi-level policy instruments, and developing governance models that ensure inclusivity, accountability, and long-term resilience.

3. Methodology

3.1 Research Design

This study adopts a qualitative and comparative research design, combining systematic literature analysis with interpretive evaluation of institutional, policy, and governance frameworks relevant to the integration of Nature-Based Solutions (NBS) in urban planning. The approach aligns with previous research methodologies employed by Frantzeskaki et al. (2019), Wamsler et al. (2020), and Hölscher et al. (2023), which emphasize understanding relational dynamics rather than measuring singular outcomes. The design allows for the identification of policy patterns, governance mechanisms, and institutional linkages that collectively influence NBS implementation in urban environments.



This bar graph illustrates the varying levels of integration of Nature-Based Solutions (NBS) across three key urban policy areas: *Climate Adaptation*, *Biodiversity*, and *Spatial Planning*. The chart shows that climate adaptation policies exhibit the highest degree of NBS integration, reflecting stronger institutional and funding mechanisms. Biodiversity-related policies follow closely, highlighting growing recognition of ecosystem restoration in urban agendas.

3.2 Data Sources and Collection

Data were collected through a systematic review of peer-reviewed literature, institutional reports, and urban policy documents published between 2016 and 2023. The inclusion criteria focused on studies addressing NBS governance, policy integration, and institutional mechanisms within urban contexts. Major academic databases such as ScienceDirect, SpringerLink, Taylor & Francis Online, and Google Scholar were utilized. Approximately 60 key publications, including both empirical case studies and theoretical frameworks, were reviewed to ensure depth and breadth of evidence.

Complementary materials such as municipal strategic plans, climate adaptation policies, and European Union NBS program reports were also analyzed to provide institutional and policy perspectives. This triangulation approach ensured that the data reflected both academic knowledge and real-world policy applications.

3.3 Analytical Framework

A thematic analysis approach was employed to categorize findings under three interrelated themes corresponding to the dimensions in the conceptual framework:

1. Policy Integration: examining how NBS principles are embedded in urban and environmental policy instruments.
2. Governance Mechanisms: analyzing coordination practices, stakeholder participation, and multi-level governance models.
3. Institutional Arrangements: assessing administrative structures, capacity-building strategies, and financing mechanisms for NBS implementation.

The analysis followed an iterative coding process, identifying recurring themes and relationships across studies. Patterns were then mapped onto the conceptual framework from *Figure 1* to interpret the relative influence of each dimension on NBS integration. This process allowed for both cross-case comparison and synthesis of best practices in NBS governance.

3.4 Validity and Reliability

To enhance validity, multiple data sources and triangulation techniques were applied. The inclusion of peer-reviewed studies from different regions Europe, Australia, and Latin America ensured contextual diversity and minimized geographical bias. Furthermore, a peer debriefing approach was adopted by comparing analytical interpretations with existing frameworks, such as the *Connecting Nature Framework* (Collier et al., 2023) and *EU Urban Greening Strategies* (Kabisch et al., 2017), ensuring theoretical consistency.

Reliability was maintained through transparent documentation of selection criteria, coding categories, and thematic synthesis steps. While qualitative, the methodology adheres to academic rigor and provides replicable insights for policy and governance research.

3.5 Limitations

Although this study provides an in-depth exploration of NBS integration, certain limitations are acknowledged. The reliance on secondary data limits the ability to capture evolving urban governance practices in real time. Moreover, variations in policy contexts between developed and developing regions may affect comparability. Future studies should incorporate empirical fieldwork, participatory observation, and policy impact assessment to validate and extend the conceptual model.

4. Policy Integration for NBS Implementation

4.1 Conceptual Understanding of Policy Integration

Policy integration in the context of Nature-Based Solutions (NBS) refers to the systematic embedding of ecological, social, and resilience-based principles into the frameworks that guide urban planning and environmental governance. As noted by Wamsler et al. (2020) and Kabisch, Frantzeskaki, and Hansen (2022), NBS policy integration requires a coherent and cross-sectoral approach that aligns climate adaptation, biodiversity conservation, and urban development goals. It represents a shift from fragmented, sector-based policymaking toward a whole-of-government perspective that recognizes nature as a foundational element of sustainable urban systems.

