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Nature-Based Solutions: Innovation or Rhetoric?

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Abstract

Nature-Based Solutions (NBS) have emerged as a prominent framework in environmental research and policy for addressing climate change, biodiversity loss, and urban sustainability. However, questions remain about the extent to which NBS represents a transformative approach rather than a symbolic discourse. This study critically evaluates the trajectory of NBS literature through a systematic analysis of 1,380 Web of Science-indexed articles published between 2014 and 2024. A mixed-methods approach combining quantitative trend analysis and thematic topic modeling (LDA) was employed to identify dominant research patterns. Findings reveal that while urban planning, climate change adaptation, and water management are recurring themes, empirical studies constitute only 36% of the dataset. The remaining 64% are dominated by theoretical and policy-oriented discussions. Furthermore, risks of greenwashing and the financialization of NBS are identified as critical challenges undermining its potential impact. The study concludes that NBS must move beyond conceptual framing by adopting rigorous empirical methodologies, standardized evaluation criteria, and inclusive governance mechanisms. Without such advancements, NBS risks becoming a rhetorical placeholder rather than a viable environmental solution.

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Highlights

- *Nature-Based Solutions (NBS) research has expanded rapidly, yet much of it remains theoretical and policy-driven, with limited real-world application.*
- *Thematic analysis of NBS literature reveals a focus on climate change adaptation, urban planning, water management, ecosystem*

conservation, and governance, but empirical validation is lacking.

- *The gap between theory and implementation raises concerns about whether NBS is a genuine environmental innovation or just another sustainability buzzword.*
- *Corporate greenwashing and the financialization of NBS pose risks, as the concept is increasingly marketed without measurable ecological or social impact.*
- *To ensure NBS becomes a transformative environmental strategy, there is an urgent need for empirical research, standardized evaluation frameworks, large-scale implementation, and interdisciplinary collaboration.*

Doğa Temelli Çözümler: Yenilik Mi Yoksa Retorik Mi?

Özet

Doğa Temelli Çözümler (Nature-Based Solutions - NBS), iklim değişikliği, biyolojik çeşitlilik kaybı ve kentsel sürdürülebilirlik gibi çevresel sorunlara yönelik etkili bir yaklaşım olarak çevre araştırmaları ve politika alanında öne

Anahtar Kelimeler

Doğa temelli çözümler, iklim değişikliğine uyum, kentsel sürdürülebilirlik, çevresel yönetişim, yeşil aklama, politika

çıkmaktadır. Ancak NBS'nin gerçekten dönüştürücü bir çözüm mü yoksa sembolik bir söylem mi olduğu hâlâ tartışmalıdır. Bu çalışma, 2014–2024 yılları arasında Web of Science veri tabanında yayımlanan 1.380 makaleyi sistematik biçimde inceleyerek NBS literatürünün gelişimini eleştirel bir bakışla değerlendirmektedir. Çalışmada nicel eğilim analizi ile tematik konu modellemesini (LDA) birleştiren karma bir yöntem kullanılmıştır. Bulgular, kentsel planlama, iklim değişikliğine uyum ve su yönetiminin literatürde en sık tekrarlanan temalar olduğunu göstermektedir. Ancak analiz edilen çalışmaların yalnızca %36'sı ampirik veriye dayalıyken, %64'ü kuramsal tartışmalar ve politika odaklı çerçevelerle sınırlı kalmaktadır. Ayrıca, yeşil aklama (greenwashing) ve NBS'nin finansallaşması gibi olgular, kavramın potansiyel etkisini zayıflatabilecek ciddi riskler olarak öne çıkmaktadır. Çalışma, NBS'nin kavramsal çerçevenin ötesine geçebilmesi için ampirik araştırmalara, standartlaştırılmış değerlendirme ölçütlerine ve kapsayıcı yönetişim mekanizmalarına ihtiyaç duyduğunu savunmaktadır. Aksi takdirde, NBS'nin uygulanabilir bir çevresel çözüm olmaktan çok, retorik bir söylem olarak kalma riski bulunmaktadır.

ve uygulama, sürdürülebilirlik retoriği
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Öne çıkanlar

- *Doğa Temelli Çözümler (NBS) üzerine yapılan araştırmalar hızla artmıştır, ancak büyük ölçüde teorik ve politika odaklı kalmış, gerçek dünya uygulamaları sınırlı kalmıştır.*
- *NBS literatürünün tematik analizi, çalışmaların iklim değişikliğine uyum, kentsel planlama, su yönetimi, ekosistem koruma ve yönetişim gibi konulara odaklandığını göstermektedir, ancak ampirik doğrulama eksiktir.*
- *Teori ile uygulama arasındaki boşluk, NBS'in gerçek bir çevresel yenilik mi yoksa sadece bir sürdürülebilirlik söylemi mi olduğu konusunda soru işaretleri yaratmaktadır.*
- *Kurumsal greenwashing ve NBS'in finansallaşması, kavramın giderek ölçülebilir ekolojik veya sosyal etkiler*

yaratmadan pazarlanması nedeniyle önemli riskler taşımaktadır.

- *NBS'in dönüştürücü bir çevresel strateji haline gelmesi için ampirik araştırmalara, standartlaştırılmış değerlendirme çerçevelerine, büyük ölçekli uygulamalara ve disiplinlerarası işbirliğine acilen ihtiyaç vardır.*

1. Introduction

Nature-Based Solutions (NBS) refer to approaches that utilize the protection, sustainable management, and restoration of ecosystems to address societal challenges such as climate change, water security, food security, and disaster risk reduction [1]. These solutions aim to harness the natural functions of healthy ecosystems to deliver environmental, economic, and social benefits [2]. The concept of NBS has gained significant traction in recent years as a response to the increasing environmental crises and the limitations of traditional engineered solutions [3].

