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Systematic Review

Nature-Based Solutions in Urban Green Infrastructure: A Systematic Review of Success Factors and Implementation Challenges

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Abstract: Nature-Based Solutions (NBSs) have gained prominence in urban planning as integrative strategies that utilize natural processes to address complex environmental and societal challenges while advancing green infrastructure development. Despite growing academic interest, the practical integration of NBSs into urban green infrastructure remains hindered by fragmented methodologies and limited understanding of context-specific implementation dynamics. This study contributes to addressing these gaps through a systematic review and bibliometric analysis of 90 peer-reviewed articles published between 2014 and 2024. It examines the range of NBSs employed in urban green infrastructure, the factors shaping their successful implementation, and the barriers, financial, technical, social, and political, that constrain their adoption. The analysis also explores the roles of key stakeholders, including local governments, private actors, and communities, in the planning, execution, and maintenance of NBS projects. The findings reveal both conceptual convergence and contextual variation in how NBSs are deployed and evaluated, highlighting critical enablers, such as spatial justice, governance integration, financial viability, and technical capacity. By clarifying the conditions under which NBSs function effectively, this review offers insights for researchers and policymakers seeking to embed these approaches within sustainable urban development frameworks.

Keywords: nature-based solutions; urban green infrastructure; environmental sustainability; implementation challenges; systematic review

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1. Introduction

Urbanization and extensive land consumption have significantly transformed cityscapes, disrupting the balance between built environments and natural ecosystems, and increasing the vulnerability of ecological and life-support systems [1–4]. These systems provide essential services to urban areas, attracting the attention of planners and policymakers seeking to address the growing pressures of urban growth [5]. In response, scholars have revisited conventional definitions of infrastructure, highlighting the structural and functional limitations of post-industrial systems and advocating for frameworks more attuned to contemporary urban complexities [6–8]. Among the most influential concepts to emerge from this rethinking is green infrastructure, introduced by Benedict and McMahon [9]. This concept underscores the critical distinction between natural and gray infrastructure (e.g., roads, water, and electricity systems), highlighting their unique characteristics and the differences in their respective planning and development approaches. Green infrastructure

refers to the spatial abundance and distribution of natural elements within the landscape, such as forests, wetlands, and other ecological features [10]. Just as gray infrastructure is essential for modern societies; green infrastructure also provides ecosystem services that are equally vital for the health of living organisms. The loss of these natural systems incurs significant societal and environmental costs [3,11,12].

Although cities continue to expand their gray infrastructure—through highways, water systems, and other urban services—they are simultaneously confronted by mounting environmental challenges, including air and water pollution, stormwater runoff, biodiversity loss, rapid population growth, and the urban heat island effect [13,14]. These pressures underscore one of the central challenges of twenty-first-century urban governance: addressing environmental degradation, inefficient resource use, and fragmented green infrastructure networks [15]. Within this context, green infrastructure emerges as a strategic means of integrating natural and built environments, redefining urban development trajectories [16]. At the urban level, green infrastructure serves as a network of strategic interventions, offering a wide range of ecosystem services to urban residents and holding significant environmental importance [17,18].

Nature-Based Solutions (NBSs) provide a framework for planning urban green infrastructure effectively. NBSs refer to interventions inspired and supported by nature that address societal challenges while simultaneously delivering environmental, social, and economic benefits [19,20]. When integrated into urban green infrastructure, they help manage material and energy flux dynamics, enhance biodiversity, and improve ecosystem services within urban spatial patterns [21]. By promoting multifunctional landscapes, NBSs contribute to climate resilience, flood mitigation, and the reduction in the urban heat island effect [22]. They also support ecological connectivity, enabling the movement of species across fragmented urban environments. Additionally, NBSs enhance social well-being by creating accessible green spaces, improving air and water quality, and fostering community engagement in environmental stewardship [23]. These combined benefits make NBSs crucial tools for achieving sustainable and resilient urban development.

Existing research highlights significant conceptual and semantic variations in how theoretical and spatial models define and interpret NBSs in urban green infrastructure projects [24,25]. Despite significant progress in the study of NBS, critical research gaps persist, hindering a comprehensive understanding and broader application of these strategies. One major gap is the absence of a comprehensive and standardized research framework. A unified framework that integrates key dimensions, such as geographic focus, research topics, methodologies, and driving forces, has yet to be developed. Without such a framework, systematic comparison and synthesis of findings across studies remain challenging, underscoring the need for a standardized approach to advance the field cohesively.

Another critical gap lies in the underexplored economic, social, and technical dimensions of NBS. Existing literature primarily focuses on governance and environmental aspects [26], while the economic, social, and technical factors remain relatively neglected despite their importance in understanding the broader impacts of NBS implementation. Holistic analyses encompassing these multifaceted dimensions are crucial for informing effective solutions and best practices. Although the environmental benefits and implementation barriers of NBSs are well-documented [16,27], there is a notable lack of rigorous, quantitative evaluations of their contributions to these global challenges. Addressing this deficiency requires robust empirical studies that quantify the effectiveness of NBSs in mitigating climate change and enhancing urban resilience. Furthermore, an overreliance on case studies (e.g., [26,28–30]) has constrained theoretical advancements in NBS research. While localized comparative analyses have provided valuable insights into practical implementation, this approach has limited the development of spatially explicit models for NBS

design and scaling. Expanding research to incorporate broader theoretical frameworks and modeling approaches is essential to enhance the generalizability of findings and advance the field beyond context-specific case studies.

This study contributes to addressing these critical research gaps by systematically reviewing how NBSs have been used to develop urban green infrastructure over the past decade. Along with a systematic investigation of prevailing research trends, thematic developments, and prospective trajectories for future exploration, this paper explores three interrelated questions: (1) What are the main NBSs employed in urban green infrastructure projects? (2) What factors shape their successful implementation across diverse urban contexts? And (3) what barriers, e.g., financial, technical, social, or political, limit their uptake and effectiveness? To answer these questions, this study applies a dual-method approach combining bibliometric mapping with in-depth qualitative content analysis. This enables both a high-level view of intellectual and geographic trends in the field and a grounded examination of the thematic priorities, stakeholder roles, and implementation dynamics reported in empirical studies. In doing so, this paper identifies not only recurring patterns in how NBSs are conceptualized and applied but also critical contextual factors—such as governance arrangements, spatial justice considerations, and knowledge capacity—that influence their performance. The findings contribute to ongoing debates on how NBSs can be more systematically integrated into urban planning and climate resilience strategies, offering insights for researchers, practitioners, and policymakers seeking to operationalize these solutions in varied urban environments.

2. Methodology

This study employs a hybrid methodological approach to achieve a comprehensive understanding of the key themes explored in NBSs within urban green infrastructure projects. By combining a bibliometric analysis using VOSviewer 1.6.20 [31] and a content analysis utilizing JetBrains WebStorm 2023.3 [32], this integrated approach leverages the strengths of both methods to interpret explicit and latent content within the literature. The bibliometric analysis plays a crucial role in evaluating scholarly outputs across diverse domains, including articles, authors, keywords, journals, institutions, and contributing countries [33]. It enables the systematic examination of a research domain's intellectual, social, and conceptual structures over time, analyzing relationships and interactions among these components [34]. Consequently, the content analysis techniques provide a systematic and structured approach for summarizing, evaluating, documenting, synthesizing, and interpreting scientific findings [35]. It adheres to structured and goal-oriented procedures, guided by predefined and established criteria for data selection, summarization, analysis, and conclusion drawing. Content analysis facilitates the identification of gaps between research and practice while offering a documented synthesis of existing knowledge [36].

The data search for this study began with the selection of the Scopus database, a comprehensive repository of scientific literature managed by Elsevier [37]. The primary methodological steps for analyzing research on NBSs in urban green infrastructure projects were systematically organized into four stages: (1) data collection; (2) document evaluation; (3) data extraction, organization, and coding; and (4) data reporting [33]. The structured sequence of these stages aims to minimize bias, enhance validity, and ensure study reproducibility. In the first stage (data collection), a systematic search was conducted within the Scopus database to retrieve peer-reviewed articles published in the last 10 years, i.e., between 2014 and 2024. To search articles focused on NBSs in urban green infrastructure, the following search query was applied: TITLE-ABS-KEY-AUTH ((“Nature-Based Solutions”) AND (“Green Infrastructure”) AND (City) OR (Cities)) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (LIMIT-

TO (DOCTYPE, "ar")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (LANGUAGE, "English")). The search was conducted on 31 December 2024.

