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Implementing Nature-based Solutions: Learning from Benchakitti Forest Park in Bangkok

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Abstract

Given the limited number of case studies reflecting Nature-based Solutions (NbS) implemented in the Global South, existing cases of NbS within the city of Bangkok offer valuable lessons. This article aims to document and discuss the design process involved in implementing the NbS concept for Benchakitti Forest Park in Bangkok. The methodology involves a narrative literature review, qualitative content analysis, and interdisciplinary discussion. The article is complemented by insights from the landscape architect responsible for the park's design and inspection during the construction process. The results are presented in three parts: optimizing the benefits of NbS, barriers to NbS, and the implementation of the design for Benchakitti Forest Park in Bangkok. The discussion centers on exploring opportunities and challenges in implementing the NbS concept, particularly in the context of a tropical monsoon climate. By deepening the understanding and contextualizing NbS, Benchakitti Forest Park is proposed as a valuable case study for learning landscape architectural design concepts and strategies related to NbS, offering efficient local construction methods, and adhering to specified time frames and budgets. At the early stage after opening to the public in 2022, there should be scientific proof of the park's performance reflected in ecosystem services and disservices. Our study emphasizes the need for a long-term site monitoring program, landscape management framework, and guidelines to manage the urban wild space which should be integrated with educational programs and multi-stakeholder visioning for NbS.

Keywords

NbS and planning policy; Multidisciplinary approaches; Ecosystem services; Landscape architecture; Benchakitti Forest Park

1. Introduction

In the Anthropocene era, pristine landscapes are scarce and cities can be considered wilderness (McKinney et al., 2018). While the green elements and infrastructure in urban areas may differ from natural landscapes, the concept of Nature-based Solutions (NbS), similar to Ecosystem Based Analysis (EBA) and Green Infrastructure (GI) (Dorst et al., 2019), is gaining attention in policy and planning to address urban challenges. Urban green infrastructure and landscape management involve a complex interplay between efficiency, human agency, and empowerment multi-actors (Gulsrud et al., 2018). NbS, as an emerging focus in urban design, offers multidisciplinary guidance to address environmental, socio-political, and ecological challenges (Dorst et al., 2019; Escobedo et al., 2019), including terrestrial and freshwater habitats, urban surface runoff reduction, and wastewater treatment.

Eggermont et al. (2015) define three typologies of NbS, including NbS with no or minimal interventions in the ecosystem (e.g., mangroves, biosphere reserves), NbS advancing multifunctional and sustainable ecosystems and landscapes (planning multifunctional landscapes, natural system agriculture, agroecology, and evolutionary-orientated forestry), and solutions designing and managing new ecosystems (greening grey infrastructure, artificial ecosystems, e.g., green roofs and green walls). By considering the dynamic landscape and time, the benefits of NbS could vary and change based on the proposed typologies. By maximizing ecosystem service benefits through strategic planning that integrates knowledge from science, policy, and practice, NbS can be used as a tool to support environmental sustainability.

Sowińska-Świerkosz and García (2022) reviewed 20 actions related to implemented NbS projects that revealed four themes: inspired and powered by nature, addressing societal challenges, providing multiple services/benefits (including biodiversity gain), and ensuring high effectiveness and economic efficiency. NbS is characterised by effective water management options facilitating habitat opportunities and community well-being (Ferreira et al., 2022; Irvine et al., 2023). Current published studies also underscore the opportunity and challenge of implementing NbS in local contexts.

The policy, governance, and planning perspective towards NbS implementation highlight the benefits of partnerships across sectors and stakeholders (Zwierzchowska et al, 2019). The approach for upscaling urban NbS should involve hybrid (or multi-actor) governance (Toxopeus et al., 2020). While most NbS cases are in Europe, the US, Australia, and China (Kabisch et al., 2016), implementing NbS in the Global South offers lessons for tropical and monsoon climate sensitivity. Climate-sensitive intervention switches based on spatially well-performing green infrastructure networks are crucial (Davies & Lafortezza, 2019). Transformative NbS implementation in informal settlements should include community consultation and multi-stakeholder engagement, particularly in the Global South (Wolff et al., 2022). Wild urban ecosystems, including conserved remnants, restored natural ecosystems, abandoned wastelands, and designed landscapes, offer both ecological and social benefits (McKinney et al., 2018). Urban landscape design in South East Asia should apply NbS concepts tailored to the tropical monsoon climate.