The origins of NBS can be traced back to the late 2000s when international organizations such as the International Union for Conservation of Nature (IUCN) and the World Bank introduced the term as part of climate adaptation and mitigation strategies. These discussions emphasized working with natural ecosystems rather than relying solely on engineered interventions [4, 5, 6]. In 2019, the United Nations Climate Action Summit highlighted NBS as a critical tool for combating climate change [7]. As a result, the concept has become a focal point in policy-making, urban planning, and ecological restoration efforts.

Despite the growing popularity of NBS, there is an ongoing debate about its actual effectiveness versus its rhetorical appeal. While some scholars argue that NBS represents a paradigm shift toward sustainable, ecosystem-based problem-solving [8, 9], others caution that the term is often used in policy and planning documents without clear implementation strategies or measurable impact [10]. Many publications emphasize the

potential of NBS rather than providing empirical evidence of their long-term success, raising concerns that the term may be serving more as a buzzword than a practical solution [11]. Additionally, the lack of standardized methodologies to assess the effectiveness of NBS complicates efforts to compare different projects and determine their actual contributions to sustainability [12].

Another critical issue is the context-dependent nature of NBS. While some solutions, such as wetland restoration or urban green spaces, may provide tangible benefits, their success depends heavily on local ecological, social, and economic conditions [13, 14]. However, in many cases, NBS is presented as a one-size-fits-all strategy that can be broadly applied without sufficient consideration of site-specific variables. This generalization risks oversimplifying complex environmental challenges and may result in superficial interventions that do not address underlying systemic issues [15]. Furthermore, some scholars argue that NBS can be co-opted by corporate and governmental actors to justify weak environmental policies or greenwashing strategies [16].

Given these concerns, this paper critically examines the extent to which NBS represents a viable approach to environmental problem-solving versus a politically appealing yet ambiguous concept. Through an analysis of Web of Science-indexed publications, this study investigates thematic trends in NBS research to assess whether the concept is primarily theoretical or action-oriented. Additionally, the paper explores the gaps in current NBS applications and suggests ways to move beyond rhetoric toward measurable, impactful solutions.

This article examines the challenges NBS faces in moving from theoretical framework to practical applications, questioning whether these solutions are truly effective.

2. Conceptual Framework: NBS as a Scientific and Policy Tool

This section outlines the conceptual landscape that underpins Nature-Based Solutions (NBS) as both a scientific construct and a practical policy instrument. It begins by presenting key definitions and international perspectives on how NBS have been framed within global policy agendas. Subsequently, it delves into the theoretical foundations of NBS, drawing on the intersecting frameworks of ecosystem services, green infrastructure, and resilience thinking. The third subsection examines how NBS have been operationalized across multiple sectors, with particular attention to their applications in urban planning, climate adaptation, and disaster risk reduction. Finally, the section concludes by critically reflecting on the limitations and implementation challenges that continue to shape the discourse around NBS. Together, these four components provide a structured understanding of NBS as a multifaceted and evolving paradigm in environmental policy and planning.

2.1. Definitions and Policy Integration

Nature-Based Solutions (NBS) have been widely defined and integrated into policy frameworks by international organizations. The International Union for Conservation of Nature (IUCN) describes NBS as “actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” [1]. Similarly, the European Commission emphasizes that NBS are strategies “inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits, and help build resilience” [3]. These definitions underline the multifunctional role of NBS in addressing contemporary challenges such as climate change, disaster risk reduction, and biodiversity loss.

2.2. Theoretical Foundations

The concept of NBS is underpinned by several key theoretical frameworks. One of the primary foundations is ecosystem services, which refer to the benefits that ecosystems provide to humans, such as clean water, air purification, pollination, and climate regulation [17, 18]. By leveraging these services, NBS aim to integrate natural processes into problem-solving strategies.

Another important theoretical foundation is green infrastructure, which involves integrating natural elements into urban environments, such as parks, wetlands, and green roofs, to enhance ecological functions while improving human well-being [12, 19]. Green infrastructure is widely used in urban planning to mitigate the effects of climate change, manage stormwater, and improve air quality.

Additionally, the concept of resilience plays a central role in NBS, as these solutions aim to enhance the adaptive capacity of both ecosystems and human communities to withstand and recover from environmental disturbances [20, 13]. Resilience-based approaches are often applied in climate change adaptation strategies, emphasizing nature’s ability to act as a buffer against extreme weather events and other stressors.

2.3. Applications in Policy and Practice

NBS have been incorporated into a range of policy frameworks and practical applications across different sectors. In urban planning, cities increasingly adopt NBS to enhance resilience against environmental challenges. For example, green roofs and urban forests are used to reduce the urban heat island effect and improve air quality [8, 21]. Similarly, green corridors and wetland restoration projects contribute to sustainable urban water management by mitigating flood risks [12].

In climate change adaptation and mitigation, NBS contribute to global efforts by enhancing carbon sequestration through ecosystem restoration and providing natural

buffers against climate-induced hazards [22, 23, 24]. Forest conservation and afforestation projects, for instance, serve as carbon sinks, reducing atmospheric greenhouse gas concentrations. Additionally, coastal restoration projects, such as mangrove reforestation, help protect shorelines from rising sea levels and extreme weather events.