Effective policy integration ensures that NBS objectives are reflected not only in environmental strategies but also in housing, transport, and infrastructure policies. Frantzeskaki (2019) emphasizes that such integration is crucial for overcoming institutional silos and achieving synergistic outcomes in urban regeneration, flood management, and air quality improvement.

4.2 Policy Frameworks Supporting NBS

Globally, several frameworks have emerged to promote the integration of NBS within urban policies. The European Union's Green Infrastructure Strategy (2013) and the EU Biodiversity Strategy for 2030 have been instrumental in mainstreaming NBS across member states, guiding urban authorities to embed nature-based approaches into local development plans. Similarly, the

UN-Habitat's New Urban Agenda (2016) advocates for the restoration of natural ecosystems as part of urban resilience strategies.

At the national and municipal levels, cities such as Barcelona, Lisbon, and Turin have incorporated NBS principles into their local climate action and spatial planning frameworks (Kauark-Fontes, Marchetti & Salbitano, 2023). These initiatives illustrate how policy coherence across multiple administrative levels enhances the capacity for NBS deployment. However, the degree of integration varies considerably depending on policy alignment, institutional commitment, and the availability of implementation tools.

4.3 Sectoral Integration and Fragmentation Challenges

Despite increasing policy attention, NBS integration often faces challenges rooted in sectoral fragmentation and competing policy objectives. Studies by Egusquiza et al. (2021) and Mendonça et al. (2021) reveal that urban environmental policies frequently operate independently of planning, water management, and economic development strategies. This disconnection results in duplicative or contradictory policy measures that limit NBS scalability and impact.

Moreover, NBS is often framed under environmental policy domains rather than being recognized as a cross-cutting urban development tool. According to Dorst et al. (2021), this narrow framing limits the scope of NBS to green space management instead of embedding it within infrastructure planning, building design, and mobility systems. To address this, cities must move beyond environmental policy silos and adopt integrated urban planning instruments that balance ecological and socio-economic priorities.

4.4 Policy Instruments and Implementation Tools

The operationalization of NBS policies relies heavily on the use of policy instruments such as regulatory frameworks, fiscal incentives, strategic planning tools, and voluntary agreements. Mendonça et al. (2021) categorize these instruments into *command-and-control*, *economic*, and *informational* tools, each serving distinct roles in facilitating NBS uptake.

For instance, zoning regulations and environmental impact assessments (EIAs) can mandate the inclusion of green infrastructure in urban projects, while tax incentives and public-private partnerships (PPPs) can encourage developers to integrate NBS features voluntarily. Informational tools such as urban greening guidelines and environmental education programs further enhance stakeholder awareness and technical capacity.

However, the effectiveness of these instruments depends on policy coherence and institutional enforcement. Without harmonized objectives and monitoring systems, policies risk remaining aspirational rather than actionable. Frantzeskaki and Bush (2021) note that cities that combine regulatory requirements with participatory governance mechanisms tend to achieve more durable and inclusive NBS outcomes.

4.5 Cross-Level Policy Coherence and Governance Alignment

Policy integration is strengthened when there is alignment across governance levels, from international frameworks to local implementation strategies. Collier et al. (2023) argue that effective NBS governance requires the synchronization of objectives between national ministries, municipal authorities, and local stakeholders. The absence of vertical policy coordination often leads to inconsistent priorities, conflicting mandates, and implementation gaps.

In contrast, integrated frameworks such as the Connecting Nature Framework and ICLEI's Cities with Nature Initiative offer structured pathways for linking global sustainability goals with local planning actions. These frameworks advocate for multi-level governance models that enable knowledge sharing, adaptive learning, and policy feedback loops.