Questions on landscape maintenance guidelines and practices to maximise the benefits of NbS-designed landscapes in cities remain. Balancing landscape management over time, considering the unmanaged concept of nature, and leveraging vacant land for urban green infrastructure pose challenges. Spontaneity assessments for ecosystem services of existing vegetation are crucial for urban greenspace management (Sikorska et al., 2021). Defining clear standards or guidelines for NbS implementation is still lacking (Sowińska-Świerkosz & García, 2022), especially in the Global South where case studies are limited (Hamel & Tan, 2022). NbS has gained traction in Southeast Asia (Wolff et al., 2023), with Singapore's Bishan Ang Mo Kio Park as a notable

case study, which has required substantial capital, political will, and agency coordination (Hamel & Tan, 2022; Dreiseitl et al., 2015). Unlike Singapore, Bangkok is new to implementing NbS, exemplified by the innovative approach to Benchakitti Forest Park, with different methods and landscape planning designs in comparison to the more traditional previous development within the park area that used a pond and grid forest approach. The new landscape design concept is focused on restoring and constructing a forest and wetland in the center of Bangkok (Figure 1).

Figure 1. Benchakitti Forest Park (within the dotted yellow line) adopting the concept of NbS to design the forest and wetland park. Also shown is the relative proximity to the more traditional pond and grid forest elements from an earlier phase of the park development.

Two main questions shape this article's adoption of the NbS concept in landscape design and implementation. First, how can landscape architecture and engineering be better integrated (form and function) to optimize NbS benefits? Second, what are the opportunities and challenges of implementing NbS in an urban park, especially in the tropics? Bridging NbS theory with landscape architectural practices in the tropical context, this article reviews the working process from theory to practice for integrated landscape design to optimize NbS benefits. It also identifies opportunities and challenges in implementing NbS in the urban forest park at Benchakitti.

2. Materials and Methods

2.1 Defining the NbS landscape

The methodology to explore the process of designing and managing the landscape under the umbrella of NbS is divided into three parts. This article uses a narrative literature review, qualitative content analysis, and interdisciplinary discussion.

First, this article uses a narrative literature review approach with publications retrieved from Scopus and Google Scholar search engines. Keywords such as 'Nature-based Solutions', 'Policy and planning', 'Bangkok Metro Regions', 'Urban forest park', 'Benchakitti Forest Park', 'Landscape design', 'Landscape planning', and 'Multidisciplinary' were utilized in the search for relevant publications. A total of 60 articles were synthesised using qualitative content analysis.

Additionally, the case study of Benchakitti Forest Park was examined based on the experience and perspective of the lead landscape architect, Chatchanin Sung, one of the authors. The data related to the landscape maintenance and biodiversity in the park were provided by the Environment Department, Bangkok Metropolitan Administration (BMA). The discussion on the design process of the forest park will encompass three key components: the design concept and strategy, construction, and landscape maintenance. Ecosystem service (ES) will be used as a framework to analyse the landscape design with NbS characteristics classified by Sowińska-Świerkosz and García (2022).

Lastly, the interdisciplinary and multidisciplinary discussion will be used to provide the recommendation and future research direction. The perspectives from the scholars, landscape practitioners, and park operators were documented with respect to the varied points related to implementation of NbS. This discussion was conducted to elucidate the benefits of implementing NbS, especially in the context of the tropics. However, future study should expand to include deeper discussion among other disciplines in support of a more complete understanding of NbS landscape.