NBS are also widely applied in disaster risk reduction, where natural solutions such as wetland restoration, reforestation, and dune stabilization mitigate the impact of natural disasters like floods, landslides, and hurricanes [9, 24, 25]. These approaches highlight the cost-effectiveness of nature-based strategies compared to traditional grey infrastructure, offering sustainable alternatives to engineered solutions.

2.4. Challenges and Considerations

Despite their growing adoption, NBS face several challenges that limit their effectiveness. One key issue is standardization, as there is a lack of clear guidelines and metrics for evaluating the success of NBS interventions [26, 27]. Without standardized methodologies, comparing the effectiveness of different NBS applications becomes difficult, leading to inconsistencies in implementation and monitoring.

Another challenge is policy integration, as aligning NBS with existing regulatory frameworks requires cross-sectoral collaboration and political commitment [3]. Many policy initiatives supporting NBS remain fragmented, lacking cohesive strategies to ensure widespread and long-term adoption.

Furthermore, ecosystem service assessment remains a critical challenge, as accurately measuring the benefits provided by ecosystems is essential for evidence-based decision-making [13, 28]. Effective NBS implementation requires robust assessment frameworks that quantify ecological, social, and economic impacts.

Despite the conceptual appeal of Nature-Based Solutions, this paper is motivated by a growing concern: the widespread enthusiasm surrounding NBS is not always matched by tangible outcomes or consistent implementation. As a researcher in the field of ecological planning, I have observed that NBS is often referenced as a panacea in policy documents and academic discourse, yet rarely subjected to rigorous empirical scrutiny. This discrepancy between rhetorical prominence and practical impact forms the core rationale for the study. Rather than adopting a neutral stance, this paper takes a critical position: unless NBS research embraces more empirical rigor and implementation-focused frameworks, it risks becoming a symbolic placeholder in sustainability discourse rather than a genuinely transformative solution. This study is therefore intended not only as a review but as a provocation—an invitation to rethink the trajectory of NBS research and practice.

3. Materials and Methodology

This study employs a mixed-methods design that combines quantitative trend analysis with qualitative thematic analysis to examine the evolution of Nature-Based Solutions (NBS) research. The integration of numerical data with topic modeling and content interpretation offers a more comprehensive understanding of both the volume and focus of NBS scholarship.

3.1. Data Collection and Inclusion Criteria

The dataset consists of 1,380 peer-reviewed research and review articles retrieved from the Web of Science (WoS) Core Collection. The search was conducted in March 2025 using two keyword variations: “nature-based solutions” and “nature based solutions”. These terms were searched specifically in the article title field to ensure topic relevance. Only English-language publications between 2014 and 2024 were included. Non-academic documents (such as book chapters, editorials, and conference proceedings) were excluded. This decision aimed to capture only academically vetted research outputs.

3.2. Quantitative Analysis: Publication Trends and Journal Distribution

Quantitative analysis was conducted using Microsoft Excel to identify yearly publication trends and the top publishing journals. The dataset was sorted by publication year and source title, and frequencies were calculated. These results served as the basis for temporal distribution charts and journal productivity rankings (see Tables 1 and 2).

3.3. Qualitative Analysis: Thematic Mapping via LDA

To uncover dominant research themes within NBS literature, a Latent Dirichlet Allocation (LDA) model was applied to the abstract texts of all retrieved articles. This unsupervised machine learning technique enables the discovery of latent thematic structures by identifying patterns in word co-occurrence. The LDA model was implemented using Python and associated libraries such as scikit-learn and NLTK. Abstracts were pre-processed through tokenization, lowercasing, stop-word removal, and lemmatization to ensure semantic clarity. The optimal number of themes was determined via coherence testing, and five main topics were identified.

Recent research has applied Latent Dirichlet Allocation (LDA) to explore thematic evolution in the NBS literature. For instance, Zhou et al. [29] analyzed 2,625 Scopus-indexed publications from 2009 to 2022, identifying dominant themes such as urban governance, green infrastructure, and flood mitigation. Similarly, Park and Lee [30] used dynamic topic modeling to track shifts in research focus across 2,902 articles, noting a growing emphasis on carbon sequestration and sustainable agriculture. While these studies have contributed to mapping the breadth of NBS-related topics, they largely remain descriptive and trend-oriented. In contrast, the present study combines LDA with

a critical discourse orientation, using thematic clustering not only to identify research concentrations but also to interrogate the imbalance between conceptual abundance and empirical scarcity.

3.4. Validity, Reliability, and Researcher Positioning

While LDA provides computational robustness, thematic interpretation of each topic was performed manually by the author to ensure contextual relevance. To minimize bias, the results were cross-validated with key literature reviews and prior meta-analyses on NBS. Although the classification of abstracts into thematic clusters is inherently interpretive, every effort was made to anchor category names and insights in empirical grounding.

Finally, the researcher's stance in this study is explicitly critical yet constructively oriented. Rather than dismissing the value of NBS, the aim is to interrogate the discrepancy between narrative and implementation, and to identify opportunities for empirical strengthening in future research.