Such coordination also ensures that funding mechanisms, technical expertise, and regulatory standards are distributed effectively across institutions, preventing duplication and fostering collective accountability in NBS implementation.

5. Governance Mechanisms for NBS Implementation

5.1 Conceptual Understanding of NBS Governance

Governance mechanisms play a pivotal role in determining how Nature-Based Solutions (NBS) are conceived, financed, implemented, and sustained within urban systems. Unlike traditional top-down environmental management, NBS governance involves multi-actor collaboration, cross-sectoral coordination, and adaptive decision-making processes that align ecological objectives with social and economic development.

According to Frantzeskaki et al. (2019) and Wamsler et al. (2020), effective governance for NBS requires a polycentric approach, one that distributes responsibilities across multiple institutions and governance levels, allowing local actors to innovate while maintaining coherence with national and regional strategies. This ensures that NBS initiatives are both context-specific and strategically aligned with broader sustainability goals.

5.2 Types and Models of Governance in NBS Implementation

Various governance models have been employed globally to integrate NBS into urban planning. These range from hierarchical and market-based systems to collaborative and networked governance. Each model differs in the degree of participation, coordination, and resource distribution it promotes.

The following table presents a comparative overview of the major governance models used in NBS implementation, highlighting their characteristics, key strengths, and potential limitations.

Table 1. Comparative Models of Governance Mechanisms for NBS Implementation

Governance Model	Core Characteristics	Strengths	Limitations	Examples in Practice
Hierarchical (Top-Down)	Centralized decision-making; policy directives from government agencies; strong regulatory control.	Clear authority lines; effective for large-scale coordination.	Limited stakeholder engagement; inflexible to local needs.	National Green Infrastructure Strategies (e.g., UK, Germany).
Collaborative Governance	Shared decision-making among public, private, and community actors; consensus-oriented processes.	Encourages inclusiveness and innovation; builds social legitimacy.	Time-consuming negotiations; may lack enforcement power.	Urban NBS projects under the EU Horizon 2020 "Connecting Nature" initiative.
Network Governance	Decentralized coordination through partnerships, networks, and alliances; flexible and adaptive structures.	Enhances cross-sectoral collaboration and resource sharing.	Potential fragmentation; reliance on informal trust mechanisms.	City networks such as ICLEI and C40 Cities integrating NBS agendas.
Market-Based	Economic incentives, PPPs, and green	Mobilizes private investment;	May prioritize profit over ecological	Green Bonds for urban greening (e.g.,

Governance	financing mechanisms to encourage NBS adoption.	promotes efficiency in resource allocation.	outcomes; equity concerns.	Singapore, Copenhagen).
Community-Based Governance	Grassroots participation in planning and managing local NBS projects; empowerment of local communities.	Enhances local ownership and stewardship of green spaces.	Limited scalability; requires strong local capacity and support.	Community-led watershed restoration projects in Nairobi and Bogotá.

The table demonstrates that while hierarchical governance ensures top-down coordination and policy control, it often limits flexibility and stakeholder participation. In contrast, collaborative and networked governance models enhance inclusiveness, innovation, and adaptive capacity but may suffer from coordination challenges. Market-based governance offers financial efficiency and resource mobilization but raises concerns about equity and ecological priorities. Community-based governance fosters local ownership and long-term sustainability but relies heavily on local capacity and institutional support.

5.3 Collaborative and Participatory Approaches

Collaborative governance has emerged as one of the most effective mechanisms for mainstreaming NBS within cities. It emphasizes stakeholder inclusivity, where government agencies, researchers, private developers, and community groups co-create urban solutions. This model fosters mutual learning and ensures that NBS designs are socially equitable and contextually appropriate.

Wamsler and Pauleit (2021) argue that collaboration not only enhances project legitimacy but also strengthens institutional learning through shared responsibility. However, successful collaboration requires strong facilitation mechanisms, such as transparent information-sharing platforms, inclusive dialogue spaces, and equitable resource distribution.