Following data collection, the second stage (document evaluation) was carried out in five steps (Figure 1). The initial dataset comprised 324 articles extracted from the Scopus database. After removing duplicate entries, the dataset was refined to 318 articles. Titles were then reviewed for relevance and clarity, reducing the dataset to 294 articles. Further evaluation of abstracts narrowed the dataset to 131 articles. To ensure the completeness and comprehensiveness of the dataset, manual searches were performed by examining the reference lists of selected studies. Ultimately, 90 studies were deemed relevant to the research objectives and included in subsequent analyses.

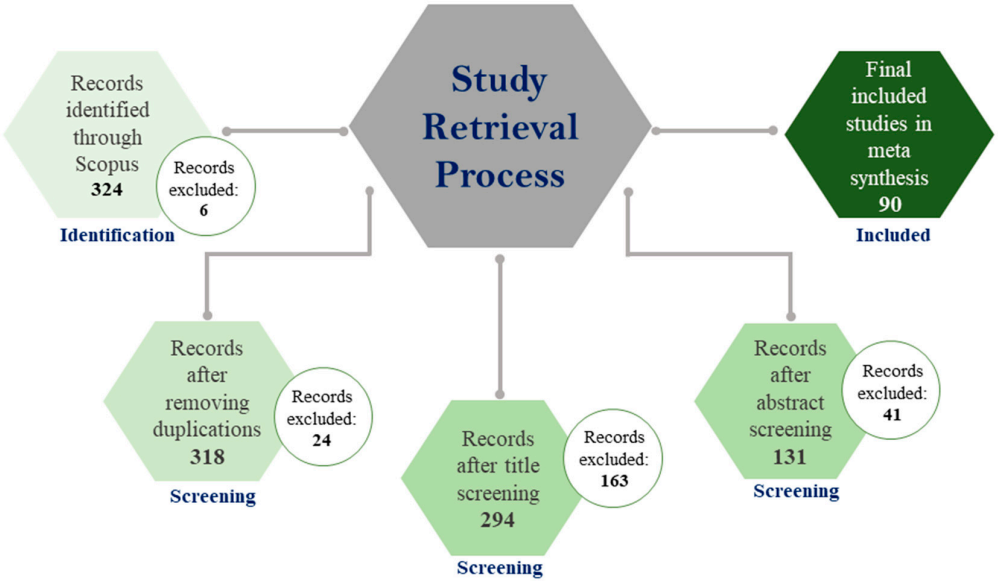

Figure 1. The five-step search and screening process used in the systematic review.

In the third stage (data extraction, organization, and coding), following the identification of relevant research studies, open-coding techniques were applied to textual data (abstracts, discussions, and conclusions) using semantic units (phrases, sentences, or paragraphs) [38]. The coding process continued iteratively until thematic saturation was achieved. Key themes were identified, and their semantic similarities and differences were analyzed [39]. Axial coding was subsequently used to examine overlaps and relationships among the emerging themes and concepts, leading to the development of categories and their associated sub-themes. In the fourth stage (reporting findings), the extracted findings were synthesized into a cohesive analytical framework comprising concepts, indicators, and thematic components for investigating NBSs in urban green infrastructure projects. This structured and multi-stage methodological approach aims to reduce bias, enhance validity, and ensure the reproducibility of the study's findings.

3. Results and Discussions

3.1. Geographical Distribution of Research on NBSs in Urban Green Infrastructure

To understand which countries and regions contribute to research on NBSs in green infrastructure, we conducted a citation analysis at the country level. As shown in Table 1, the United Kingdom and other European countries are the primary contributors to this field, with 49 academic studies on NBSs in urban green infrastructure. The EU plays a leading role in global environmental policy by supporting NBSs through initiatives such as Horizon Europe and the European Green Deal.

Table 1. Ten leading countries in NBS research for urban green infrastructure based on citation metrics.

	Country	No. of Publications	No. of Citations	Average No. of Citation per Paper	Total Link Strength
1	United Kingdom	12	1013	84.4	68
2	The Netherlands	12	994	82.8	64
3	Germany	11	957	87	57
4	Italy	13	916	70.4	73
5	Sweden	8	855	106.8	53
6	Romania	3	726	242	40
7	Belgium	3	508	169.3	24
8	United States	15	450	30	16
9	Denmark	6	269	44.8	19
10	Australia	11	230	20.9	42

East and Southeast Asia follow, with 22 studies examining the ecological and socioeconomic impacts of projects like Singapore's Gardens by the Bay, Beijing's Green Belt, and Malaysia's River of Life. In North America, 12 studies focus on urban resilience initiatives, including New York's High Line and Toronto's wetland system. South America is underrepresented, with only two studies on São Paulo and San José, while Africa has five, including Accra's Green Accra Initiative. Oceania has four studies, highlighting Melbourne's Urban Forest Strategy and New Zealand's native forest restoration, which integrate technology and indigenous knowledge.

Globally, 11 comparative studies explore the adaptability and scalability of NBSs across different contexts. While NBS research and implementation are concentrated in Europe and East Asia, Africa and South America remain underrepresented. Addressing these disparities through collaboration, capacity-building, and knowledge transfer is essential to maximizing the global impact of NBSs on sustainable urban development and climate resilience (see Figure 2, created using ESRI ArcGIS Pro 3.4.2).

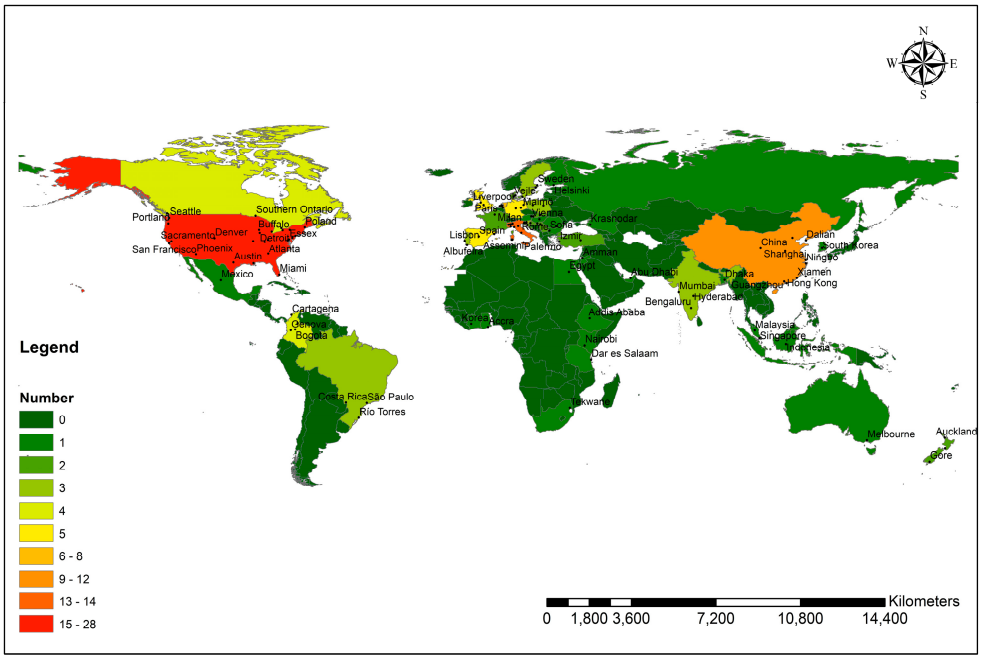

Figure 2. Geographical distribution of research on NBSs in urban green infrastructure.

3.2. How Do Various Analytical Approaches and Methodologies Contribute to the Assessment of NBSs in Urban Green Infrastructure?

An assessment of the selected articles revealed that 53% (48 studies) predominantly employed qualitative methodologies. These studies were primarily concerned with the theoretical elaboration and development of indicators pertinent to NBSs in urban green

infrastructure. In contrast, 31% (28 studies) adopted mixed-methods approaches, while only 16% (14 studies) utilized quantitative methods. The notable underrepresentation of quantitative approaches highlights a research gap, particularly in light of their potential to generate measurable and scalable insights that could advance NBS objectives.

The application of analytical methods varied across the studies, depending on the nature of the data and the research design, whether qualitative, quantitative, or mixed methods. A categorization of the analytical techniques employed in the reviewed studies was undertaken to inform future research efforts. Content analysis emerged as the predominant method among qualitative studies, supplemented by methods such as observational and situational analysis, although these were employed less frequently. Quantitative studies, by contrast, primarily relied on descriptive statistical models, reflecting the survey-driven nature of many of these research designs. However, this often limited the analytical capacity of these studies, underscoring the need for more sophisticated statistical frameworks and methodologies to effectively address the multifaceted nature of NBS challenges. Table 2 summarizes the primary methodologies and analysis methods utilized in the reviewed papers.