4. Results

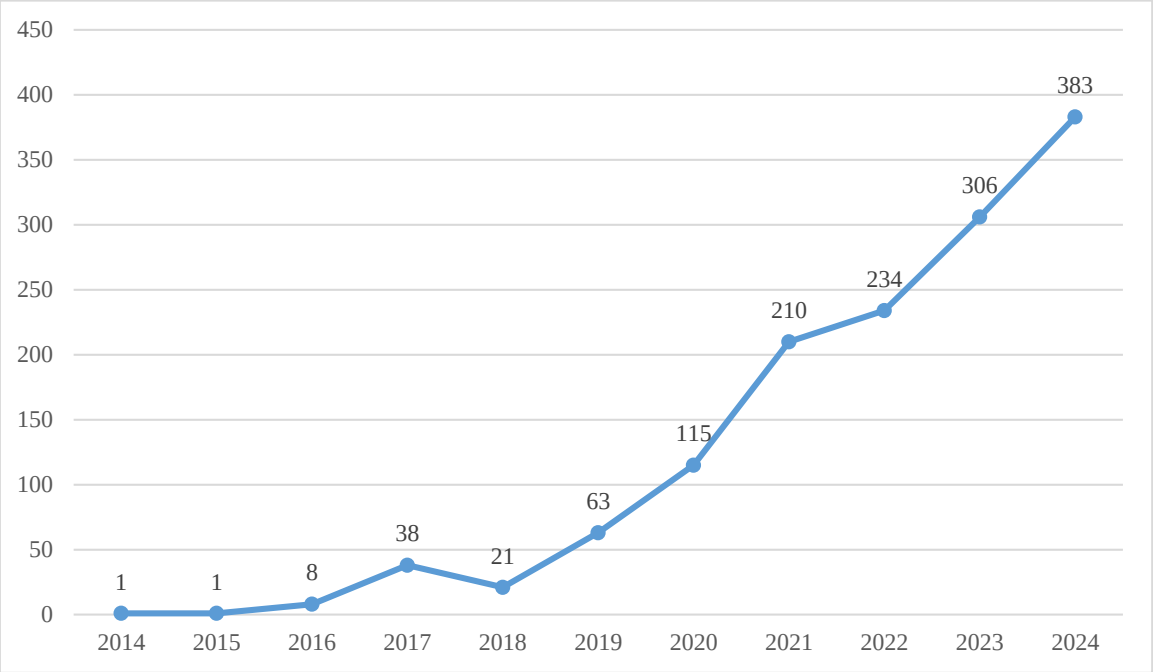
The results of this study provide a detailed breakdown of how NBS research has evolved over time and the extent to which it aligns with theoretical or applied frameworks. The findings are structured into three key sections:

- temporal trends in NBS research,
- thematic distribution of publications, and
- the balance between conceptual and empirical studies.

4.1. Temporal Trends in NBS Research

An analysis of publication trends from 2014 to 2024 indicates a significant rise in NBS-related research over the past decade. The number of articles published annually has increased, particularly after 2020, coinciding with the inclusion of NBS in major global policy frameworks such as the UN Climate Action Summit and the European Green Deal (Table 1). The steep increase suggests growing academic and policy interest in NBS; however, the extent to which this interest translates into practical implementation remains uncertain.

Table 1. Distribution of the number of articles with "nature based solutions" in their titles by year.



In line with the findings of the research, the top ten journals that published the most articles on nature based solutions are given in Table 2.

Table 2. Top ten journals publishing the most articles on nature based solutions between 2014 - 2024.

	Journal	Number of articles
1	Sustainability	94
2	Science of the total environment	46
3	Environmental science & policy	37
4	Journal of environmental Management	37
5	Land	35
6	Water	32
7	Urban forestry & urban greening	28
8	Ambio	21
9	Land use policy	17
10	Ecological engineering	16

4.2. Thematic Distribution of Publications

To further analyze the dominant themes within NBS research, a word frequency analysis was conducted on the article titles and abstracts. Figure 1 illustrates the most frequently occurring terms, revealing key focus areas in the literature.



Figure 1. The most frequently occurring meaningful words in the titles of articles on nature-based solutions.

The categorization of the reviewed articles into five primary themes—urban planning and infrastructure, climate change adaptation, water management, biodiversity and ecosystem conservation, and green spaces and carbon sequestration—reveals distinct research priorities. Urban planning and infrastructure emerged as the most frequently studied topic, comprising 32% of the analyzed studies. Climate change adaptation followed closely, accounting for 26% of the articles. Water management and biodiversity conservation were also prominent, making up 23% and 21% of the dataset, respectively. Green spaces and carbon sequestration had the lowest representation, appearing in 19% of the reviewed studies. These results suggest that while NBS is broadly recognized across various disciplines, its application is predominantly discussed within the context of urban development and climate adaptation.

4.3. Conceptual vs. Empirical Research

A key focus of this study was to determine whether NBS research is predominantly conceptual or application-oriented. The content analysis revealed that 64% of the reviewed studies primarily presented theoretical discussions, policy discourse, or conceptual frameworks without empirical validation. Only 36% of the publications contained case studies, quantitative assessments, or implementation-focused analyses. This imbalance highlights a critical gap in the literature—while NBS is frequently referenced as an essential component of sustainability transitions, the number of studies providing measurable outcomes and evaluations remains limited. This finding raises concerns regarding the operational feasibility of NBS and underscores the need for further empirical investigations. While the studies were evaluated within the scope of thematic categories, the total number of articles within the scope of thematic groups in this

evaluation exceeds 1380, as some studies were produced in a way that could be included in more than one thematic group.Thematic distribution of articles written on the subject (Figure 2):

- Urban Planning and Infrastructure (696 studies): Emphasis on theoretical frameworks rather than implementation.
- Climate Change Adaptation (568 studies): Frequent mention of resilience and mitigation but limited empirical evidence of effectiveness.
- Water Management (518 studies): A more balanced mix of conceptual and applied research.
- Biodiversity and Ecosystem Conservation (493 studies): Conservation-oriented approaches dominate over actionable restoration.
- Green Spaces and Carbon Sequestration (419 studies): Carbon sequestration potential often estimated rather than measured.

