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Analysis and Evaluation of the Application of NbS Concept in Ecological Restoration Projects in Healthy Cities

—— Example of the Award-winning Projects of the 18th National Exhibition of Korean Landscape Architecture

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Abstract

With the intensification of the global ecological crisis, how to effectively balance the contradiction between human development and nature conservation has become a common concern for academics and policy makers. In recent years, nature-based solutions (NbS) have been highly valued for their potential to integrate ecological, social and economic dimensions (Eggermont et al., 2015). In Europe, the European Union (EU) has promoted the practice of NbS through the Green Cities Programme, which has successfully combined biodiversity conservation and urban development to significantly improve the quality of life of residents (Maes & Jacobs, 2017). In contrast, the application of NbS in South Korea is still in its infancy, but has shown a positive trend (Myung, 2021). This study investigates the application of NbS concepts in the process of restoring ecological structure of a site from a single level to a complex level, using the winning project of 'Landscape for Healthy City' in the 18th National Exhibition of Korean Landscape Architecture as an example. Project 1 reduces pollution and enhances biodiversity by changing the topography of abandoned hilly areas, installing windbreaks, and installing wetlands for purification, and brings economic benefits to the site through waste utilization. Project 2 transforms an over-refined nature into a self-regulating and sustainable nature by restoring soil strength. At the same time, both projects were scored and examined for their compliance with the NbS concept according to the <IUCN Global Standard for Nature-based Solutions : first edition>. The results of the examination showed that both projects scored 'adequately matched'. Both projects identified current societal challenges that humanity is addressing, while improving biodiversity and ecosystem integrity to a certain extent, and some of the strategies involved matched the global criteria of the NbS concept. However, because both projects were student competitions rather than actual completed projects, they lacked up-front economic feasibility and evidence-based adaptive management, and were superficial in reaching joint decisions with governments or stakeholders based on cultural and social context. However, this study gives three implications. First, it validates the usefulness of <Global Criteria for Nature-Based Solutions> in scoring and examining project NbS concepts. Second, designers can continuously update and refine the content of their solutions through NbS self-assessment prior to project implementation. Third, this study provides a preliminary demonstration of the role of NbS in solving social challenges and bringing about urban health. It provides a development direction for future NbS research when responding to the biodiversity crisis, climate crisis, and inclusiveness crisis context in Korea. And the study promotes the concrete implementation of NbS in cities and nature in the future.

1. Introduction

1.1 Social Background

The challenges facing contemporary human society, including climate change, food insecurity, land degradation, and biodiversity loss (Steffen et al., 2015; Rockström et al., 2009), are growing more severe. As these global environmental crises escalate, it has become increasingly evident that nature is fundamental to human survival, health, and quality of life (Cohen-Shacham et al., 2016; Myung & O, 2021). Consequently, efforts have intensified to reconcile human development with environmental conservation through engineering solutions. However, traditional approaches often prioritize socio-economic benefits, focusing on singular objectives while neglecting ecosystem integration and sustainability (He, 2021; Luo et al., 2020). This has sparked significant interest in nature-based solutions (NbS).

Research on NbS spans a wide array of fields, including ecological restoration, disaster management, and water resource utilization (Cohen-Shacham et al., 2016). NbS offers a holistic framework that leverages natural processes and fosters a symbiotic relationship between humans and ecosystems to address environmental and societal challenges (IUCN, 2020a; Eggermont et al., 2015).

In India, NbS has been employed to mitigate the impacts of coastal storms, such as by planting mangroves to reduce flooding risks (Gómez-Baggethun & Barton, 2013). Similarly, Brazil's Amazon rainforest conservation programs have effectively combined NbS practices with local economic development by promoting community engagement and sustainable agriculture (Rosenzweig et al., 2014). These cases demonstrate the adaptability of NbS in addressing diverse challenges. Nonetheless, existing research predominantly focuses on qualitative analyses of practical outcomes, lacking systematic evaluation standards and quantifiable indicators (Seddon et al., 2020). To address this gap, this study adopts the IUCN Global Standard to conduct a quantitative analysis of NbS projects.

1.2 Definition and Development of NbS

Nature-based Solutions (NbS) is based on existing practices in forest landscape restoration, water management, and ecosystem-based disaster mitigation (IUCN, 2020a). The term NbS was first introduced by the World Bank in its 2008 report Biodiversity, Climate Change and Adaptation: Nature-based Solutions in World Bank Investments, which called for a more systematic understanding of the relationship between people and nature (World Bank, 2008). In 2009, the World Conservation Union (IUCN) recommended NbS in its working report to the 15th Conference of the Parties (COP 15) of the United Nations Framework Convention on Climate Change (UNFCCC). In 2010, the IUCN, WB and the World Wide Fund for Nature (WWF) jointly published the Nature Programme Report - Protected Areas for Climate Change, which formally applied NbS to biodiversity conservation (He Qiu, 2021). At the 2016 IUCN Annual Meeting, NbS was first defined as 'NbS is the action to conserve, sustainably manage and restore natural and modified ecosystems that effectively and adaptively address societal challenges while providing human well-being and biodiversity benefits' (IUCN 2020). The fundamental goal of NbS is to address specific human societal challenges with a focus on nature-based benefits, while providing multiple important ecosystem services to society (Luo Ming 2020). In 2020, the IUCN introduced the Global Standard for Nature-Based Solutions and its accompanying Guidance for Using the IUCN Global Standard for Nature-Based Solutions, establishing the first comprehensive, globally recognized standards for NbS (IUCN, 2020a; IUCN, 2020b). These standards provide structured methodologies and assessment tools to support NbS implementation across diverse environmental and socio-economic contexts (Fan et al., 2018; Gómez-Baggethun & Barton, 2013).