2.2 Case study background and context

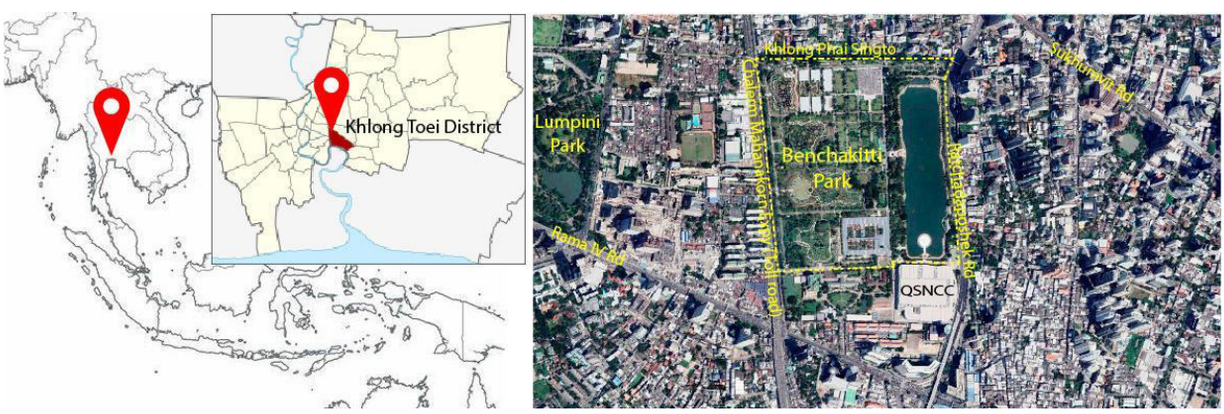


Figure 2. Benchakitti Park location and surroundings.

Benchakitti Park is located in the Khlong Toei District in the heart of Bangkok. The climate of this area is characterized by hot and humid summers, wet rainy seasons, and warm winters, with a Tropical Savanna (Aw) designation based on the Koppen climate classification system. The average annual temperature is 27.7 C and the annual precipitation is 1270 mm. (Available online:https://en.climate-data.org/asia/thailand/bangkok/bangkok-6313/). Khlong Toei, is bordered by the districts of Watthana, Phra Khanong, and Phra Pradaeng in Samut Prakan province (across the Chao Phraya), as well as Yan Nawa, Sathon, and Pathum Wan districts. The park is surrounded by Khlong Phai Singto (north), Ratchadaphisek Road (east), Queen Sirikit National Convention Centre (QSNCC) (south), and Chalerm Mahanakorn Expressway (west) (Figure 2). The surrounding area has long been known for its informal settlement communities and Bangkok port. Now it has become a fast-developing area attracting new business forms and investments.

The opportunities and challenges for designing and programming the landscape respond to the urban issues on water (both quality and quantity), biodiversity, resource and energy management, as well as accessibility and public use. For the water quality issue, from 2017 to 2021, the average BOD of Khlong Phai Singto (survey point by the old Tobacco Factory) was 24.5, 35, 37.2, 25.8, and 25.8 mg/L (Drainage and Sewage Department, 2024) (Available online:https://docs.google.com/spreadsheets/d/1J-e7zsioniuVyjYEXuJ17iewSukW049Q/edit?gi

d=376494751#gid=376494751). A survey of public perception on the active park (the pond area and the surrounding tracks, see Figure 1) identified a low score on accessibility (Chandrasiri & Arifwidodo, 2017). The new landscape design of the Benchakitti Forest Park aims to respond to the mentioned urban challenges.

Initially proposed to honor Her Majesty Queen Sirikit for her 60th birthday in 1992, the park was developed on the grounds of the former Tobacco Factory, which belonged to the Treasury Department. The pond and grid forest park were opened for public use in 2004 and 2016. Notably, the Tobacco Authority of Thailand allocated an additional 259 rai (41.44 ha) for the programming of Benchakitti Forest Park in 2020. Consequently, the design and construction period for Benchakitti Forest Park spanned from 2020 to 2022 (Sung, 2023). Figure 3 shows the site transformation compared from 2006, 2020, and 2022.

Figure 3. The aerial photographs of the old Tobacco Factory in 2006, before the construction in 2020 and the site transformation to the new Benchakitti Forest Park in 2022 (left to right).

Due to the early stage after the construction and a few years of operations, our case study of the Benchakitti Forest Park still lacks empirical data to scientifically prove the park's performance. The article could provide the insight but might not be able to fully furnish the scientific proof that links to the NbS benefits.

3. Results

The results are divided into three parts. The first section focuses on the theory, emphasizing how to optimize the benefits of NbS. This will include a review of the benefits of NbS, planning and managing NbS, and public perception of NbS. The second part concentrates on the barriers to NbS implementation identified in the literature review. The last part delves into the case study, explaining the implementation of the design of Benchakitti Forest Park in Bangkok. This section also leads to a discussion on the opportunities and challenges of implementing the concept of NbS in the tropical context.