Table 2. Pioneering methods and their uses in NBS research.

Methodology	Analysis Method		References
Quantitative	Multi-Criteria Decision Analysis	Spatial Multi-Criteria Analysis	[40,41]
	Hydrological Modeling	I-Tree Hydro Plus Model	[42]
		HEC-HMS Model	[43]
		HEC-RAS Model	[43]
	Descriptive Statistics	Tables and Charts	[23,44,45]
		Analysis of Variance	[45,46]
		Analysis of Covariance	[46]
		Mann–Whitney U Test	[46]
		Pearson Correlation Coefficient	[47]
		Multiple Linear Regressions	[48]
	Forecast Model	Adoption and Diffusion Outcome Prediction Tool	[49]
		Ordinary Least Squares Regression	[47]
	Documentary Method	Heat Flow Meter (HFM) Method	[50]
	Economic Analysis Methods	Cost-Effectiveness Analysis	[51]
	Assessment Method	Adoption and Diffusion Outcome Prediction Tool	[49]
		SCS-CN Method	[47,52]
		Pollution Flux Method	[47]
Qualitative	Situational Analysis	Case Study Method	[53–56]
		Geographic Comparative Analysis	[57–61]
	Critical Analysis	Literature Review	[16,26–30,55,62–65]
		Critically Analyzing	[66]
	Conversation Analysis	Semi-Structured Interviews	[3,67–73]
		Depth Interviews	[74]
		Structured Face to Face Interviews	[19,75]
		Interviews	[25,29,55,63]
		Survey	[25,63]
	Content Analysis	Transcribed and Coded	[24,29,70,75–85]
	Observational Analysis	Mapping Analysis	[86–90]
Mixed Method	Mixed Technique	Mixed Quantitative and Qualitative Methods	[1,2,10,18,21,91–113]

3.3. What Are the Key NBSs That Have Been Used to Develop Urban Green Infrastructure?

Concerning the key NBSs that have been used to develop urban green infrastructure, we identified five key themes and thirty sub-themes. The key themes include the creation and expansion of urban green ecosystems, storm water management, the protection, sustainable management, and restoration of natural ecosystems; planning and designing cities in harmony with nature; and the development of urban agriculture. In Figure 3, these themes are systematically structured, with recurring codes consistently identified across the analyzed literature.

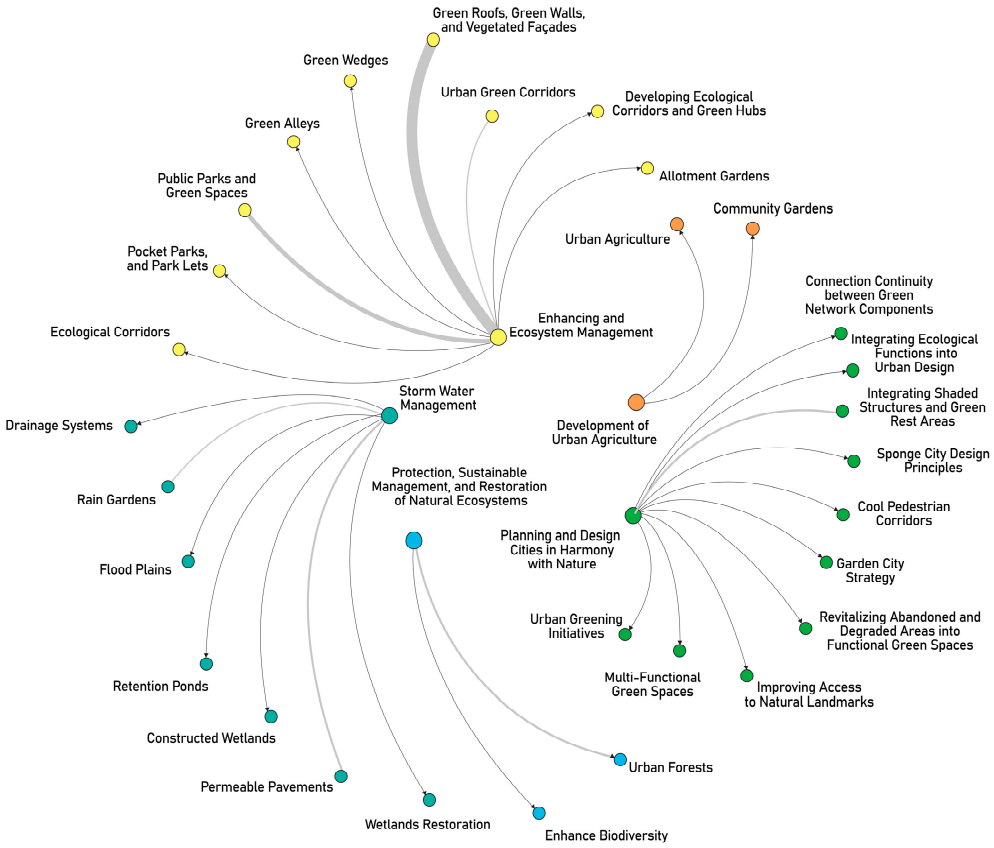

Figure 3. Main themes of NBSs in developing urban green infrastructure.

The first main theme, i.e., the creation and expansion of urban green ecosystems, emerged in its initial form through the development of public parks and green spaces in the 18th and 19th centuries [3,18,45,47,52,53,63,77,86,90,92]. The expanding urban population drove the demand for escapes from the pollution and unhealthy conditions of industrial cities. Public parks came to be viewed as essential 'lungs' of the metropolis, while the growing awareness of the need for accessible urban greenery contributed to the emergence of ecological corridors and green hubs [79]. Frederick Law Olmsted, in collaboration with Calvert Vaux, designed and executed Central Park in New York, the first modern park in the United States. Such initiatives evolved into the design of urban green corridors [50,66,75,77,92,93,100], ecological corridors [2,103], green alleys [96], green wedges [54], allotment gardens [114], pocket parks, and park lets [57]. Additionally, green roofs, green walls, and vegetated façades [18,21,27,29,30,43,44,48–50,52,56,57,63,77,91,96,98,100,101,106,113] have emerged as modern solutions to urban challenges, offering various benefits, such as reducing heating and cooling loads, improving air quality, managing wastewater, mitigating noise pollution, and reducing energy consumption.

The second main theme, i.e., storm water management, represents an integrated approach aimed at justifying the environmental impact of urbanization on watersheds. This approach involves utilizing natural systems to facilitate infiltration, evaporation, or storm water reuse at its source. These strategies focus on controlling and reducing runoff at its origin, restoring natural hydrological flows to their pre-disturbance state. Techniques such as rain gardens [18,42,48,50,51,77,96,97], floodplains [100], retention ponds [100], permeable pavements [18,48,51,52,57,62,77,78,80,104], wetland restoration [30], and constructed wetlands [21,30,41,76] are crucial in mitigating urban storm water runoff's quantitative and qualitative adverse effects. Furthermore, these techniques enhance the performance of

conventional urban drainage systems [50,63] and, in some cases, can even replace them, enabling more sustainable and environmentally friendly hydrological management.

The third main theme concerns the protection, sustainable management, and restoration of natural ecosystems. According to the International Union for Conservation of Nature (IUCN), NBSs safeguard, sustainably manage, and reestablish natural or modified ecosystems to address societal challenges [115] effectively and adaptively. These solutions significantly benefit human well-being and enhance biodiversity [10,84], mainly by developing urban forests [63,85,94,97,98,100] that contribute to ecosystem restoration and environmental resilience.

The fourth main theme relates to the planning and design of cities in harmony with nature. NBSs in urban green infrastructure provide innovative solutions by integrating shaded structures and green rest areas [43,57,66,95], contributing to cool pedestrian corridors [97] that mitigate urban heat island effects and support broader urban greening initiatives [60]. The scope of such green infrastructure extends across entire cities, and when combined with multifunctional green spaces [68,81], it delivers several benefits by integrating ecological functions into urban design [61]. One of the primary advantages of green infrastructure is the construction of a unified urban landscape, which strengthens the connection continuity between green network components [45,110], ensures physical and spatial integration, and aligns with other urban landscape layers. This integration is achieved through revitalizing abandoned and degraded areas into functional green spaces [48], improving access to natural landmarks [48], implementing garden city strategies [54], and adopting sponge city design principles [1].