Although South Korea's Fourth National Biodiversity Strategy (2019-2023) did not explicitly include NbS, discussions to incorporate NbS-related targets have emerged in the development of the Fifth National Biodiversity Strategy (Myung, 2021). For NbS to succeed in South Korea, detailed frameworks and national objectives will need to be established, grounded in robust research on both domestic and international NbS applications (Wong et al., 2021; Raymond et al., 2017).

2. Project Overview

2.1 Project Selection

Based on the award-winning projects of the 18th National Exhibition of Korean Landscape Architecture 'Landscape for Healthy City' , the grand prize work and gold prize work that conform to the NbS concept while creating a healthy landscape were selected for analysis and scoring.

The grand prize work is Project 1. It is located in the hilly design between the reclaimed land in the Seoul metropolitan area and Sawol Village. Since the 1980s, the landfill site in Wanggil-dong, Seo-gu, Incheon , has been used for heavy metal pollution from landfills, and pollutants have been infiltrating Sawol Village through air and water, posing a great health risk to the residents.In order to solve the pollution problem in Sawol Village, we chose the hilly area between the reclaimed land in the Seoul metropolitan area and Sawol Village, which had been left unused for a long time, as the site for the project, and operated the topography of the hilly area and built an ecological project to restore the healthiness of Sawol Village. The gold prize work is Project 2. It is a natural restoration process for a golf course. The refined land in urban development loses its natural original ability of self-regulation and ecological sustainability, and the problems arising from the soil will gradually rise to the surface of the earth and will soon threaten human beings. So the project aims to return the refined land to an indefinite state and lay the foundation of a healthy city, making the city dwellers who visit there face the real nature without refinement (Lai et al., 2020; Rosenzweig et al., 2014).

The idea of NbS is to restore ecology as the main object (He Qiu, 2021; Fan et al., 2018), while Project 1 as an abandoned land lacking management and Project 2 as an over-refined lawn site both need to restore biodiversity by means of NbS, and both need to restore from a single ecological structure to a natural state with a complex and sustainable ecological structure (Chazdon et al., 2016; Lindemayer et al., 2012). And both projects have different degrees of relevance to NbS strategies. Therefore, it is proposed to analyze the strategies of both projects as a reference for the future development of NbS in Korea, which will help to explore the future development direction of NbS in Korea using nature to solve major social challenges and to promote the concrete implementation of the NbS concept in Korea (Seddon et al., 2020; Frantzeskaki et al., 2019).

2.2 Project 1

2.2.1 Project Background

Urbanization and industrialization have increased the overall standard of living in cities, but have reduced the quality of physical health in some cities (McDonald et al., 2016). The pollution brought by the process of urbanization is having a bad impact on urban health.The landfill site in Wanggil-dong, Seo-gu, Incheon, which has been in use since the 1980s, has generated heavy metal pollution from landfills and carried pollutants through the west wind to Sawol Village, which is located only 1km east of the site, resulting in a higher than average percentage of harmful substances in the urine and blood of Sawol Village residents, and causing depression and anxiety among the villagers (Myung et al., 2021). Also, the factory wastewater flowing from Sawol Village has deteriorated the water quality. Although Sawol Village is an area with a high rate of elderly people, medical facilities and welfare facilities are inadequate (Kim et al., 2020).

2.2.2 Project Strategy

The main idea of this project is to purify heavy metals in the air and water by changing the topography and installing windbreak forests and wetland purification. The design strategy is divided into four main aspects as follows :

1. Topography: Steep slopes are steeply sloped with a stepped design, so that the original steep slopes with a slope ratio greater than 1:3 become steps where trees can be planted. Fill in the soil of the villagers' frequent land use to the low-lying areas of the terrain. Polishing the overall terrain into a curved shape to effectively absorb the wind containing heavy metals (Huang et al., 2018).

2. Purify the air: Set up magnetic mounds on the hillside to absorb harmful substances from the wind. The wind-proof forest is set up with beech trees, cypress and other plants, and heavy metals are sunk by the principle of high humidity and low temperature in the forest, and heavy metals are adsorbed by laying wooden pillows on the ground (Fan et al., 2018).

3. Water purification: Set up purification gardens and wetlands. Inject polymer coagulant and iron powder into the purification garden, and let the reusable stainless steel mesh adsorb harmful components after electricity is applied, and the water flowing out will enter the planting wetland again for secondary purification (Zhang et al., 2019).