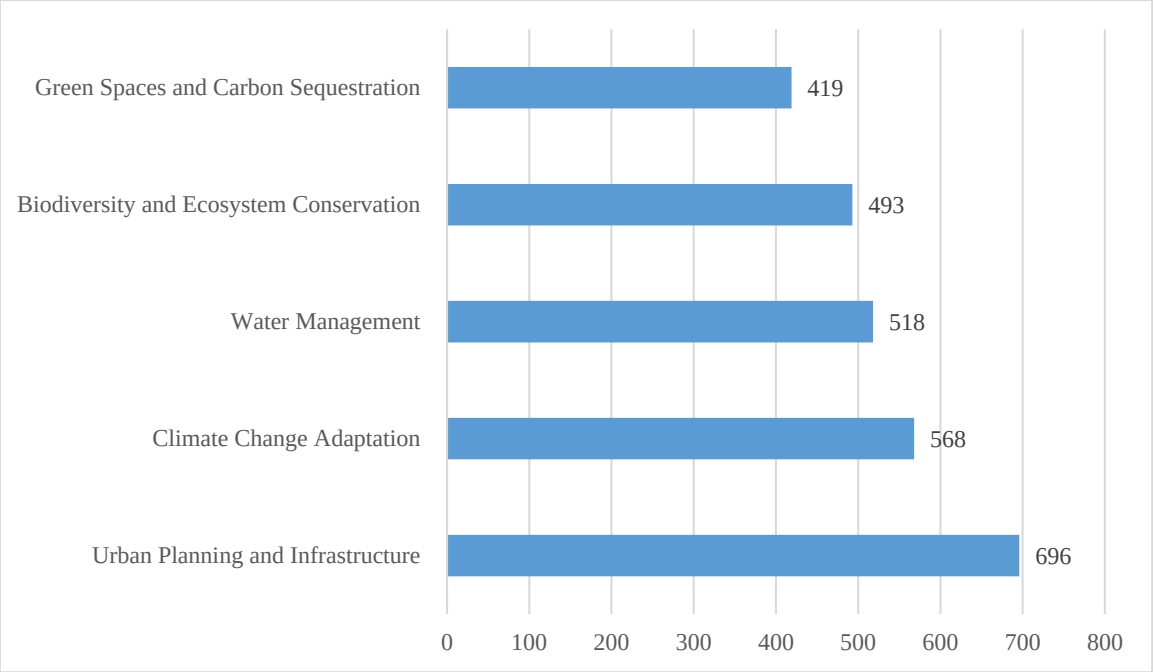


Figure 2. Thematic distribution of articles written on the subject.

According to the findings, the top ten words most frequently used in article titles and reflecting the content of the study are urban (1688), climate (994), water (740), management (527), potential (526), implementation (523), environmental (508), ecosystem (501), planning (498), and challenges (496).

5. Discussion: Is NBS a Solution or a Buzzword?

5.1. Growth in NBS Research: Hype or Genuine Advancement?

The analysis of publication trends in Web of Science indicates that Nature-Based Solutions (NBS) research has seen an exponential rise since 2020, particularly in urban planning, water management, and climate adaptation. This rapid expansion suggests that NBS has become a mainstream topic in environmental sciences and policy-making. However, increased academic attention does not necessarily translate into real-world effectiveness.

The significant increase in NBS-related publications between 2014 and 2024—particularly after 2020—demonstrates the growing institutional and academic interest in the concept (see Table 1). However, this upward trend does not necessarily signal a proportional advancement in implementation-focused research. As the analysis in Section 4.3 reveals, only 36% of the reviewed articles provide empirical assessments, while the remaining 64% are dominated by theoretical and policy-oriented discussions. This imbalance suggests that the growth in publication volume may reflect rhetorical enthusiasm more than practical progress. The sharp rise in scholarly attention, especially in the wake of the UN Climate Action Summit and the European Green Deal, underscores how NBS has become a mainstream narrative—yet one still struggling to deliver measurable impact on the ground. Thus, the expansion of NBS research risks generating an illusion of advancement, while real-world applications remain underexplored.

A critical question arises: Are these publications driving actionable, nature-based interventions, or merely repeating a conceptual framework that remains largely unimplemented? The high volume of policy-focused papers, as seen in this thematic analysis, suggests that much of the discourse still operates at the theoretical level, rather than focusing on empirical case studies with measurable success.

5.2. Key Themes: What is Actually Being Discussed?

The thematic analysis of 1,380 NBS-related publications reveals a distinct concentration of scholarly focus around a limited set of recurring topics. As illustrated in Figure 2, urban planning and infrastructure emerge as the most dominant theme, comprising 32% of the dataset. This is followed by climate change adaptation (26%), water management (23%), biodiversity and ecosystem conservation (21%), and green spaces and carbon sequestration (19%). These findings suggest that while NBS is being applied across multiple domains, the discourse is heavily skewed toward urban-centric strategies and high-level climate narratives.

This thematic concentration raises important concerns. The prominence of urban planning and climate adaptation in the literature, while understandable given the urgency of urban resilience and climate crises, also reflects a pattern of conceptual over-representation.

Many of these studies emphasize NBS as a visionary planning ideal rather than offering concrete implementation pathways or success metrics. For example, references to "urban transformation through green infrastructure" or "resilience via nature-based planning" are common, yet often remain abstract and unaccompanied by data-driven assessments. As a result, the repetition of such themes risks creating rhetorical density—an echo chamber where certain concepts gain traction more for their normative appeal than for demonstrated efficacy.