5.4 Networked and Polycentric Governance

Networked governance, often framed within polycentric systems, involves multiple centers of authority interacting at various scales. This approach is particularly suited for complex environmental challenges such as climate adaptation and urban ecosystem management.

In NBS governance, networked models allow local municipalities, NGOs, research institutions, and international organizations to coordinate through knowledge-sharing networks. Examples include the EU Nature-Based Cities Platform, which promotes cross-border collaboration, and ICLEI's "Cities with Nature" initiative, which supports cities in integrating NBS into policy and planning frameworks.

Such models enhance flexibility and adaptability, enabling governance systems to respond dynamically to environmental uncertainties. However, they also demand robust coordination mechanisms to avoid duplication and ensure coherence among actors.

5.5 Market-Based and Financing Mechanisms

Governance of NBS increasingly incorporates market-based instruments to bridge funding gaps and enhance long-term sustainability. Tools such as green bonds, payment for ecosystem services (PES), and public-private partnerships (PPPs) provide financial incentives for NBS investments.

For instance, the Singapore Green Plan (2021) employs PPPs to finance vertical gardens and stormwater management infrastructure, while cities like Copenhagen and Rotterdam utilize green infrastructure bonds to fund climate adaptation projects. These mechanisms not only mobilize private capital but also embed environmental responsibility within market systems.

Nevertheless, market-based governance faces challenges related to profit orientation and equity distribution. Policies must therefore ensure that financial mechanisms support ecological outcomes rather than purely economic returns.

5.6 Community-Based and Co-Production Governance

Community-based governance places citizens at the center of NBS design, implementation, and maintenance. It promotes local empowerment, stewardship, and social innovation. Co-production a related concept emphasizes collaboration between formal institutions and local communities in co-designing urban green infrastructure.

Examples include community-led watershed restoration in Nairobi, urban agriculture projects in Medellín, and green corridor initiatives in Lagos. These projects illustrate how community ownership fosters resilience and ensures long-term maintenance of NBS. However, their success depends on sustained institutional support, funding continuity, and technical capacity building.

5.7 Challenges and Opportunities in NBS Governance

Despite progress, several governance challenges persist. These include:

- Institutional fragmentation across government tiers and sectors.
- Limited stakeholder coordination and inconsistent communication channels.
- Short-term political cycles that hinder long-term NBS planning.
- Lack of financial accountability and monitoring systems for NBS outcomes.

Conversely, emerging opportunities such as digital governance tools, open-data platforms, and multi-stakeholder partnerships are enhancing transparency and adaptive management capacities. Integrating these innovations into governance frameworks could substantially improve NBS scalability and impact.

6. Institutional Frameworks and Capacity Building

6.1 The Role of Institutions in NBS Integration

Institutions form the structural backbone of Nature-Based Solutions (NBS) implementation in urban planning. They provide the legal, administrative, and operational platforms that enable coordinated decision-making and policy continuity. According to Kabisch et al. (2022) and Collier et al. (2023), institutional frameworks are essential not only for policy enforcement but also for mobilizing financial and human resources necessary for long-term ecological governance.

Effective institutions bridge the gap between policy intention and practical execution by translating strategic objectives into actionable urban programs. They ensure coherence among multiple sectors such as water management, urban forestry, land use, and climate adaptation thereby enabling integrated NBS delivery within cities.

6.2 Institutional Structures Supporting NBS Implementation

Institutional structures for NBS implementation vary widely depending on governance systems and administrative hierarchies. In most cases, NBS-related responsibilities are distributed across three interconnected levels:

1. National institutions that establish regulatory standards and funding mechanisms.
2. Regional or municipal agencies responsible for spatial planning and operational execution.
3. Local institutions and community groups that manage and maintain NBS projects on the ground.

The effectiveness of these institutional layers depends largely on the clarity of roles, coordination mechanisms, and accountability frameworks that guide their interactions. Weak inter-agency coordination or overlapping mandates often lead to fragmented urban greening efforts and inefficient resource utilization.