4. Revenue and energy creation: Set up an ink processing plant to manufacture ink from refined heavy metal substances, and create a certain economy after the ink is sold. And organize a tour of the plant for students to achieve educational effect. Covering the place where waste is illegally landfilled to generate new energy. Covering the waste with a certain amount of soil so that rainwater will not seep in and prevent the groundwater from being polluted by rainwater washing. The gas generated from the waste is collected and used for heating the museum, medical treatment and integrated cultural center built (Oberndorfer et al., 2007).

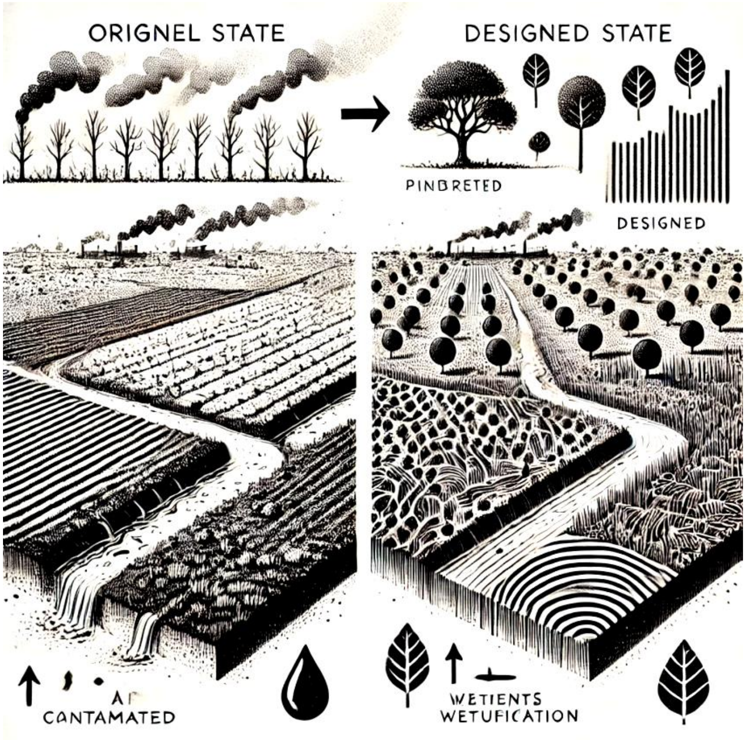

Figure 1.Sawol Village in its original state vs. its designed state

2.3 Project 2

2.3.1 Project Background

In the development of the modern city, the human vision of nature has led to the creation of various spaces that resemble nature in various parts of the city. However, most of them only imitate the shape of nature without considering the structure and order of nature, and focus only on the naturalistic space of shape, i.e. 'refined nature'. The representative space of naturalism in the city is the golf course. Golf courses are the greatest reflection of people's desire to enjoy leisure in nature. Golf courses are superficially very similar to nature, but actually stand out more when placed side-by-side with nature, so they are built in the midst of mostly lush mountains and forests. But in order to maintain the exquisite turf space, not only does it consume huge expenses, but it also destroys the biological and ecological communities that inhabit the surrounding natural space (Rosenzweig et al., 2014; Tzoulas et al., 2007). This negatively affects the subsurface ecological community such as surface erosion, topographic damage, changes in the water table, and suppression of microorganisms. The problems that arise from the soil will gradually rise to the surface of the earth.

The Taereung Physical Fitness Course is the only golf course in Seoul and a large green space in the center of the city. Therefore, Taereung Physical Fitness Course was chosen as a target for soil restoration, and various spaces and facilities were planned to observe this restoration process (Chapin et al., 2000).

2.3.2 Project Strategy

This project is a process of restoring modern green areas to natural green soils as well as the land surface. Topsoil is the soil layer with the highest concentration of organic matter and microorganisms within the soil and forms the most active life activity. It takes more than 200 years to produce topsoil with a thickness of 1 cm. In order to return to the earth in its unrestricted form, soil forces should first be restored by generating topsoil. Based on the needs of the project site type and ecological restoration process, the main strategies of the project can be divided into four parts as follows:

1. Soil restoration: The polluted soil is purified and restored by using plant purification process and composting method with microbial decomposition reaction. Afterwards, legumes that promote nitrogen fixation are planted, and the hugelkultur method is used to create an environment where organic matter and microorganisms coexist within the soil, allowing the organic matter and microorganisms in the soil to naturally form a new natural topography and ecosystem (Bradshaw, 1983).

2. Vegetation restoration: Research the surrounding plant communities and imitate planting on the site, so as to achieve the purpose of restoring planting on the site and provide the possibility of sustainable development of the ecosystem by using local native plants (Chapin et al., 2000).

3. Water restoration: Use the wetland to connect the originally cut off water source and restore the groundwater level (Maes & Jacobs, 2017).

4. Sustainable ecology: A soil exhibition hall is set up, using the original soil purification facilities so that visitors can see a demonstration of the entire purification process. At the same time, by observing the restoration process of the earth, people can realize again the importance of nature and natural order in the city (Gómez-Baggethun & Barton, 2013).