The fifth main theme involves the development of urban agriculture, which has emerged as a novel urban green space development model. This approach integrates ecosystem-based food production with cultural, recreational, and economic functions. From an ecological and financial standpoint, urban agriculture [18,63,75] promotes environmentally compatible food production, shortens food supply chains, and enhances food security within cities. Moreover, agricultural parks, community and allotment gardens [24,25,63,77,95], and agroforestry systems represent key components of urban agriculture, where agrarian production coexists with rural landscapes, esthetic values, and cultural identity. This approach is considered a fundamental pillar of NBSs in developing urban green infrastructure. Across all five key themes, these innovations and strategies emerged in response to deteriorating urban conditions, notably pollution and environmental degradation. Historically, the concept of ecological networks in Europe and greenways in the United States first gained traction in the early 20th century, intending to link urban green systems to surrounding natural and forested areas. This period also marked the global emergence of sustainable urban design, emphasizing the necessity of integrating ecology-driven approaches into contemporary urban planning.

3.4. Which Factors Contribute to the Successful Implementation of NBSs in Developing Urban Green Infrastructure?

Our content analysis identified six key themes, ten categories, and forty-eight subthemes. The key themes include the perspective of spatial justice in the implementation of NBS projects, enhancing and ecosystem management, integrated governance strategies, financial resources and economic benefits, technical knowledge and expertise, and optimizing stakeholder engagement in NBS implementation. Figure 4 systematically organizes these themes, highlighting recurring codes observed across the analyzed literature.

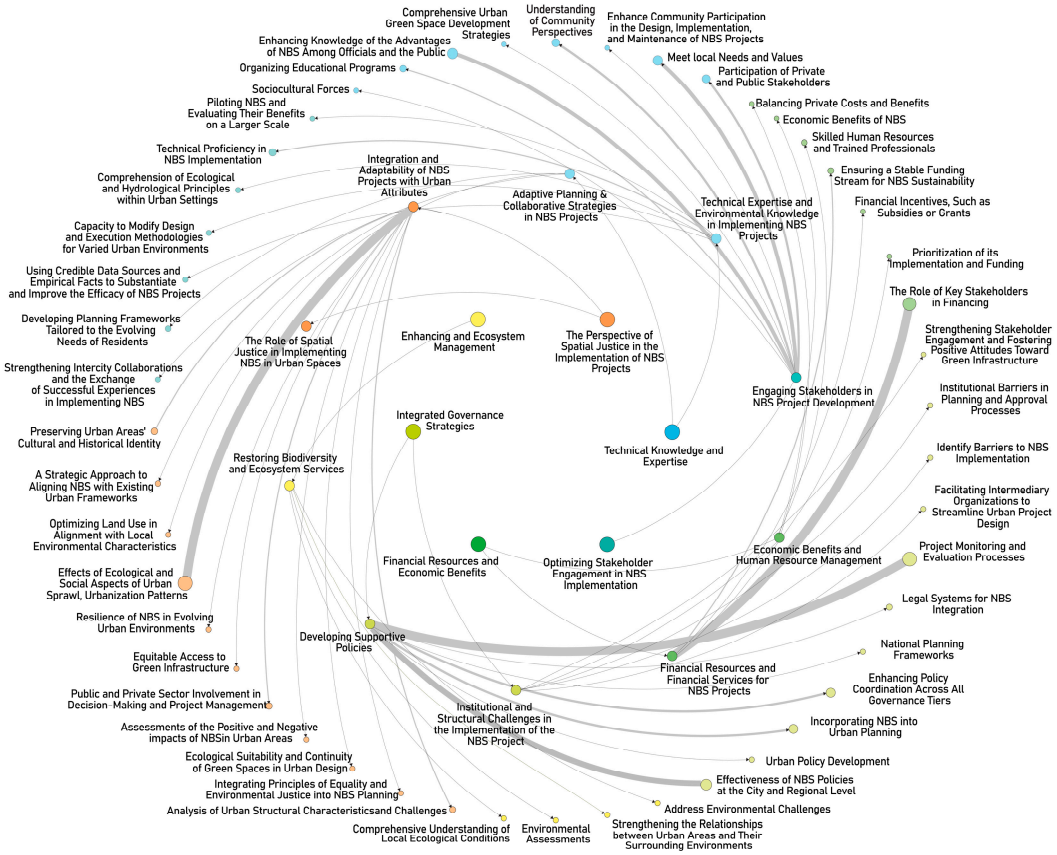

Figure 4. Key factors shaping the successful implementation of NBSs in urban green infrastructure.

3.4.1. The Perspective of Spatial Justice in the Implementation of NBS Projects

- Integration and Adaptability of NBS Projects with Urban Attributes

According to Moorish & Brown [116], green infrastructure should become a foundation for humanity's existence, identity, presence, and collective history. Beyond its profit-driven functions, it can encompass broader cultural, social, and ecological applications. Essentially, rather than being merely profit-oriented, green infrastructure could fulfill objectives such as enriching the sense of place, linking public benefit and interest, and preserving urban areas' cultural and historical identity [1,28,61,105]. In its primary function, green infrastructure is a strategic approach to aligning NBSs with existing urban frameworks [75,110] to protect land. It enables the identification and prioritization of conservation opportunities for future development planning, optimizing land use in alignment with local environmental characteristics [2,10,18,23,24,27,45,51,70,72,74,76,87,91,93,94,96–101,106,107,112,113]. Additionally, the resilience of NBSs in evolving urban environments [103] allows for implementing innovative conservation strategies, which contrasts with the concept of smart growth that emerged in the U.S. to curb uncontrolled urban expansion [117]. This approach affects the ecological and social aspects of urban sprawl, patterns of urbanization [79], land consumption, and fragmentation of open spaces.

- The Role of Spatial Justice in Implementing NBSs in Urban Spaces

Spatial justice is conceptualized through distributive patterns that, by nature, are possibly just or unjust within geographical domains [118]. The incorporation of spatial justice in urban planning requires identifying relevant criteria. Based on humanistic principles, five key criteria for spatial justice are as follows: (1) equality of opportunities, ensuring equitable access to green infrastructure [95,96] for all individuals based on their abilities and merits; (2) participation, emphasizing active citizen engagement, along with public

and private sector involvement in decision-making and project management [86,95–97], to ensure spatial justice in NBS initiatives; (3) outcomes, requiring comprehensive assessments of the positive and negative impacts of NBSs in urban areas [24]; (4) Merit, recognizing individuals' capabilities in the social sphere while ensuring the ecological suitability and continuity of green spaces in urban design [112,119,120]; (5) public benefit, integrating principles of equality and environmental justice into NBS planning [87] through the analysis of urban structural characteristics and challenges [50,52,74].

3.4.2. Enhancing and Ecosystem Management

- Restoring Biodiversity and Ecosystem Services

The European Commission [121] defines green infrastructure as a strategically planned network of natural and semi-natural areas designed and managed to provide a wide range of ecosystem services, including water purification, air quality improvement, recreational spaces, pollution reduction, and climate adaptation. Thus, green infrastructure enables multiple ecosystem services through a comprehensive understanding of local ecological conditions [103] and environmental assessments [108]. In this regard, it restores biodiversity, enhances ecosystem services, and fosters ecological relationships between urban areas and their surrounding environments [19,69,122]. This approach also helps address environmental challenges [113], such as air and water pollution, loss of vegetation cover, urban heat effects, and land-use changes to improve urban quality of life.

3.4.3. Integrated Governance Strategies

- Developing Supportive Policies

In regions where land value and economic development drive policymaking, such as China [30,52], engaging politicians and developers in discussions about the added value of green infrastructure is particularly challenging. Increasing green infrastructure visibility through evidence-sharing, regulatory interventions, and policy development is essential to address this. The effectiveness of NBS policies at the city and regional level [16,23,29,45,49,52,64,72,75,78,79,88,95,101,102] varies, as legislators, developers, and planners contribute variably to the accumulating evidence advocating for investments in green infrastructure. Critical considerations for advancing green infrastructure in urban policy development [110] include incorporating NBSs into urban planning [27,42,48,61–63,94,99,104,106], acknowledging green infrastructure's economic, social, and ecological advantages, and enhancing policy coordination across all governance tiers [1,10,21,26,29,30,43,50,91,113]. This entails developing regulatory frameworks, including corporate, public, and environmental partners, and synchronizing policy objectives with enduring urban sustainability aims. Nonetheless, the governance of this process is challenging, especially when national planning frameworks [23], legal systems for NBS integration [24,61,94], and project-monitoring and -evaluation processes [1,2,27,29,30,47–49,52,55,59–61,64,67,70,79,80,83,84,86,91–93,102,110] are inconsistently applied or overly tailored to individual interests or localized agendas.