Hölscher et al. (2023) note that a lack of institutional coherence remains one of the major barriers to scaling up NBS. Strengthening vertical integration (across governance levels) and horizontal integration (across sectors) is therefore essential for institutional effectiveness.

6.3 Policy–Institutional Linkages and Strategic Alignment

Institutional frameworks are most effective when directly aligned with national and regional sustainability strategies. Alignment ensures that NBS initiatives are not treated as isolated environmental projects but as cross-cutting strategies embedded within urban policy agendas.

For instance, the European Union's *Green Deal* and *Biodiversity Strategy for 2030* encourage institutional linkages between environmental, infrastructure, and social policy domains. Similarly, cities like Rotterdam and Barcelona have established Urban Resilience Offices that act as institutional hubs coordinating NBS-related policies across departments.

Such strategic alignment enhances not only administrative efficiency but also the political legitimacy and continuity of NBS interventions, even amid leadership changes or fiscal constraints.

6.4 Institutional Capacity Building

Institutional capacity building involves strengthening the technical, managerial, and financial competencies of organizations engaged in NBS planning and management. This process ensures that institutions are equipped to design, implement, and monitor complex interdisciplinary projects.

Capacity building operates at multiple levels:

- **Human Capacity:** Developing expertise in ecological design, climate modeling, and participatory urban planning.
- **Organizational Capacity:** Establishing clear procedures, data systems, and coordination units dedicated to NBS governance.
- **Systemic Capacity:** Creating enabling environments that foster innovation, collaboration, and resource sharing across institutions

The table below outlines key institutional capacity-building strategies relevant to urban NBS implementation, along with their objectives and observed impacts.

Table 2. Institutional Capacity-Building Strategies for NBS Implementation

Capacity-Building strategy	Objectives	Implementation Approach	Expected Impact	Example
Training and Knowledge Development	Enhance technical and managerial expertise in NBS design and maintenance	Conduct workshops, exchange programs, and certifications for planners and engineers.	Improved technical competence and project quality.	Nature-Smart Cities" program, EU Horizon 2020.
Institutional Coordination Mechanisms	Strengthen inter-agency collaboration and reduce policy overlap.	Establish interdepartmental task forces and steering committees.	Improved coherence and resource efficiency.	Rotterdam Climate Adaptation Office
Digital Infrastructure	Facilitate monitoring and decision-making	Develop NBS monitoring	Enhanced transparency and	Barcelona Green Infrastructure

Capacity-Building strategy	Objectives	Implementation Approach	Expected Impact	Example
Training and Knowledge Development	Enhance technical and managerial expertise in NBS design and maintenance	Conduct workshops, exchange programs, and certifications for planners and engineers.	Improved technical competence and project quality.	Nature-Smart Cities” program, EU Horizon 2020.
and Data Systems	using spatial and ecological data.	dashboards, GIS systems, and open-data platforms	adaptive management.	Monitoring Portal.
Financial and Resource Mobilization	Ensure sustainable financing and resource allocation for NBS.	Introduce green budgeting, PPPs, and climate adaptation funds.	Long-term project sustainability.	Singapore Green Plan Financing Model.
Community Engagement and Co-production	Build local ownership and capacity for NBS maintenance.	Implement participatory planning and community-led design.	Increased public support and long-term stewardship.	Medellín Green Corridors Initiative.

This table presents a structured overview of key strategies designed to strengthen institutional capacity for effective Nature-Based Solutions (NBS) implementation in urban environments. It identifies five core strategies: Training and Knowledge Development, Institutional Coordination Mechanisms, Digital Infrastructure and Data Systems, Financial and Resource Mobilization, and Community Engagement and Co-production each linked to its specific objective, implementation approach, and anticipated impact.

6.5 Capacity-Building Challenges

Despite growing institutional interest in NBS, several challenges hinder effective capacity building. These include limited technical expertise, inadequate funding for training, and insufficient institutional incentives for innovation. In many developing cities, bureaucratic rigidity and lack of cross-sectoral coordination constrain adaptive governance and experimentation with new ecological planning models.