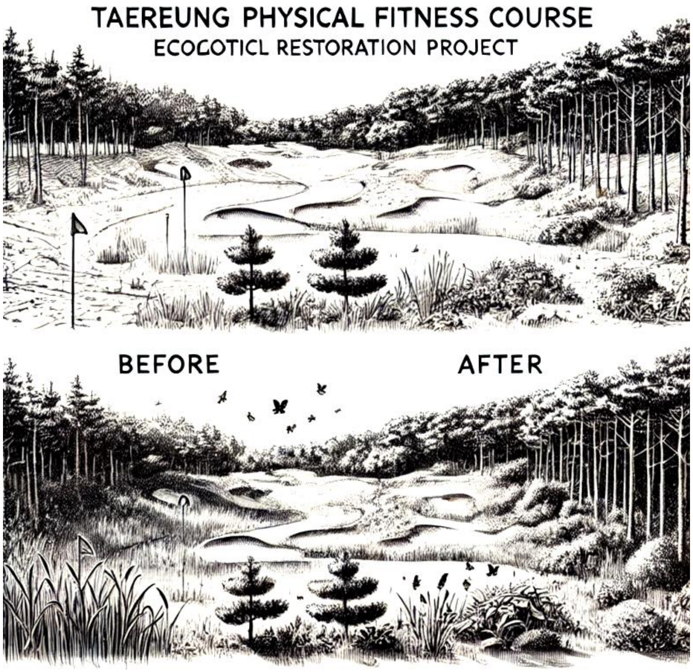

Figure 2. Before and after revegetation of Taereung Physical Fitness Course project

2.4 Practical Considerations for Project Implementation

While the proposed projects demonstrate clear ecological restoration strategies aligned with Nature-based Solutions (NbS), the manuscript lacks sufficient discussion of practical applications. Addressing potential implementation challenges, public engagement, and alignment with global standards will enhance the manuscript's impact. This section explores these considerations in detail.

2.4.1 Feasibility of Implementation

The successful realization of ecological restoration projects requires addressing potential technical challenges and resource demands.

Technical Challenges and Solutions:

Windbreak Forests: Selecting plant species suitable for the local climate and soil is critical. Low survival rates in the initial phase can be mitigated through soil improvement measures and supplemental irrigation. Additionally, the identification and use of heavy metal-absorbing plants should be supported by experimental evidence and long-term monitoring.

Wetland Purification Systems: Effective water purification relies on precise control of water flow and retention time. Excessive water volumes may overwhelm the system, while insufficient water may hinder pollutant filtration. Integrating intelligent monitoring systems to dynamically adjust water flow could address this issue.

Pollution Treatment Facilities: Technologies such as magnetic adsorption for heavy metal removal must balance long-term operational costs with maintenance requirements. Furthermore, safely storing or repurposing treated heavy metals remains a critical issue to resolve.

Cost and Resource Considerations:

Phytoremediation: Implementing phytoremediation involves costs related to plant acquisition, planting, and maintenance. A cost-benefit analysis can be conducted to compare this method with alternative techniques, such as chemical remediation.

Microbial Decomposition: Although eco-friendly, microbial remediation requires careful consideration of the environmental factors (e.g., temperature and humidity) affecting microbial activity. The training of personnel for managing these processes is an additional cost factor.

Social and Policy Support: Collaborative efforts between government bodies, community organizations, and academic institutions are essential. Securing funding, building public awareness, and fostering multi-stakeholder partnerships will be critical to ensuring smooth project implementation.

2.4.2 Public Engagement and Educational Significance

Engaging local communities and promoting public awareness are vital for the sustainability of ecological restoration projects.

Project 1 (Sawol Village):

Public Education Activities: Community education programs can be organized to raise awareness of heavy metal pollution and its effects. Workshops and demonstrations on soil and water quality testing can empower residents with practical knowledge.

Community Participation: Establishing local environmental groups to oversee the maintenance of windbreak forests and wetlands can increase community involvement. Regular activities, such as tree planting and wetland cleanups, can foster a sense of ownership among residents.

Long-Term Monitoring: A participatory monitoring framework can be developed, enabling residents to contribute to tracking the progress and effectiveness of restoration efforts.

Project 2 (Taereung Physical Fitness Course):

Educational Role of Soil Exhibition Hall: The proposed soil exhibition hall could showcase the entire soil purification process through interactive demonstrations. Visitors could observe live microbial decomposition experiments or participate in hands-on activities, such as simulating soil restoration in a sandbox model.

Eco-tourism and Public Interaction: The restored ecological area could be integrated into an eco-tourism initiative, offering guided tours and themed experiences. This would not only enhance public understanding of ecological restoration but also generate financial support for project maintenance.

Collaboration with Educational Institutions: Partnering with local schools to develop curriculum modules focused on NbS and ecological restoration can provide long-term educational benefits. Students can participate in site visits and engage in data collection activities to support research efforts.

2.4.3 Alignment with Global Standards

To position the projects within the broader context of international ecological restoration efforts, it is essential to examine their compliance with established NbS standards.