Moreover, the comparatively lower frequency of publications on biodiversity conservation and carbon sequestration—both of which require long-term ecological monitoring—highlights a reluctance to engage with empirical complexity. These domains often demand quantitative measurements and ecosystem-based metrics, which may explain their relative underrepresentation. The focus instead remains on domains where policy rhetoric is easier to generate and harder to verify.

In short, the data suggest that thematic saturation around politically resonant but practically underdeveloped areas may contribute to the symbolic inflation of NBS—a scenario where frequency of discussion substitutes for functional evidence.

While previous LDA-based studies have mapped the thematic expansion of NBS research (Zhou et al., 2024; Park & Lee, 2023), they have largely remained at a descriptive level. This study contributes to the field by linking thematic concentration to discursive saturation, offering a critical interpretation of how rhetorical emphasis may displace empirical depth.

5.3. The Critique: The Gap Between Theory and Practice

Despite the increasing academic enthusiasm for Nature-Based Solutions, a persistent disconnect between theory and implementation remains evident. As detailed in Section 4.3, only 36% of the reviewed publications offer empirical validation, while the vast majority—64%—are grounded in conceptual frameworks, policy analysis, or theoretical discourse. This imbalance signals a structural weakness in the field: while NBS is frequently cited as a cornerstone of sustainability transitions, there is limited evidence to support its effectiveness on the ground.

The data also show that even within application-heavy themes such as water management or urban planning, many studies stop short of presenting implementation outcomes. Instead, they tend to reframe established sustainability narratives through the lens of NBS without introducing new models, metrics, or field-tested interventions. This tendency risks reducing NBS to a discursive proxy—a placeholder concept that gestures toward ecological change without delivering measurable results.

Moreover, the absence of long-term monitoring and evaluation frameworks in the literature exacerbates this gap. Projects are often discussed in terms of their intended

benefits rather than verified impacts. Even when implementation is described, follow-up assessments that track social, ecological, or economic outcomes are rarely provided. This not only limits the scalability of successful initiatives but also weakens the credibility of NBS as a replicable policy mechanism.

The findings therefore raise a fundamental question: can NBS live up to its transformative promise without methodological accountability? Unless the research community shifts toward data-driven approaches and standardized evaluation protocols, NBS may struggle to move beyond its current rhetorical appeal and establish itself as a genuinely impactful environmental strategy.

5.4. Greenwashing Risks and Capitalization of NBS

As Nature-Based Solutions have gained traction in global policy arenas, they have also become attractive to corporate and financial actors seeking to brand themselves as environmentally responsible. However, this increasing interest raises significant concerns about greenwashing and the financialization of ecological discourse. Without rigorous accountability standards, NBS risks being co-opted as a marketing tool rather than an ecological intervention.

One striking example is the rise of carbon offsetting schemes that use tree planting or ecosystem restoration as a justification for continued emissions elsewhere. For instance, oil and gas companies such as Shell and BP have promoted large-scale reforestation projects under the NBS label while simultaneously expanding fossil fuel operations. Critics argue that these projects serve more to sustain extractive industries' public image than to advance genuine environmental repair.

Similarly, the proliferation of green financial instruments, such as “nature-based” bonds or sustainability-linked loans, further commodifies NBS. In many cases, investors receive sustainability ratings or tax incentives without verified ecological outcomes. For example, some urban green infrastructure projects funded through “green bonds” in major European cities have been criticized for displacing marginalized communities and providing little measurable ecological value.

This instrumentalization of NBS also extends to urban redevelopment strategies. Real estate developers increasingly incorporate “green” branding—such as green roofs, rain gardens, or bio-corridors—into high-end housing projects, often under the NBS umbrella. Yet these projects frequently prioritize aesthetics and market appeal over ecological restoration or social inclusion.

What unites these examples is the symbolic use of nature as a branding mechanism. Rather than addressing root causes of ecological degradation—such as deforestation, overconsumption, or industrial pollution—NBS is often invoked to justify existing

practices. This trend dilutes the transformative potential of NBS and may ultimately erode public trust in nature-based approaches.

Unless NBS initiatives are backed by measurable standards and independent evaluation mechanisms, they remain vulnerable to co-optation by actors whose primary interests may not align with ecological or social integrity.

5.5. Moving Forward: Towards a More Critical and Empirical NBS Framework

If Nature-Based Solutions are to move beyond conceptual endorsement and fulfill their potential as transformative environmental strategies, a paradigm shift in research, policy, and implementation is essential. This shift begins with prioritizing empirical research. Future studies must go beyond aspirational language and focus on quantifying the ecological and social impacts of NBS initiatives. Measurable indicators—such as biodiversity indices, carbon sequestration rates, water retention capacity, or community well-being metrics—are crucial for evaluating effectiveness and informing adaptive management.

Secondly, there is a pressing need for standardized definitions and evaluation frameworks. The flexibility of the NBS concept has allowed for broad and sometimes opportunistic interpretation, undermining its credibility. To counter this, scientific institutions and international agencies should develop clear criteria for what constitutes a legitimate NBS initiative. This includes guidelines on design, implementation, monitoring, and reporting that can be adapted to local contexts while maintaining global accountability.

Third, scaling up implementation remains a major challenge. Many NBS projects remain confined to small pilot programs or short-term interventions. Moving toward regional or national-scale integration requires not only funding and political will, but also institutional coordination across urban planning, environmental management, and public health sectors. Embedding NBS within long-term infrastructure and climate adaptation strategies will help legitimize them as mainstream planning tools rather than experimental add-ons.

Fourth, interdisciplinary collaboration is key to unlocking the full potential of NBS. Ecologists, engineers, social scientists, economists, and urban designers must work together to create holistic solutions that are both scientifically grounded and socially equitable. Such collaboration will ensure that NBS initiatives are not only ecologically effective but also resilient to socio-political pressures and inclusive of diverse community needs.