Additionally, data fragmentation and lack of open-access urban environmental information systems reduce the ability of institutions to monitor NBS performance effectively. Overcoming these challenges requires sustained investment in education, digital transformation, and knowledge co-production between governments, academia, and local communities.

6.6 Emerging Institutional Innovations

Recent trends indicate a gradual institutional shift toward more integrated and adaptive models of urban environmental management. Cities are increasingly establishing dedicated NBS coordination offices, embedding environmental planning units within local authorities, and adopting multi-level partnership frameworks with academic and private stakeholders.

For instance, Lisbon’s *Urban Greening Strategy* institutionalized a “City Laboratory Model,” integrating universities, businesses, and citizen groups into policy implementation. Such innovations demonstrate how institutional flexibility and inclusiveness can accelerate the mainstreaming of NBS in complex urban settings

7. Discussion

7.1 Interconnectedness of Policy, Governance, and Institutional Dimensions

The integration of Nature-Based Solutions (NBS) in urban planning relies on the synergistic interaction between policy coherence, governance innovation, and institutional capacity. The earlier sections reveal that these three dimensions are mutually reinforcing, forming a systemic framework that determines how effectively cities can plan, finance, and maintain NBS interventions.

Policy frameworks provide the strategic direction, governance mechanisms operationalize these policies through stakeholder collaboration, and institutions supply the administrative backbone for implementation and monitoring. A disconnect among these pillars such as strong policy but weak governance or inadequate institutional capacity often results in fragmented outcomes and poor sustainability of NBS projects.

This finding aligns with Frantzeskaki et al. (2019) and Wamsler et al. (2020), who argue that the transformative potential of NBS depends less on their technical design and more on the institutional and governance ecosystems that support their delivery.

7.2 Policy Alignment and Cross-Sectoral Integration

The analysis demonstrates that effective NBS implementation requires cross-sectoral policy integration, where climate, biodiversity, and spatial planning agendas are harmonized. Cities with well-aligned environmental and urban policies such as Rotterdam, Copenhagen, and Barcelona have shown higher levels of NBS uptake because their planning frameworks allow for flexible land use, integrated financing, and innovation in green infrastructure design.

However, in many developing regions, policies remain sectorally fragmented, with overlapping mandates among urban, environmental, and infrastructure agencies. This fragmentation often leads to duplication of efforts and inefficient resource use. As suggested by Kabisch et al. (2022), addressing these challenges demands a “whole-of-government” approach, where urban planning policies incorporate NBS objectives as integral components rather than as optional add-ons.

7.3 Governance as an Enabler of Adaptive Implementation

Governance emerged as the most dynamic dimension influencing the success of NBS integration. Collaborative, networked, and polycentric governance models enable adaptive management, where learning, flexibility, and innovation guide NBS implementation.

The comparative analysis revealed that collaborative governance is particularly effective because it bridges institutional silos and ensures that local knowledge informs decision-making. Through multi-stakeholder platforms, cities can integrate scientific evidence, community needs, and private sector resources in designing context-specific NBS solutions.

Yet, collaborative governance is not without challenges; it demands time, trust, and strong facilitation capacities. Without well-defined accountability and coordination mechanisms, it may lead to decision paralysis. To address this, successful NBS governance systems, as seen in EU-funded projects like *Connecting Nature* and *URBAN GreenUP*, blend collaboration with regulatory oversight, ensuring both participation and accountability.

7.4 Institutional Capacity as the Cornerstone of Sustainability

Institutional frameworks determine whether NBS initiatives can move from pilot projects to long-term, scalable programs. Institutional capacity building enhances not just the technical competence of planners and engineers but also the adaptive capability of organizations to manage complex, evolving environmental challenges.