Sustainability of Ecosystems: Both projects emphasize restoring ecological complexity by transitioning from degraded or overly simplified systems to diverse and resilient ecosystems. For instance, Project 1 integrates natural terrain modification with biological remediation, while Project 2 reconstructs topsoil layers using native plants and microbial processes.

Societal Benefits: NbS standards emphasize delivering societal co-benefits alongside ecological restoration. The health improvements for Sawol Village residents and the educational opportunities provided by the soil exhibition hall are clear examples of how these projects contribute to social well-being.

Climate Adaptation: Both projects enhance urban resilience to climate change by increasing green cover, improving air and water quality, and restoring natural hydrological cycles. These interventions align with global objectives to mitigate urban heat islands and enhance carbon sequestration capacities.

Innovative Approaches: Both projects offer innovative solutions to ecological challenges. Project 1 addresses heavy metal pollution by combining topographical modifications with advanced purification technologies. Project 2 focuses on soil regeneration through the hugelkultur method, emphasizing long-term ecosystem sustainability. These approaches provide replicable models for similar urban contexts.

3. Project Scoring and Results

3.1 Scoring Methodology

The evaluation of Projects 1 and 2 was conducted using the IUCN Global Standard for Nature-Based Solutions (NbS), a comprehensive framework that provides a structured approach to assessing the effectiveness of NbS interventions. This standard is composed of eight overarching standards, subdivided into 28 detailed indicators. Each standard represents a key dimension of NbS, encompassing environmental, social, economic, and adaptive considerations:

Identifying the societal challenge to which the NbS responds: This involves determining the specific issues the NbS aims to address, such as biodiversity loss, urban pollution, or climate change adaptation.

Designing the solution to respond to the geographic, ecological, social, and economic scale of the issue: Solutions must be context-specific, considering local biophysical and socioeconomic factors to maximize relevance and impact.

Ensuring environmental sustainability: Interventions should contribute to ecosystem resilience and not exacerbate environmental degradation.

Ensuring social equity: The design and implementation must be inclusive, addressing the needs of marginalized groups and fostering equitable access to benefits.

Ensuring economic viability: Projects should demonstrate financial feasibility, either through direct economic benefits or cost-effective implementation strategies.

Balancing trade-offs between short- and long-term benefits: NbS must address immediate *challenges without compromising future sustainability.*

Ensuring adaptive management: Mechanisms for monitoring and flexibility must be integrated to allow for iterative improvements based on performance and external changes.

Increasing sustainability by mainstreaming the NbS into policy and linking it to national or international commitments: Embedding NbS within policy frameworks ensures alignment with broader objectives and promotes long-term sustainability (IUCN, 2020).

For each of the 28 indicators, interventions were assessed on a four-point scale: high match, sufficient match, partial match, or no match. The scoring results for each indicator were then aggregated to calculate a degree of alignment for each standard. Based on these scores:

Highly matched: Scores greater than 75%.

Sufficiently matched: Scores between 50% and 75%.

Partially matched: Scores between 25% and 50%.

No match: Scores below 25%.

The scores were normalized to ensure equal weighting across all standards, allowing for a balanced assessment. Importantly, a "no match" rating for any single standard disqualifies the project from meeting the IUCN NbS global standards. This method ensures that projects must achieve minimum thresholds across all dimensions to be considered a viable NbS intervention. The scoring results are critical not only for evaluating the current performance of NbS projects but also for identifying areas requiring improvement and making targeted recommendations.

For each indicator, one of the four score options of high match, sufficient match, partial match and no match was recorded. This result was used to calculate the degree of match for each individual standard, and scores greater than 75%, 50%-75%, 25%-50% and less than 25% were given a rating of highly match, sufficient match, partial match and no match, respectively. These metric scores were then standardized so that each standard had the same weighting. After normalization, the sum of the standard scores was calculated to give the overall percentage of match. Regardless of the overall match rate, if an intervention scores ‘no match’ for any of the standards, the intervention will not meet the IUCN's NbS global standards. The match rate can then be used to indicate whether the match is a high match, a sufficient match, or a partial match (Table 1.1).

Table 1 Individual Evaluation Form

Indicator(%)		Output
≥75	Highly Match	The intervention follows the IUCN's NbS global standard.
≥50 & <75	Sufficient Match	
≥25 & <50	Partial Match	
<25	No Match	The intervention does not follow the IUCN's NbS global standard.

Source: Self-drawn by the author

The standard provides an assessment examination of the program's NbS to translate NbS concepts into targeted implementation behaviors that promote best practices while addressing and correcting deficiencies. The use of the standard provides recommendations for improvements in interventions and uses the results to identify gaps and solutions. Also for investors, donors and other stakeholders, the results lend more credibility to the project (IUCN 2020).

3.2 Scoring content and results

The IUCN Guidelines for Using Global Standards for Nature-based Solutions were used to score Project 1 and Project 2, with Project 1 scoring 51.15% and Project 2 scoring 51.6%, both matching the 8 guidelines to a degree greater than 50%, which is a sufficient match (Table 2.)(Fig1.)