Finally, NBS research and practice must incorporate a critical awareness of power dynamics and equity. Marginalized communities often bear the brunt of environmental degradation while being excluded from decision-making. NBS projects should avoid

reproducing this inequity by adopting participatory planning models and prioritizing environmental justice as a core principle. Without such inclusivity, the risk remains that NBS will serve elite agendas rather than public good.

In sum, the way forward demands a collective commitment to empirical accountability, structural clarity, and ethical integrity. Only through such a commitment can NBS evolve from a promising idea into a resilient, measurable, and just solution for the environmental challenges of our time.

5.6. Innovation or Rhetoric?

The rapid ascent of Nature-Based Solutions in both academic and policy discourse reflects a global appetite for sustainable alternatives that align ecological integrity with societal well-being. Yet, as this study has demonstrated, the substance beneath the rhetoric remains uneven. The dominance of theoretical and policy-driven literature, the limited proportion of empirically grounded studies, and the co-optation of NBS by corporate interests collectively raise doubts about the concept's transformative capacity.

At present, NBS straddles a precarious line between innovation and rhetorical inflation. On one hand, it holds genuine promise: restoring ecosystems, mitigating climate risks, and offering cost-effective strategies for urban resilience. On the other hand, its flexibility and popularity have rendered it vulnerable to symbolic appropriation, where invocation of the term substitutes for tangible action. In this sense, NBS risks becoming a semantic vessel—filled with aspirations but emptied of enforceable commitments.

This study does not claim that NBS is inherently flawed or irredeemably co-opted. Rather, it argues that the concept's future depends on how critically it is applied and how rigorously it is evaluated. If NBS is to be more than a sustainability slogan, the research community must shift from celebratory narratives to accountability-based inquiry. Governments, funding agencies, and civil society must likewise insist on evidence, equity, and enforceable outcomes.

Nature-Based Solutions are not yet a failed promise—but they are at risk of becoming one. Whether they evolve into a meaningful framework for environmental transformation or remain a sophisticated policy buzzword will depend on the collective will to confront their limitations and close the gap between language and action.

6. Conclusion and Recommendations

Addressing these challenges is essential to the meaningful integration of Nature-Based Solutions (NBS) into both scientific research and policy-making. To move beyond abstract discourse, a more rigorous, standardized, and implementation-focused approach is required—one that ensures NBS deliver measurable, transformative outcomes for sustainability.

6.1. Conclusion: The Need for a Reality Check on Nature-Based Solutions

Nature-Based Solutions have gained significant academic and policy attention in recent years, yet this study reveals a persistent imbalance between theory and practice. While NBS is frequently championed as a transformative paradigm, only a minority of studies offer empirical validation or large-scale, outcome-driven evaluations. Instead, the literature is overwhelmingly shaped by conceptual frameworks and policy rhetoric. As a result, there is a growing risk that NBS may become symbolic placeholders—concepts that resonate well in political narratives but fail to translate into real-world change.

This paper's contribution lies in both its critical stance and methodological approach. By combining quantitative trend analysis with topic modeling and content interpretation, the study maps dominant research themes and exposes structural gaps in the literature. In doing so, it challenges the assumption that increasing visibility equates to increasing impact.

6.2. Recommendations: Bridging the Gap Between Concept and Implementation

To address these concerns, the following recommendations are proposed:

- Empirical Orientation: Future research should prioritize not only theoretical contributions but also quantifiable assessments of NBS outcomesusing metrics such as biodiversity indices, carbon sequestration rates, and climate resilience indicators.
- Standardization: Clear criteria and global/regional frameworks should be developed to define what constitutes an authentic NBS. This will curb inconsistent interpretations and reduce risks of greenwashing.
- Scaling Up: Small-scale pilot projects must transition into institutionalized, long-term implementations. This requires structural support from governments, policy alignment, and targeted funding.
- Social Inclusion: Environmental justice and community participation must be embedded into the design and delivery of NBS projects. Without equitable involvement, NBS risks becoming an elite planning concept.
- Corporate Accountability: With the rise of private sector interest in NBS, regulatory oversight is crucial. Firms using the NBS label must be required to demonstrate measurable ecological and social outcomes.

6.3. Towards a More Meaningful and Effective NBS Framework

Moving forward, the NBS field must adopt a more critical, impact-oriented research agenda. This means going beyond rhetorical appeal and focusing on implementation outcomes.

Scholars should interrogate how NBS are implemented, whom they serve, and what trade-offs they entail. Such a shift requires not only interdisciplinary collaboration, but also an ethical commitment to avoid repeating past sustainability narratives that failed to deliver transformative change.

Only by demanding empirical evidence, enforcing accountability, and broadening the scope of inquiry can NBS fulfill their promise—not as a buzzword, but as a cornerstone of ecological and social resilience.

References

[1] IUCN (2022). Nature-based solutions. Website: https://iucn.org/our-work/nature-based-solutions. Accessed: 04.03.2025.

[2] World Resources Institute. (2023). What Exactly Are 'Nature-based Solutions'?. Retrieved from https://www.wri.org

[3] European Commission. (2021). Evaluating the impact of nature-based solutions: A handbook for practitioners. Directorate-General for Research and Innovation.

[4] Pontee, N., Narayan, S., Beck, M. W., & Hosking, A. H. (2016, March). Nature-based solutions: lessons from around the world. In Proceedings of the Institution of Civil Engineers-Maritime Engineering (Vol. 169, No. 1, pp. 29-36). Thomas Telford Ltd.