A major finding is that institutional maturity measured through coordination efficiency, knowledge management, and funding mechanisms correlates strongly with NBS success. Cities that invest in institutional strengthening, digital data systems, and inter-agency collaboration demonstrate higher resilience in maintaining NBS projects beyond initial funding cycles.

However, institutional gaps remain, especially in low-income and developing cities where limited funding, inadequate training, and bureaucratic rigidity constrain NBS integration. Strengthening partnerships between governments, universities, and international agencies can help address these gaps by promoting shared learning and resource pooling.

7.5 Financial and Policy Instruments as Catalysts

The role of financing and policy instruments has gained increasing attention in recent years. Green bonds, ecosystem service payments, and climate adaptation funds are emerging as practical mechanisms for NBS financing. These instruments bridge the traditional divide between environmental goals and economic systems by monetizing ecological benefits.

For instance, the use of green bonds in Singapore and Copenhagen demonstrates how financial innovation can accelerate urban greening and resilience-building. However, without robust institutional oversight, such market mechanisms risk reinforcing inequalities or prioritizing profit-driven outcomes over ecological integrity. Hence, financial instruments should be embedded within policy safeguards and governance accountability structures to ensure sustainability.

7.6 The Human and Community Dimension

Another key insight is that community participation significantly enhances the long-term success of NBS projects. Community-based governance and co-production create local ownership, ensuring that projects remain functional and maintained after implementation.

Examples from Medellín, Nairobi, and Bogotá demonstrate that when local communities are involved in planning and maintenance, NBS initiatives are more resilient, cost-effective, and socially accepted. However, meaningful participation requires capacity support and transparent communication to prevent exclusion or tokenism. Therefore, institutions should integrate community engagement frameworks into official planning and monitoring systems.

7.7 Challenges and Lessons Learned

Across global contexts, several recurring challenges hinder the systemic integration of NBS:

- Fragmented policy landscapes and inconsistent regulatory frameworks.
- Insufficient institutional capacity and limited financial flexibility.
- Gaps in inter-agency coordination and data-sharing mechanisms.
- Short-term political agendas that undermine long-term ecological investments.

Nevertheless, key lessons have emerged:

1. Integration across scales local, regional, and national enhances policy coherence.
2. Collaborative governance fosters innovation and stakeholder legitimacy.
Capacity building and institutional learning sustain long-term impact.
3. Financial diversification secures continuity and scalability of NBS projects.

These lessons align with findings by Mahmoud and Morello (2021) and Hölscher et al. (2023), confirming that NBS success depends as much on social and institutional innovation as on ecological design.

7.8 Synthesis: Toward an Integrated Framework

The findings suggest that the most effective approach to mainstreaming NBS in urban planning lies in developing integrated frameworks that connect policies, governance systems, and institutional arrangements. The conceptual model presented earlier (Figure 1) captures these interactions, emphasizing that integration should occur across both vertical (governmental) and horizontal (sectoral) dimensions.

In practice, this means embedding NBS objectives into national climate policies, municipal urban plans, and community-level actions simultaneously. Integration is not merely structural but also cultural and operational, requiring a shift in institutional mindset toward adaptive, cross-sectoral, and participatory governance.

Such an integrated approach transforms NBS from isolated environmental interventions into mainstream components of sustainable urban development, contributing directly to climate resilience, biodiversity enhancement, and social well-being.

8. Conclusion and Recommendations

8.1 Conclusion

The integration of Nature-Based Solutions (NBS) in urban planning represents a transformative paradigm that aligns environmental sustainability with social equity and economic resilience. This research demonstrates that the success of NBS is not solely dependent on ecological design or technical feasibility, but rather on the strength and coherence of policy, governance, and institutional frameworks supporting their implementation.

A key finding is that policy coherence serves as the foundation upon which successful NBS integration is built. Cities that harmonize climate adaptation, biodiversity protection, and urban development policies are better positioned to implement scalable and sustainable NBS initiatives. However, fragmented policies, regulatory overlaps, and the absence of unified strategic direction continue to hinder systemic adoption, especially in developing regions.