Table 2. Scoring Results

Source: Self-drawn by the author

Indicator	Grand Prize	Average	Indicator	Gold Prize	Average
C-1.1	H	H	C-1.1	P	P
C-1.2	H		C-1.2	P	
C-1.3	S		C-1.3	P	
C-2.1	H	S	C-2.1	S	P
C-2.2	H		C-2.2	S	
C-2.3	P		C-2.3	P	
C-3.1	S	S	C-3.1	H	H
C-3.2	S		C-3.2	H	
C-3.3	P		C-3.3	H	
C-3.4	S		C-3.4	H	
C-4.1	H	S	C-4.1	P	P
C-4.2	P		C-4.2	P	
C-4.3	P		C-4.3	P	
C-4.4	S		C-4.4	P	
C-5.1	N	P	C-5.1	P	P
C-5.2	S		C-5.2	S	
C-5.3	S		C-5.3	P	
C-5.4	N		C-5.4	P	
C-5.5	N		C-5.5	P	
C-6.1	P	P	C-6.1	P	P
C-6.2	S		C-6.2	N	
C-6.3	P		C-6.3	S	
C-7.1	P	P	C-7.1	S	S
C-7.2	N		C-7.2	S	
C-7.3	N		C-7.3	S	
C-8.1	S	S	C-8.1	H	S
C-8.2	S		C-8.2	S	
C-8.3	H		C-8.3	H	

H: Highly match S: Sufficient match P: Partial match N: No match

Among them, Project 1 highly considers the most pressing current social challenges and designs NbS at an appropriate scale to promote net biodiversity growth and ecosystem integrity, while being economically viable and sustainable. However, little has been said about the empowerment of stakeholders and the trade-off boundaries among the agreed parties prior to NbS implementation, and the management of post-NbS monitoring and evaluation needs to be elaborated.

Project 2 takes great account of net biodiversity growth and ecosystem integrity. It takes fully into account the adaptive management and sustainability experiences needed in the later stages of NbS. However, it gives less consideration to the synergies between economic, social and ecosystems and across sectors. Economic aspects related to project costs and benefits are also rarely mentioned. It is also less adequate in terms of stakeholder empowerment and trade-offs between primary objectives and multiple benefits.

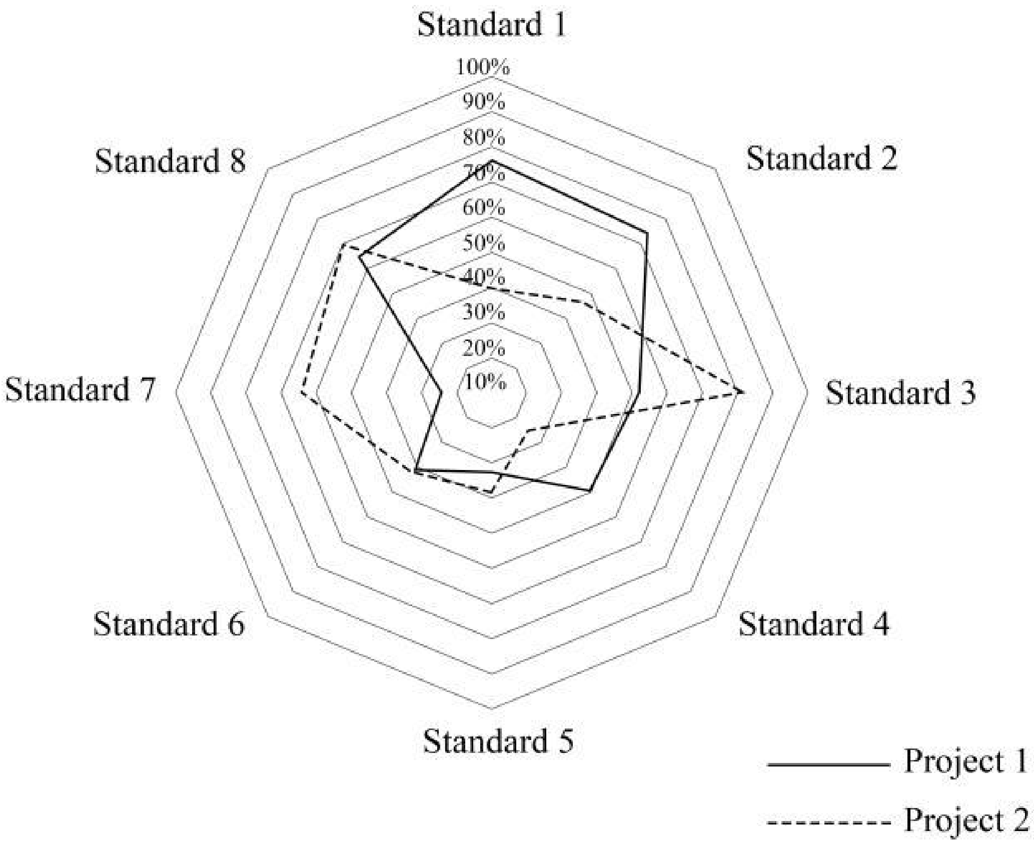

Figure 3. Scoring of Projects Based on NbS Global Standard

3.3 Comparative Analysis of Results

A comparative analysis of the two projects reveals several key insights. Both initiatives demonstrate a commendable effort to align with the IUCN standards, particularly in promoting biodiversity and restoring ecosystem integrity. However, their shared deficiencies—most notably in stakeholder engagement, economic analysis, and trade-off management—highlight systemic challenges in translating NbS principles into practice.