3.1 Optimizing the benefits of NbS

3.1.1 Benefits of NbS

From policy to implementation, applying the concept of NbS links multidimensional benefits. NbS shares similarities with existing concepts like natural capital, ecosystem services, ecosystem-based analysis, blue and green infrastructure, and landscape functions in environmental planning (Dorst et al., 2019; Zwierzchowska et

al., 2019; Albert et al., 2017; Javier et al., 2021). The intervention of NbS also can be identified under other terms related to urban design practices, such as Low Impact Development (LID), Water Sensitive Urban Design (WSUD), Sustainable Drainage Systems (SUDS), and Integrated Urban Water Management (IUWM) (Ramírez-Agudelo et al., 2020). Implementing NbS requires multidisciplinary/interdisciplinary learning and practice in planning and design (Ferreira et al., 2022; Irvine et al., 2022). Advantages of NbS, as classified by Ferreira et al. (2022), include a sustainable, systematic, and integrative approach, resource efficiency, long-term cost-efficiency, and co-benefits. This emerging concept in urban design provides multidisciplinary guidance (Irvine et al., 2023; Bush & Doyon, 2019) and its implementation should be related to other existing urban interventions that share similar multi-benefits.

The implementation of NbS is linked to landscape intervention and innovation, including wetland parks, river parks, constructed wetlands, agroforestry, green roofs, green walls, and permeable pavements (Ramírez-Agudelo et al., 2020). Key characteristics of NbS involve providing effective water management options that allow habitat opportunities and community well-being (Ferreira et al., 2022; Irvine et al., 2023). For NbS to serve as a tool for urban greening, it should be a fully integrative design with performance based on geographical location (Ferreira et al., 2022). Raising awareness of the multi-benefits of NbS is crucial (Zwierzchowska et al., 2019), requiring analysis of both direct benefits and co-benefits. When implementing NbS as a form of landscape intervention, it should be an integrated design tailored to the contextualized location to maximize the multi-benefit.

An example of a landscape intervention defined as NbS is the constructed wetland. The NbS toolkit, when plugged into urban landscapes to mimic natural processes missing in cities, aligns with the ecosystem service values of constructed wetlands (Irvine et al., 2023; Stefanakis, 2019). Constructed wetlands are one form of NbS that improves water quality, provides flood protection areas, and promotes biodiversity (Agaton & Guila, 2023). Ecosystem services of constructed wetlands include direct benefits providing provisioning services (biomass production and water supply) and regulation services (primary wastewater treatment and purification, climate regulation, flood prevention, and erosion control). Indirect benefits include cultural services (recreation, aesthetic values, biodiversity, education, and research) and supporting services (habitat formation for urban wildlife, nutrient cycling, and hydrological cycling). Past studies also emphasizes the values of constructed wetlands through monetization techniques, including contingent valuation, shadow pricing, cost–benefit analysis, benefits transfer, habitat evaluation procedures, replacement cost, and travel cost. To optimize the benefits of implementing constructed wetlands, methods and techniques to identify the economic value of ecosystem services should be considered.

3.1.2 Planning and managing NbS

Given that most NbS cases are concentrated in Europe, the US, Australia, and China (Kabisch et al., 2016), there remains a gap in understanding NbS case studies between the Global North and Global South.

In Europe, NbS planning intertwines with discussions on planning frameworks and landscape management guidelines to effectively balance rich biodiversity and public understanding. Wilderness, a key landscape quality in the public debate in Europe, becomes a focal point for NbS planning. European case studies (UK, Belgium, and Poland) emphasize the need for policies to implement NbS, suggesting the enrichment of cities' knowledge base and targeted capacity building programs (Frantzeskaki et al., 2020). Mainstreaming NbS into landscape planning requires frameworks and principles such as Place-specificity, Evidence based, Integration, Equity, and Transdisciplinary (Albert et al., 2021). Contextualized frameworks and guidelines are crucial for planning and

managing NbS in Europe, bridging the policy for NbS projects with landscape management that aligns with public understanding.

As people perceive natural environments differently based on their values, tools to measure general valued attributes of landscapes become essential for better planning and management approaches (Kendal et al., 2015). Understanding the role of different types of green spaces in cities is crucial for both planning and management of urban landscapes (Threlfall & Kendal, 2018). Case studies highlight differences in the management of traditional urban green spaces and urban wild spaces, emphasizing the need to debate and reframe the management of NbS as infrastructure (Sikorska et al., 2021).

In Australia, the case study 'Living Melbourne – Our metropolitan urban forest' explores the conditions and mechanisms for scaling up NbS within city contexts (Fastenrath et al., 2020). For scaling up NbS, it is crucial to frame and focus on complex discussions involving multiple stakeholders. The collaborative process at various sites and contexts also should be explored and discussed accordingly.