The study also underscores that governance mechanisms play an enabling role in translating policies into actionable outcomes. Collaborative and networked governance structures encourage knowledge exchange, innovation, and adaptive management—key ingredients for addressing complex urban challenges. Yet, governance effectiveness depends heavily on inclusivity, accountability, and long-term institutional commitment.

Finally, the analysis of institutional frameworks reveals that capacity building, data-driven systems, and inter-agency coordination are crucial determinants of NBS sustainability. Institutions that are flexible, knowledge-oriented, and participatory tend to manage environmental projects more effectively and are better equipped to secure funding and community trust.

Overall, the research affirms that NBS integration must evolve from isolated project-based interventions to systemic, policy-anchored strategies embedded within national and municipal development agendas. When institutions, governance models, and policies are aligned, NBS become powerful instruments for advancing climate resilience, enhancing urban livability, and restoring ecological integrity.

8.2 Recommendations

To operationalize the findings and enhance NBS mainstreaming, the following recommendations are proposed for policymakers, urban planners, and institutional actors:

1. Strengthen Policy Coherence and Integration

Governments should adopt a multi-sectoral policy alignment framework that harmonizes climate adaptation, biodiversity, and land-use planning. This involves embedding NBS targets within urban development laws and national environmental strategies, ensuring consistent implementation across agencies.

2. Institutionalize Collaborative Governance Platforms

Cities should establish multi-stakeholder governance platforms that include local authorities, communities, academia, and private sector actors. Such structures encourage shared ownership, resource pooling, and innovation in NBS design and maintenance, while reducing policy fragmentation.

3. Invest in Institutional Capacity and Knowledge Infrastructure

Institutional performance can be enhanced through targeted capacity-building programs, digital monitoring systems, and inter-departmental coordination units. Investments in training, geospatial data platforms, and environmental performance tracking will strengthen accountability and transparency in NBS implementation.

4. Mobilize Sustainable Financing Mechanisms

Urban NBS projects require diverse and long-term funding sources. Policymakers should promote green bonds, ecosystem service payments, and public-private partnerships (PPPs) as financing tools, while maintaining environmental integrity through strong regulatory oversight.

5. Embed Community Participation and Co-Production

Community engagement should move beyond consultation toward active co-production. Empowering communities through education, participatory mapping, and local stewardship programs ensures that NBS projects remain contextually relevant and sustainable beyond government funding cycles.

6. Develop Clear Monitoring and Evaluation Frameworks

To assess NBS effectiveness, cities should implement standardized monitoring systems linking environmental outcomes (e.g., flood reduction, biodiversity gains) with social and economic indicators. These frameworks enhance evidence-based policy adjustments and continuous improvement.

7. Foster Regional and International Collaboration

Cross-city partnerships and international collaborations particularly within networks such as ICLEI, C40, and the EU's Green City Initiative should be leveraged to share best practices, technical expertise, and funding opportunities for NBS innovation and scalability.

8.3 Policy Implications

The findings have broad implications for urban policy and planning. They highlight the need for institutional reform that shifts from fragmented, project-oriented management to integrated urban ecosystem governance. Policymakers must recognize NBS as infrastructure assets that deliver measurable ecological and social benefits, deserving equal priority to traditional gray infrastructure.

Incorporating NBS principles into city master plans, zoning codes, and environmental assessment frameworks can mainstream their application. Additionally, incentivizing private sector participation through tax benefits or regulatory relief could expand investment in urban greening and climate adaptation initiatives.

8.4 Future Research Directions

Future research should explore:

- Quantitative evaluation of NBS performance indicators (e.g., cost-benefit, carbon sequestration, and social equity metrics).
Comparative case studies between developed and developing cities to examine contextual enablers and barriers.
- The role of AI and digital twin technologies in optimizing NBS design, monitoring, and decision support systems.

Such research will deepen understanding of how policy, governance, and institutional dynamics evolve over time and how digital innovation can accelerate the global transition toward nature-positive urban systems.

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