The scoring results underscore the importance of adopting a holistic approach to NbS design and implementation. While ecological and adaptive considerations are crucial, they must be complemented by robust social and economic frameworks to ensure that interventions are both effective and equitable. For instance, future projects should prioritize:

Stakeholder Inclusion: Actively involving local communities, governmental agencies, and other stakeholders from the outset to foster collaboration and shared ownership of the project.

Economic Viability: Developing detailed cost-benefit analyses to demonstrate the financial feasibility and long-term sustainability of interventions.

Integrated Planning: Ensuring that NbS strategies address the interconnectedness of social, economic, and ecological systems to maximize co-benefits and minimize trade-offs.

4. Conclusion and Insight

4.1 Project 1: Innovative Approaches to Pollution Mitigation and Biodiversity Enhancement

Project 1 utilizes a multifaceted ecological restoration strategy tailored to mitigate air and water pollution while simultaneously enhancing biodiversity in a neglected hilly region. By altering the topography, the project not only reduces the risk of soil erosion but also creates a favorable microenvironment for vegetation growth. The introduction of windbreaks—comprising native tree species known for their pollutant-absorbing properties—effectively filters airborne contaminants. Meanwhile, wetland purification systems leverage natural processes to treat water pollutants, improving the overall health of the ecosystem.

An innovative aspect of this project lies in its economic component. By reprocessing waste materials into marketable products, such as ink derived from heavy metal residues, the initiative addresses environmental issues while generating financial returns. This dual benefit showcases the potential for NbS to bridge ecological restoration and economic viability. However, the project is not without its limitations. As a conceptual design from a student competition, it lacks a rigorous cost-benefit analysis and real-world implementation experience. Future iterations would benefit from stakeholder engagement and adaptive management to ensure the scalability and sustainability of these interventions.

4.2 Project 2: Restoring Ecological Complexity in Over-Refined Landscapes

Project 2 focuses on reversing the ecological homogenization caused by over-refinement, specifically in a former golf course. This site typifies human-engineered landscapes that prioritize aesthetics over ecological integrity, resulting in degraded soil quality and disrupted hydrological cycles. The project adopts a restorative approach by rehabilitating topsoil, reintroducing native vegetation, and reconnecting water sources through constructed wetlands. These interventions not only enhance biodiversity but also reestablish the site’s natural self-regulating mechanisms, reducing maintenance costs and reliance on artificial inputs.

One of the most compelling aspects of Project 2 is its focus on ecological education. By incorporating a soil exhibition hall, the project invites visitors to observe the restoration process firsthand, fostering public awareness and appreciation for NbS. However, similar to Project 1, this project faces challenges in practical implementation. The lack of detailed economic modeling and the absence of collaborative frameworks with governmental and community stakeholders limit its applicability as a large-scale solution. Addressing these gaps would be crucial for the project's success in real-world scenarios.

4.3 Broader Implications and Future Directions

The comparative analysis of these two projects underscores the versatility of NbS in addressing diverse societal challenges. Both initiatives demonstrate the potential of NbS to tackle pollution, restore biodiversity, and promote sustainable urban development. Their strategies align with global NbS criteria, contributing to ecological integrity and societal well-being. Nevertheless, their status as conceptual designs highlights a recurring issue in the field: the gap between theoretical models and practical application.

For NbS to realize its full potential, future projects must integrate robust economic analyses, evidence-based adaptive management practices, and inclusive decision-making processes. This requires active collaboration among designers, policymakers, and local communities to ensure that interventions are contextually relevant and culturally sensitive. Additionally, long-term monitoring frameworks should be established to evaluate the effectiveness of NbS implementations and adapt them to changing environmental and societal conditions.

The insights gained from these projects offer valuable guidance for the advancement of NbS research and application in Korea. As the nation grapples with crises in biodiversity, climate resilience, and social inclusivity, NbS provides a promising pathway toward a sustainable and equitable future. By leveraging lessons learned from pilot projects and fostering interdisciplinary collaborations, Korea can position itself as a leader in integrating NbS into urban and natural landscapes. This study not only contributes to the academic discourse on NbS but also serves as a call to action for translating innovative ecological concepts into tangible outcomes.

5. Optimized Summary and Insights

This study highlights the significant potential of nature-based solutions (NbS) in addressing pressing societal challenges such as pollution, biodiversity loss, and urban sustainability. Through a detailed analysis of two innovative projects, it has been demonstrated that NbS can effectively restore ecological integrity while providing societal and economic benefits. Project 1 showcased how strategic interventions in topography, vegetation, and water management could mitigate pollution and enhance biodiversity, while simultaneously creating economic opportunities through waste utilization. Project 2 illustrated the transformative potential of restoring over-refined landscapes into self-regulating, ecologically diverse systems, with added value in promoting public awareness and education through interactive elements.