- Institutional and Structural Challenges in the Implementation of the NBS Project

With the growing focus on localized green infrastructure projects, urban-scale strategies that extend across broader spatial domains have become more common. Regulations in cities such as New York [87] and Philadelphia [110] have sought to institutionalize green infrastructure principles by improving connectivity, environmental access, and sustainability through strategic investment programs. However, achieving consensus at this scale requires long-term efforts, as multiple challenges, including stakeholder participation, land ownership, funding, and competing urban development objectives, must be addressed.

Therefore, facilitating intermediary organizations to streamline urban project design [25], enhance community cooperation, and identify barriers to NBS implementation is crucial [29]. Nevertheless, institutional barriers in planning and approval processes [60], real estate market dynamics, and speculative landholding practices continue to pose challenges. Strengthening stakeholder engagement and fostering positive attitudes toward NBSs in green infrastructure [113] as equivalent to traditional infrastructure is essential. Historical trends, such as Liverpool's prioritization of other urban investments over green spaces, illustrate these difficulties [67]. However, growing recognition of climate adaptation benefits, flood management, and public health are shifting the perspectives of policymakers.

3.4.4. Financial Resources and Economic Benefits

- Financial Resources and Financial Services for NBS Projects

Key stakeholders, including local governments, developers, communities, and businesses, play central roles in funding [1,10,23,27,42,45,48,52,55,60,62,64,71,75,77–79,83,94,99,103,106,110] green infrastructure. However, their relationships with green infrastructure investments have undergone significant transformation. The increasing awareness of the economic, social, and ecological value of green infrastructure has led to more prioritization of its implementation and funding [97]. Financial incentives, such as subsidies or grants [24], are expected to support urban greening efforts. Although green infrastructure may not yield immediate financial returns comparable to traditional infrastructure, it has the potential for higher long-term economic benefits. Ensuring a stable funding stream for NBS sustainability [2,91,101] can ultimately reduce overall city costs. In the UK, some developers have integrated green infrastructure to enhance the value of residential and commercial properties. Initiatives such as green walls, sustainable drainage systems, and public space greening have been employed to increase property desirability and value [123].

- Economic Benefits and Human Resource Management

Numerous municipal governments and private investors are committing resources to facilitate the development of NBSs in urban green infrastructure. This encompasses renovating structures with green roofs and walls and cultivating public–private partnerships, exemplified by the Atlanta BeltLine in the United States [124]. These partnerships align strategic local government needs with commercial interests, supported by skilled human resources and trained professionals [83,85]. However, private sector entities often express concerns regarding the economic benefits of NBSs [30], balancing private costs and benefits [49], and ensuring transparency in agreements, particularly when land use or access to green infrastructure changes. Transparent policies are essential to ensure that private economic gains do not overshadow green space benefits for the public.

3.4.5. Technical Knowledge and Expertise

- Technical Expertise and Environmental Knowledge in Implementing NBS Projects

Aligning stakeholders' interests, which often focus primarily on outcomes, is not always straightforward. Consequently, many green infrastructure strategies are being developed at city and regional scales. While this expansion provides opportunities for green infrastructure advocates to invest in landscape quality enhancement projects, inconsistencies between policies, strategies, or regulations can lead to conflicts. When formulating plans and policies at the local level, the focus might be on various regions or neighborhoods. This approach facilitates a more detailed analysis of local contexts and the potential value of green infrastructure in these settings. It allows for piloting NBSs and evaluating their benefits on a larger scale [49]. Locally focused programs may, however, overlook broader value propositions, functions, and investment implications of green infrastructure,

including ongoing maintenance costs, alignment with other resources, or the effects of investment on urban environmental systems. However, the potential lack of strategic thinking regarding ensuring broader benefits and aligning interventions with city-scale developments remains a fundamental challenge. Effective integration of local policies with broader strategic frameworks necessitates technical proficiency in NBS implementation [27,48,49,55,84], comprehension of ecological and hydrological principles within urban settings [52], and the capacity to modify design and execution methodologies for varied urban environments [112]. Moreover, using credible data sources and empirical facts to substantiate and improve the efficacy of NBS projects [23] may promote sustainable development and the coherence of green infrastructure initiatives.

- Adaptive Planning and Collaborative Strategies in NBS Projects

When residents participate directly in NBS projects, they not only contribute to implementation but also engage more deeply with their surroundings through social interaction, learning, and the enjoyment of nature. This participatory engagement empowers local communities and strengthens their sensory and emotional connection with the natural environment, ultimately enhancing their quality of life. A key challenge in this context lies in overcoming the limitations of contemporary urban landscapes by creating innovative networks that integrate nature more effectively into the built environment. Accordingly, developing planning frameworks that respond to the evolving needs of residents is crucial [55,86]. These frameworks not only support the attainment of long-term sustainability objectives but also promote biodiversity conservation and urban resilience. Moreover, strengthening inter-city collaboration and facilitating the exchange of successful practices in NBS implementation [23] can help scale up adoption. Through shared strategies, cities can collectively move towards more sustainable, inclusive, and nature-adaptive urban futures.

3.4.6. Optimizing Stakeholder Engagement in NBS Implementation

- Engaging Stakeholders in NBS Project Development

While the participation of private and public stakeholders plays a central role in creating and managing green infrastructure [2,27,84,89,92,105,110], there remains significant scope for social groups and environmental organizations to engage as key actors in governance and service delivery, particularly in addressing local needs and values [21,25,77]. To empower these groups and enable the integration of local knowledge, it is essential to promote community participation in the design, implementation, and maintenance of NBS projects [60]. This requires, where possible, the allocation of spaces specifically designated for the establishment and delivery of green infrastructure. The Community Forest Partnership in the UK [125], notably Mersey Forest [126] and initiatives in Manchester [127], offers illustrative examples of successful collaborations between community groups and local authorities. These partnerships have mobilized concerns around climate change, public health and well-being, recreation, and environmental management to strengthen community engagement while generating revenue to reinvest in green infrastructure.

Additionally, debates persist regarding whether communities should assume responsibility for managing and financing green infrastructure. This issue requires careful consideration, as not all governmental and private entities possess the experience, knowledge, or appreciation of community perspectives and the importance of active resident participation in planning processes [1,2,10,50,51,53,61,62,93,96,97]. Even when the transfer of community assets is proposed, these groups may struggle to perform effectively over time without continued support from professionals experienced in social development or landscape management. Moreover, such efforts are likely to remain incomplete or unsustainable unless they are embedded within comprehensive urban green space development strate-

gies [93], especially given the tendency of some institutions to resist high levels of social participation.

Consequently, initiatives must prioritize enhancing awareness of the benefits of NBSs among both public officials and the wider community [3,30,45,52,56,57,65,80,82,88,106,107,113]. This can be achieved through targeted educational programs [2,64,70,88] and through NBS projects that clearly specify the types of green infrastructure to be developed, their optimal locations, and potential funding mechanisms. Such efforts are particularly important in contexts where sociocultural factors [30] shape local perceptions of nature and the environment, often alongside a diverse array of stakeholders engaged in negotiations over investment. In response, many municipal governments and private investors are allocating resources to public spaces to support the expansion of urban green infrastructure.

3.5. What Are the Key Barriers That Hinder the Implementation of NBSs in Urban Green Infrastructure?

Our content analysis identified five key themes, six categories, and twenty-seven subthemes. The key themes include physical–spatial, economic, technical, social, and political. The findings, presented in Figure 5, highlight the primary barriers to implementing NBSs in urban green infrastructure. These themes are systematically categorized, with recurring codes identified across the analyzed literature.