[5] Nesshöver, C., Assmuth, T., Irvine, K. N., Rusch, G. M., Waylen, K. A., Delbaere, B., & Wittmer, H. (2017). The science, policy, and practice of nature-based solutions: An interdisciplinary perspective. Science of the Total Environment, 579, 1215–1227.

[6] O'Hogain, S., McCarton, L., O'Hogain, S., & McCarton, L. (2018). Nature-based solutions. A technology portfolio of nature-based solutions: innovations in water management, 1-9.

[7] Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2019). Nature-based solutions to address global societal challenges. International Union for Conservation of Nature (IUCN).

[8] Frantzeskaki, N., McPhearson, T., Faivre, N., Kabisch, N., Radhakrishnan, M., & Naumann, S. (2019). Nature-based solutions for urban climate change adaptation: Linking science, policy, and practice communities for evidence-based decision-making. BioScience, 69(6), 455–466.

[9] Albert, C., Brillinger, M., Guerrero, P., Gottwald, S., Henze, J., Schmidt, S., ... & Schröter, B. (2021). Planning nature-based solutions: Principles, steps, and insights. Ambio, 50, 1446-1461.

[10] Wamsler, C., Pauleit, S., Zölch, T., Schetke, S., & Mascarenhas, A. (2020). Mainstreaming nature-based solutions in urban planning and governance. Cities, 105, 102853.

[11] Pascual, U., Palomo, I., Adams, V. M., Chan, K. M. A., Daw, T. M., & Garmendia, E. (2022). Nature-based solutions and their blind spots: A critical review of current research and practice. Conservation Letters, 15(3), e12875.

[12] Kabisch, N., Korn, H., Stadler, J., & Bonn, A. (2017). Nature-based solutions to climate change adaptation in urban areas: Linkages between science, policy, and practice. Springer.

[13] Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C., … & Turner, B. (2021). Getting the message right on nature-based solutions to climate change. Global Change Biology, 27(8), 1518–1546.

[14] Welden, E. A., Chausson, A., & Melanidis, M. S. (2021). Leveraging Nature-based Solutions for transformation: Reconnecting people and nature. People and Nature, 3(5), 966-977.

[15] Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., … & Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environmental Science & Policy, 77, 15–24.

[16] Lave, R., & Lutz, J. (2022). The political economy of nature-based solutions: Greenwashing, neoliberalism, and environmental governance. Environmental Politics, 31(4), 657–678.

[17] Maes, J., & Jacobs, S. (2017). Nature-based solutions for Europe's sustainable development. Conservation Letters, 10(1), 121-124.

[18] Calliari, E., Staccione, A., & Mysiak, J. (2019). An assessment framework for climate-proof nature-based solutions. Science of the Total Environment, 656, 691-700.

[19] Dorst, H., Van der Jagt, A., Raven, R., & Runhaar, H. (2019). Urban greening through nature-based solutions–Key characteristics of an emerging concept. Sustainable Cities and Society, 49, 101620.

[20] Randrup, T. B., Buijs, A., Konijnendijk, C. C., & Wild, T. (2020). Moving beyond the nature-based solutions discourse: introducing nature-based thinking. Urban Ecosystems, 23, 919-926.

[21] Lafortezza, R., & Sanesi, G. (2019). Nature-based solutions: Settling the issue of sustainable urbanization. Environmental research, 172, 394-398.

[22] Keesstra, S., Nunes, J., Novara, A., Finger, D., Avelar, D., Kalantari, Z., & Cerdà, A. (2018). The superior effect of nature based solutions in land management for enhancing ecosystem services. Science of the Total Environment, 610, 997-1009.

[23] Chausson, A., Turner, B., Seddon, D., Chabaneix, N., Girardin, C. A., Kapos, V., & Seddon, N. (2020). Mapping the effectiveness of nature-based solutions for climate change adaptation. Global Change Biology, 26(11), 6134-6155.

[24] Girardin, C. A., Jenkins, S., Seddon, N., Allen, M., Lewis, S. L., Wheeler, C. E., ... & Malhi, Y. (2021). Nature-based solutions can help cool the planet—if we act now. Nature, 593(7858), 191-194.

[25] Sutton-Grier, A. E., Wowk, K., & Bamford, H. (2015). Future of our coasts: The potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies, and ecosystems. Environmental Science & Policy, 51, 137-148.

[26] Cohen-Shacham, E., Andrade, A., Dalton, J., Dudley, N., Jones, M., Kumar, C., & Welling, R. (2021). Nature-based solutions: From concept to practice. International Union for Conservation of Nature (IUCN).

[27] Kumar, P., Debele, S. E., Sahani, J., Rawat, N., Marti-Cardona, B., Alfieri, S. M., ... & Zieher, T. (2021). An overview of monitoring methods for assessing the performance of nature-based solutions against natural hazards. Earth-Science Reviews, 217, 103603.

[28] Pereira, P., Yin, C., & Hua, T. (2023). Nature-based solutions, ecosystem services, disservices, and impacts on well-being in urban environments. Current Opinion in Environmental Science & Health, 33, 100465.

[29] Zhou, Y., Zhang, H., & Chen, M. (2024). Research trends of nature-based solutions: From urban to climate change. *Frontiers in Forests and Global Change*, *7*, 1351189. https://doi.org/10.3389/ffgc.2024.1351189

[30] Park, J., & Lee, S. (2023). Analysis of nature-based solutions research trends and integrated strategies using dynamic topic modeling. *Atmosphere*, *14*(12), 1775. https://doi.org/10.3390/atmos14121775