However, both projects reveal certain limitations inherent in their conceptual nature. The absence of comprehensive economic feasibility studies and stakeholder engagement processes underscores the need for more holistic approaches in future NbS applications. Furthermore, the lack of adaptive management strategies and evidence-based long-term monitoring poses challenges to their scalability and sustainability. These gaps point to the necessity of integrating multidisciplinary expertise, including ecology, economics, and social sciences, to develop more robust NbS frameworks.

Looking ahead, this research provides critical insights into the broader implications of NbS for urban and ecological planning. By aligning with global standards and emphasizing the interconnection between social and ecological well-being, NbS can serve as a cornerstone for addressing the biodiversity crisis, climate resilience, and social inclusivity in Korea and beyond. The findings encourage policymakers, researchers, and practitioners to prioritize the concrete implementation of NbS strategies that are adaptable to diverse environmental and cultural contexts.

As Korea continues to explore innovative solutions to environmental challenges, these projects offer a blueprint for integrating NbS into national and urban development agendas. By fostering collaborations among stakeholders and incorporating continuous feedback mechanisms, NbS can evolve from conceptual frameworks into practical, impactful interventions. This study underscores the urgent need to bridge the gap between theory and practice, ensuring that NbS becomes a driving force for sustainable development in both urban and natural ecosystems.

References

Bradshaw, A. D. (1983). The reconstruction of ecosystems. Journal of Applied Ecology, 20(1), 1–17.

Chapin, F. S., Zavaleta, E. S., Eviner, V. T., Naylor, R. L., Vitousek, P. M., Reynolds, H. L., … & Díaz, S. (2000). Consequences of changing biodiversity. Nature, 405(6783), 234–242.

Chazdon, R. L., Brancalion, P. H., Laestadius, L., Bennett-Curry, A., Buckingham, K., Kumar, C., … & Wilson, S. J. (2016). When is a forest a forest? Science Advances, 2(4), e1500327.

Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). Nature-based solutions to address global societal challenges. IUCN.

Fan, H., He, X., & Zheng, S. (2018). Plant and microbial remediation of heavy metal-polluted soils in China: A review. Science of the Total Environment, 643, 1333–1352.

Frantzeskaki, N., et al. (2019). Nature-based solutions for urban climate resilience. Nature Climate Change, 9(7), 512–516.

Gómez-Baggethun, E., & Barton, D. N. (2013). Classifying and valuing ecosystem services for urban planning. Ecological Economics, 86, 235–245.

He, Q. (2021). IUCN develops first global standard for nature-based solutions global standard. China Forestry Industry, 07, 25–28.

Huang, L., Yang, Y., Zhang, S., & Li, K. (2018). Ecological restoration for heavy metal pollution. Journal of Hazardous Materials, 351, 202–214.

International Union for Conservation of Nature [IUCN]. (2020a). IUCN global standard for nature-based solutions: First edition. Gland, Switzerland: IUCN.

International Union for Conservation of Nature [IUCN]. (2020b). Guidance for using the IUCN global standard for nature-based solutions: First edition. Gland, Switzerland: IUCN.

Kim, S., et al. (2020). Assessing the health impacts of urban pollution on elderly populations in South Korea. Environmental Research, 184, 109–116.

Luo, M., et al. (2020). Analysis and enlightenment of the global standard of NbS. China Land, 04, 33–40.

Luo, M. (2020). Exploring the effectiveness of NbS in urban biodiversity conservation. Ecology Letters, 23(4), 581–589.

Maes, J., & Jacobs, S. (2017). Nature-based solutions for Europe's sustainable development. Science of the Total Environment, 579, 1340–1351.

McDonald, R. I., et al. (2016). Urban growth, climate change, and freshwater availability. Science Advances, 2(2), e1501272.

Myung, S., & O, I. (2021). A study on nature-based solution (NbS) for response to environmental crisis. KEI Occasional Research Report, 10.

Myung, S. J. (2021). Implementing NbS strategies in South Korea. Sustainability, 13(10), 5280.

Nesshöver, C., et al. (2017). The science, policy, and practice of nature-based solutions. Ambio, 46(5), 493–505.

Oberndorfer, E., et al. (2007). Green roofs as urban ecosystems. BioScience, 57(10), 823–833.

Rockström, J., et al. (2009). A safe operating space for humanity. Nature, 461(7263), 472–475.

Rosenzweig, C., et al. (2014). Green infrastructure for climate adaptation in cities. Nature Climate Change, 4(8), 717–725.

Seddon, N., et al. (2020). Harnessing the potential of nature-based solutions. Global Change Biology, 26(4), 2078–2083.
Steffen, W., et al. (2015). Planetary boundaries: Guiding human development on a changing planet. Science, 347(6223), 1259855.
Tzoulas, K., et al. (2007). Promoting ecosystem and human health in urban areas. Landscape and Urban Planning, 81(3), 167–178.
Wong, T. H. F., et al. (2021). Mainstreaming nature-based solutions. Environmental Science & Policy, 124, 44–54.