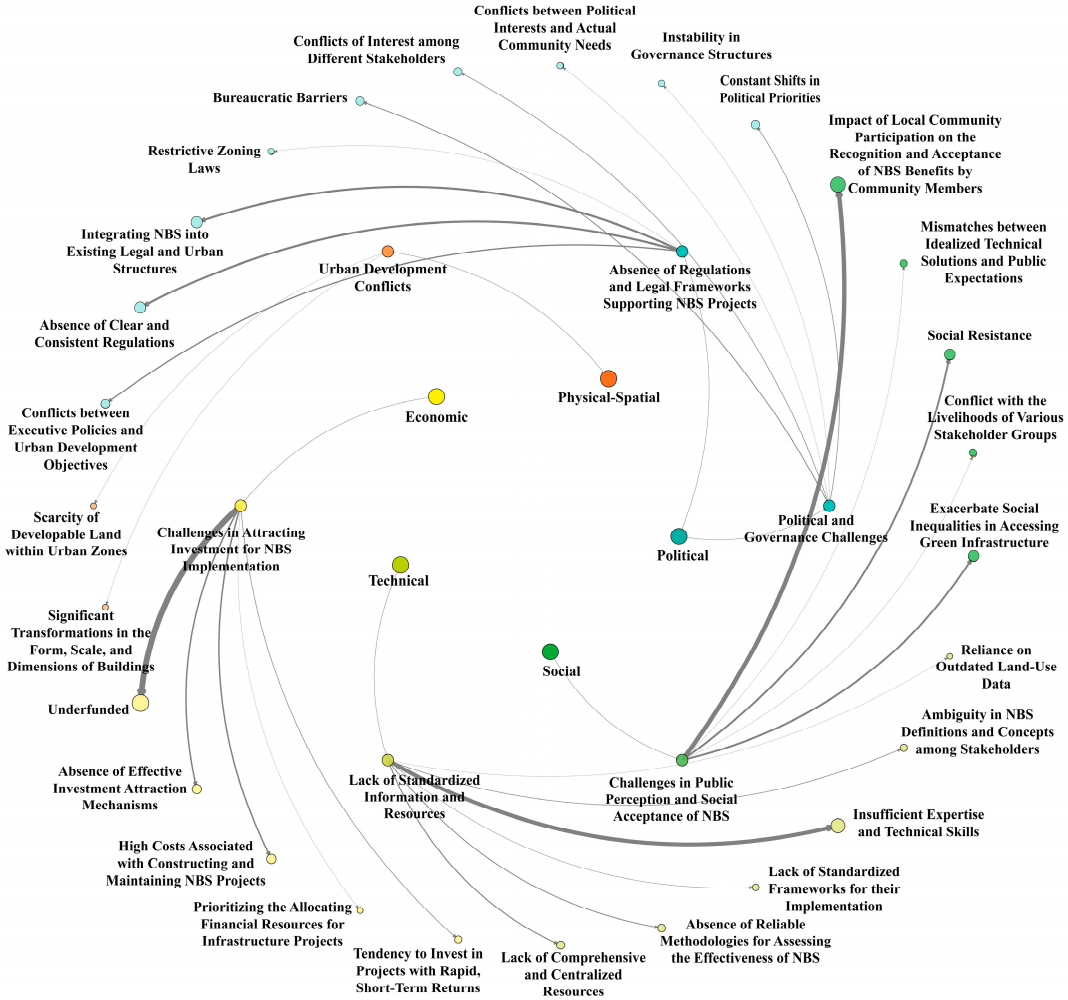

Figure 5. Barriers to implementing NBSs in urban green infrastructure.

3.5.1. Physical–Spatial

- Competing Claims on Urban Land

In many metropolitan areas, the scarcity of developable land [51] often leads to the marginalization of green infrastructure within urban planning agendas. The economic dynamics of land value further compound this challenge; for instance, the escalation of housing prices in proximity to high-quality green spaces tends to reduce the financial incentives for expanding such areas. Properties situated near scenic landscapes typically exhibit higher rental values and improved commercial performance, which, while economically beneficial, can inadvertently disincentivize the allocation of land for NBSs in green infrastructure. A notable example is Maggie Daley Park in downtown Chicago [128], where the development significantly increased local revenues, stimulated business activity, and attracted private investment. However, such projects often require substantial alterations to the built environment, affecting the form, scale, and configuration of buildings [109], as well as associated engineering systems, which can heighten tensions between infrastructure development and the ecological requirements of urban green spaces. More fundamentally, the lack of a coherent and integrated urban green network results in spatial fragmentation, a decline in environmental quality, and reduced urban livability. The situation is further exacerbated by the rapid and often unregulated expansion of urban areas, which has led to the loss of significant green spaces and peri-urban agricultural land, thereby deepening the disconnection between natural ecosystems and urbanized zones.

3.5.2. Economic

- Challenges in Attracting Investment for NBS Implementation

Implementing NBS projects is often hindered by financial constraints [1,2,10,24,27,40,42,48,51,56,60,62,65–67,70,71,74,75,77,78,82,86,93,96,99,107,112] and limited institutional support. Cities require investment strategies that are tailored to their specific economic conditions, yet the absence of effective mechanisms for attracting investment [49,79,89,91,99,100,113] continues to discourage private sector participation. Furthermore, the high costs associated with the construction and maintenance of NBS projects [10,24,43,49,91,100,106] have led many municipalities to abandon initiatives such as sustainable drainage systems, extensive tree planting, and the optimization of urban green land use. For example, in Madrid, large-scale projects such as Madrid Río, dedicated to the development of green space, have incurred substantial costs, thereby limiting the availability of financial resources for other urban areas [129]. Moreover, prioritizing the allocation of financial resources for infrastructure projects [95] sometimes obstructs the advancement of green infrastructure. In Rome, for instance, urban budgets are largely allocated to transportation and heritage restoration, relegating green initiatives such as urban parks and rainwater-harvesting systems to the margins of policy agendas [130]. A further constraint is the prevalent focus on projects promising rapid, short-term returns, while green infrastructure, despite its long-term environmental and social benefits—continues to face chronic underinvestment [2,10,87,95]. In many European cities, commercial and residential developments attract greater investor interest, whereas the expansion of green space requires a long-term vision and sustained financial commitment.

3.5.3. Technical

- Lack of Standardized Information and Resources

NBSs should be tailored to local environmental conditions and socio-spatial challenges, while also ensuring resilience to climate variability and environmental change. Given their site-specific nature, the integration of indigenous and local knowledge can significantly en-

hance the relevance and effectiveness of NBS interventions. Traditional knowledge, shaped over centuries of community-based resource management and environmental adaptation, contributes meaningfully to the physical, functional, and semantic dimensions of these solutions. Nevertheless, the effective implementation of NBSs continues to encounter substantial barriers. The absence of comprehensive and centralized repositories of knowledge and resources constrains the ability of planners and policymakers to learn from previous experiences [1,2,10,87,93,111]. In parallel, the lack of robust methodologies for evaluating NBS performance [23,78,84,100], along with the absence of standardized implementation frameworks [53,89], impedes the scaling-up of such initiatives. Moreover, limited technical expertise and insufficient capacity in the relevant domains present critical challenges during the execution phase [10,21,27,40,42,44,59,62,65,72,75,82,89,91,95,96,113]. Further complications arise from conceptual ambiguities and inconsistencies in the understanding of NBSs among stakeholders [16,53,70], which hinder coordination and collaborative decision-making. Lastly, reliance on outdated or incomplete land-use data [95] undermines the accuracy and reliability of planning and implementation processes.

3.5.4. Social

- Challenges in Public Perception and Social Acceptance of NBS

Public acceptance of NBS, along with the motivational factors shaping perceptions in participatory processes, remains insufficiently examined. Many NBS initiatives presuppose that the priorities and perspectives of local communities and other stakeholders are aligned with project goals and policy agendas. However, such assumptions can inadvertently reinforce social inequalities in access to green infrastructure [1,2,23,24,62,88,91,97,99,131]. In some cases, these projects may conflict with the livelihoods and interests of particular stakeholder groups [72], leading to adverse consequences for ecosystem integrity and human well-being. In such scenarios, these projects may lack the necessary realism and face social resistance [2,10,18,21,42,48,51,67,84] due to mismatches between idealized technical solutions and public expectations [40], ultimately diminishing their feasibility. Achieving broad-based consensus is vital for strengthening social resilience and supporting the long-term development of green infrastructure. In this context, intermediaries play a crucial role in facilitating dialog, identifying shared priorities, developing co-produced solutions, and cultivating collective knowledge and understanding among stakeholders. Furthermore, the active engagement of local communities is central to enhancing public recognition of, and support for, the benefits of NBSs [1,24,27,44,47–49,54,59,62,63,65,67,71,82,89,91,99,104,105,113]. Addressing these challenges requires moving beyond theoretical discourse towards actionable, inclusive practices that ensure the successful implementation and sustainability of NBS initiatives.

3.5.5. Political

- Political and Governance Challenges

Implementing NBSs in urban green infrastructure projects face fundamental political and managerial challenges affecting their development and conservation. Frequent shifts in political priorities [87,89,101], instability in governance structures [40], and misalignments between political agendas and actual community needs [96] undermine the implementation of sustainable development policies. These challenges weaken long-term programs and complicate coordination among executive institutions. Furthermore, conflicts of interest among different stakeholders [10,101,106], lack of transparency in governmental decisions, and bureaucratic barriers [1,59,60,99], such as those encountered in the Paris Rainwater Plan, can erode public trust and intensify internal resistance within organizations, ultimately slowing or halting environmental projects [132]. Local governments must devise strategies to integrate

green infrastructure into local development plans within the framework of national policies without relying on mandatory legislative changes [123]. The Green Belt policy provides a pertinent example: while it has succeeded in preserving a landscape reminiscent of the rural character of the 1950s, it has also faced criticism for lacking contemporary political support. This underscores the importance of stronger engagement by environmental organizations in advocating for green infrastructure. Such organizations play a critical role in promoting awareness of the environmental, economic, and social benefits of investment in green infrastructure, thereby supporting the broader goals of sustainable development. In the UK, institutions such as Community Forests, Natural England, the National Trust, and the Environment Agency have been particularly influential in advancing policies aimed at protecting and enhancing urban green infrastructure [133,134].

- Regulatory and Legal Barriers to NBS Implementation

One of the central questions in green infrastructure discourse is whether the absence of coherent regulatory and legal frameworks significantly constrains investment in landscape enhancement. While developing new policies, regulations, and strategies can foster positive changes, restrictive zoning laws [18] and conventional urban planning approaches continue to pose significant challenges. Furthermore, integrating NBSs into existing legal and urban structures [2,24,75,77,79,83,84,90,100,103] remains a complex and often protracted process, further complicating efforts to mainstream these approaches. Nonetheless, there is growing recognition of these challenges within urban policymaking circles, and in some regions, more robust support mechanisms have begun to emerge. Over the past two decades, green infrastructure has gained increasing prominence in urban planning, becoming a core element of sustainable urban development strategies. Despite this growing recognition, the implementation of NBSs has not been uniformly successful. In several national contexts, the absence of clear and consistent regulatory frameworks [21,24,40,51,64,70,78,89,106], coupled with inadequate oversight mechanisms and a governmental emphasis on short-term economic development goals, has limited progress. Furthermore, in some regions, conflicts between executive-level policy directives and urban development objectives [18,29,43,75,78,113] have obstructed the institutionalization and expansion of NBS. These persistent regulatory misalignments underscore the need for integrated governance approaches that reconcile environmental priorities with broader urban development agendas.

3.6. What Roles Do Stakeholders Play in Planning and Delivering NBSs in Urban Green Infrastructure?

The content analysis identified three main themes, four categories, seventeen sub-themes related to the roles of local governments, private sector actors, and communities. Figure 6 presents the core findings, emphasizing the crucial roles of stakeholders in the planning, implementation, and maintenance of NBSs in urban green infrastructure, with themes systematically categorized and recurring codes identified across the reviewed literature.

3.6.1. Local Governments

- Policy-Making and Regulatory Frameworks

Each NBS project, owing to its specific functions, highlights different aspects of green infrastructure planning. These dimensions are critical for enhancing the capacity of responsible institutions to integrate NBSs into broader urban planning frameworks [42,51,53,56,75,112]. Such integration often necessitates the reallocation of resources across various organizations and planning sectors. While this raises important questions about which actors should oversee the targeted distribution of these resources [21,25,64,88],

it also underscores the challenges faced by stakeholders who may lack the traditional expertise required to assume these responsibilities effectively.

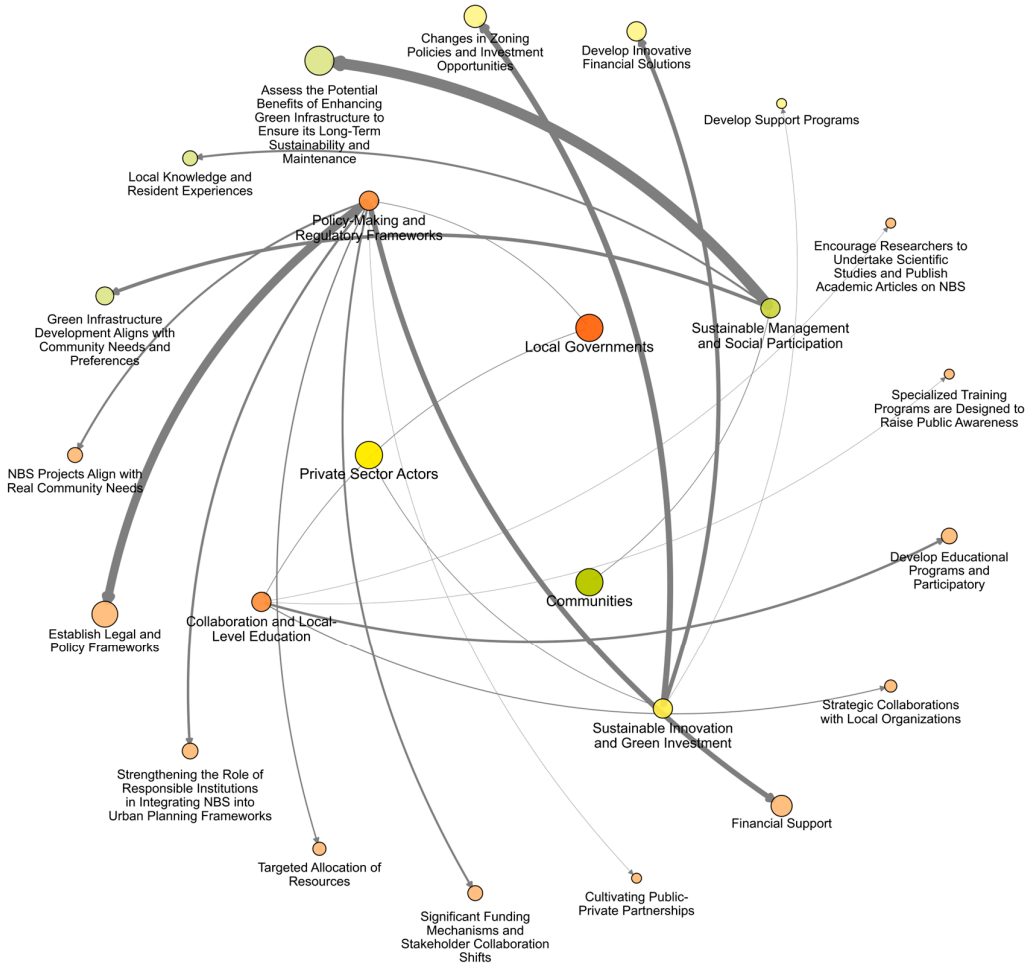

Figure 6. Key stakeholder roles in the planning, implementation, and maintenance of NBSs in urban green infrastructure.

There remains an urgent need to establish legal and policy frameworks that adequately reflect the resource dynamics of green infrastructure and clarify the capacity of different stakeholders to manage it [1,2,18,24,25,27,42,44,46,51,53,61,62,64,70,75,78,87,91–93,95,96,100]. This issue is particularly salient in England, where community asset transfers have raised concerns regarding the long-term governance of green spaces [135]. Even when community groups obtain the necessary legal, managerial, and operational rights, they may lack the knowledge, skills, or time required to govern parks or natural areas effectively.

This situation highlights the need for more robust support mechanisms to ensure that NBS projects are aligned with the actual needs of communities [21,43,62,86,101,111]. These may include direct payments, financial incentives [1,21,24,27,42,44,49,53,61,73,91,95,96,100,107], or public–private partnerships [3,21,24,27,29,44,48,52,54,55,59,65,68,74,77,79,87,89–91,94,95,100,104,105]. Significant shifts are currently underway in both funding mechanisms and stakeholder collaboration models [47,74,79,91,95,96], opening the door for innovative and adaptive financial strategies. These emerging approaches have the potential to ensure long-term investment and enhance the sustainability of NBS initiatives.

- Collaboration and Local-Level Education

NBSs in urban green infrastructure present distinct political advantages for policymakers. When environmental resources are managed efficiently through strategic collaborations

with local organizations [2,62,99], they gain public, business, and political value. Completing the Cheonggyecheon urban renewal project in Seoul is a clear example of positive public and business responses to increased urban usage, prolonged visitor presence in city centers, and economic growth driven by rising expenditures [136]. In this sense, environmental stewardship can translate into electoral gains. If urban governments seek to protect their natural surroundings, they must develop educational programs and participatory [21,24,27,29,44,92,100] workshops involving government agencies, private sectors, and local communities. Specialized training programs are designed to raise public awareness [62] and encourage researchers to undertake scientific studies and publish academic articles on NBSs [62]. The adoption of such collaborative and educational approaches can also provide cities with strategic competitive advantages. For example, urban indices focusing on quality of life and place-making, such as the Green City Index developed by Siemens AG in 2011, have influenced business investment decisions. Cities like Singapore [137] and Vancouver [138] have successfully incorporated NBSs and green infrastructure into their urban branding strategies, enhancing their global competitiveness.

3.6.2. Private Sector Actors

- Sustainable Innovation and Green Investment

A range of new financial models for green infrastructure development has emerged in recent years, providing diverse stakeholders with opportunities to more effectively manage and allocate resources for landscape investment. The involvement of actors from the private, public, voluntary, and social sectors raises important questions about which groups are best positioned to oversee environmental resource management. This issue has become particularly salient in many countries, where diminishing public funds for landscape conservation and management have compelled both governments and environmental professionals to pursue innovative financial strategies [3,42,48,49,52–55,68,89,96,104]. In England, for instance, there is broad consensus that central government funding can no longer be relied upon, prompting a growing interest in alternative mechanisms, such as the sale, transfer, or corporate sponsorship of green infrastructure, particularly by businesses and the real estate development sector [139]. This transition aligns with an increasing awareness among private sector actors that investment in sustainable, nature-based development models may yield higher returns and lower long-term costs compared to conventional engineered solutions. Policy tools, such as zoning reforms and new investment frameworks [1,21,25,27,42,46,51,56,61,72,77,78,87,91,92,95,96], could be used to facilitate funding for green infrastructure, particularly if private actors take proactive steps to develop support programs [56] that encourage public engagement and align urban greening objectives with broader development agendas. In this context, green infrastructure is becoming a strategic business consideration, as corporations increasingly recognize the value of sustainability in enhancing brand identity and promoting high-productivity work environments. Several successful models reflect this emerging shift from state-centric investment and governance towards private-sector-led development (PSD) with a strong environmental orientation. Notable examples include the Parks Trust model in Milton Keynes [140], London's Business Improvement Districts (BIDs) [141], and Paris' participatory budgeting program [142]. These cases illustrate how the private sector can play a leading role in financing and governing urban green infrastructure in ways that are both economically viable and environmentally sustainable.

3.6.3. Communities

- Sustainable Management and Social Participation

Community interactions with green infrastructure are diverse, shaping how individuals perceive, use, and value their surrounding landscapes. These interactions not only influence the immediate functionality of green spaces but also play a critical role in determining their long-term sustainability. As such, global perspectives on the development and stewardship of green infrastructure are highly relevant. Importantly, the variation in community engagement is not inherently problematic; rather, it offers multiple pathways for enhancing landscape quality through the integration of local knowledge and lived experience [45,46,51,65,95,99]. Different communities bring distinct motivations and expectations to their use of green spaces, highlighting the importance of prioritizing public understanding in planning and decision-making processes. Ensuring that green infrastructure development aligns with community needs and preferences [3,48,54,68,84,89,104] is essential for creating urban spaces that are both functional and contextually appropriate. This requires a continuous and iterative process involving a wide range of stakeholders, who must regularly assess their expectations and evaluate the potential benefits of green infrastructure. In doing so, they contribute to its long-term maintenance and sustainability [1,19,21,42,43,48,49,62,63,88,92,94–96].

4. Conclusions

This systematic review has sought to advance the understanding of how NBSs have been conceptualized, implemented, and evaluated in the context of urban green infrastructure over the past decade. By analyzing 90 peer-reviewed articles published between 2014 and 2024, this study has mapped the intellectual contours of the field, identified emerging research trends, and critically examined the conditions that shape the success or failure of NBS initiatives across diverse urban contexts.

The findings suggest that NBSs have increasingly been recognized as a cornerstone of sustainable urban development, particularly in the Global North, where cities such as Barcelona, Milan, Amsterdam, and Paris have embedded NBSs into broader urban greening and climate adaptation strategies. This proliferation is accompanied by growing methodological sophistication, with researchers employing advanced hydrological models, cost-effectiveness tools, and spatial analyses to support evidence-based planning. However, this technical advancement has not been evenly distributed. The geographical distribution of scholarship reveals a concentration of research in Europe and parts of East Asia, with significant gaps in empirical knowledge from the Global South. Addressing these disparities is crucial if NBSs are to fulfill their promise as globally relevant strategies for inclusive and resilient urbanism.

This review has shown that NBS interventions commonly address five interrelated domains: the expansion of urban green ecosystems, stormwater management, the restoration and conservation of natural habitats, nature-integrated urban design, and urban agriculture. These domains reflect the multifunctionality of NBSs, which can simultaneously support biodiversity, enhance climate resilience, improve public health, and foster social cohesion. However, the implementation of such solutions is rarely straightforward. Their success depends not only on ecological suitability or design excellence but also on how effectively they are embedded within governance structures, policy frameworks, and community dynamics.

This study identifies six cross-cutting factors that underpin successful NBS implementation. These include spatial justice, which emphasizes the fair distribution of green infrastructure and equal access to its benefits; effective ecosystem management, which supports ecological integrity and service delivery; integrated governance, which ensures alignment across institutional levels and sectors; sustainable financing, which is necessary for both initial implementation and long-term maintenance; technical capacity, which includes design, engineering, and ecological

expertise; and finally, meaningful stakeholder engagement, which builds legitimacy and ensures alignment with local needs and aspirations.

Critically, the analysis has illuminated several persistent barriers that inhibit the wider adoption of NBS. Spatial constraints, such as land scarcity and fragmented green networks, continue to undermine the ecological coherence of urban landscapes. Financial limitations remain acute, especially in contexts where green infrastructure competes with other urban priorities. Technical barriers, such as the lack of standardized data, replicable frameworks, and skilled personnel, further hinder progress. Socially, NBS projects sometimes suffer from low public visibility or acceptance, particularly when designed without adequate community input. Politically, shifting priorities, weak regulatory mechanisms, and institutional silos complicate efforts to integrate NBSs into urban planning in a coherent and sustained manner.

These challenges suggest that the realization of NBS benefits is as much a question of governance and institutional capacity as it is of ecological design. The roles of local governments, private sector actors, and communities are therefore pivotal. Local governments are uniquely positioned to develop enabling policies, coordinate planning processes, and channel public investment towards green infrastructure. At the same time, the private sector can play a complementary role by investing in NBSs as part of broader sustainability strategies, particularly when economic incentives and zoning regulations are aligned. Community actors, in turn, are essential not only as beneficiaries but also as co-creators and stewards of green spaces, contributing valuable local knowledge and fostering long-term care.

Importantly, this study argues that the future of urban green infrastructure planning is poised to diverge from conventional, technocratic approaches. As cities grapple with the compound pressures of climate change, urban inequality, and environmental degradation, there is a growing need to reimagine planning as a more participatory, context-sensitive, and adaptive practice. This includes not only a reconfiguration of how NBSs in green infrastructure are financed and managed but also a shift in how their value is understood, beyond economic returns, to include social well-being, ecological regeneration, and cultural meaning.

Moving forward, several avenues for future research are evident. There is a need to explore the internal dynamics of the thematic clusters identified in this review, examining how technical, institutional, and social dimensions interact to shape project outcomes. Greater attention should also be given to the interconnections among these clusters, particularly in understanding how multi-scalar governance, cross-sectoral partnerships, and temporal factors influence implementation processes. Moreover, comparative research that spans diverse urban contexts can illuminate how local specificities mediate the translation of NBS principles into practice.

In sum, the findings of this review highlight the importance of embracing a more integrated and systemic approach to the planning, implementation, and governance of NBSs in urban green infrastructure. As cities continue to evolve in response to environmental, economic, and social transformations, NBSs offer a promising yet complex pathway toward more resilient and equitable urban futures. Their success, however, will depend on our collective capacity to move beyond narrow sectoral thinking, forge new forms of collaboration, and embed ecological thinking into the very fabric of urban governance.

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