In China, studies identify positive benefits of NbS implementation on both planning and management of urban public parks. Research on ecological and aesthetic perceptions of spontaneous vegetation in urban parks of Beijing highlights different perspectives between the public and professionals, suggesting opportunities for ecological education (Li et al., 2019). Case studies in Shenzhen Litchi Park show relationships between vegetation enclosure and landscape preferences, emphasizing positive attributes of urban weeds and unmanaged landscape spaces. Studies in Tianjin suggest applying forest–wetland ecological networks in spatial planning to promote synergies between forest, wetland, and grey infrastructure (Li et al., 2022a).

In the context of informal settlements within the Global South community, six types of NbS, including constructed wetlands, green open spaces, community gardens, street trees, rehabilitation of riparian or waterfront vegetation, and infiltration devices, have been identified (Wolff et al., 2023). More case studies from the Global South are needed to apply the concept of NbS in different scales and conditions.

3.1.3 Public perception of NbS

To understand public perception related to NbS, frameworks evaluating users' understanding and perception of NbS planning and landscape management levels are necessary. Public perception often is defined by aesthetic value, mental health, and well-being.

Studies on landscape aesthetic values highlight two approaches: expert-based assessment and perception-based assessment, emphasizing the importance of individual feelings, needs, and imagination (Skřivanová & Kalivoda, 2010). High hardscape ratios can negatively affect visual quality in urban parks (Gungor & Polat, 2018). Landscape elements in urban parks relate to both aesthetic preference and mental restoration (Jahani et al., 2022). The assessment of cultural ecosystem services and landscape features in urban parks reveals differences in preferences between tourists and local people (Huai et al., 2022). Public perceptions of landscape values and appreciation related to NbS can vary based on different stakeholders' views and backgrounds.

Studies on the aesthetic value of protected wetlands in South Korea using photographic and meta-data analysis reveal emotional connections (Do & Kim, 2020). Computer science studies have analyzed the aesthetic quality of plant and water forms in urban landscape parks (Aboufazeli et al., 2021). Artificial neural network techniques have evaluated environmental modelling of landscape aesthetic value (Jahani et al., 2022). Blue space is shown to promote positive emotions and big data analytics and art vision have been used to evaluate urban ecological wetland parks (Li et al., 2022b). The research on value appreciation can leverage social media platforms to analyze shared facial expressions of urban park users, incorporating different landscape elements

and management levels. However, results from social media may have some bias, relying on a quick snapshot of emotions from users.

A review on wetland ecological aesthetics encourages public participation in wetland conservation (Lee, 2017). Wilderness areas in urban parks provide opportunities for relaxation, deep connection, and reflection related to health and well-being (Cheesbrough et al., 2019). The level of landscape management in urban parks with the NbS concept needs debate to establish a landscape management plan to maximize ecosystem service values. Public perceptions of the level of messiness may vary based on backgrounds and personal judgments.

For optimizing the benefits of NbS, planning and management should respond to the urban challenges and contextualized to the local conditions. The perception of the public also could be understood to reflect multiple values of ecosystem services. For implementing the NbS landscape design in context of the Global South, there is an opportunity to apply the ES framework which could tie to the landscape management guidelines. At the same time, the design implementation of NbS landscape also might create barriers and challenges to implementation which are reviewed in the next session.

3.2 Barriers of implementing NbS

While the concept of NbS is favored for addressing urban challenges, it comes with associated risks and barriers.

Eggermont et al. (2015) suggest considerations for planning NbS, including not replacing traditional landscape management entirely; exploring win-win situations while coping with trade-offs and uncertainties; and addressing ethical, intellectual, and relational challenges. Ramírez-Agudelo et al. (2020), based on 35 peer-reviewed articles, identified factors such as accountancy, monitoring, and communication linked to the success of NbS projects. Despite advantages, Ferreira et al. (2022) also point out several disadvantages to NbS implementation, including a longer time frame for achieving maximum benefit and impacts compared to grey solutions, space consumption, ecosystem disservices, and segregation with environmental injustice.

Sarabi et al. (2020) identified fifteen barriers using interpretive structural modelling related to NbS policy, planning, and management. Barriers include a lack of political will and long-term commitment, insufficient urgency among policymakers, limited public awareness and support, resistance to change, silo mentality, misalignments between short-term plans and long-term goals, lack of supportive policy and legal frameworks, absence of design standards and maintenance guidelines, shortage of skilled knowledge brokers and training programs, functionality and performance uncertainties, perceived high cost, lack of available financial resources, absence of financial incentives, property ownership complexities, and space constraints. This study suggests each city prioritizes and manages NbS, providing recommendations for project managers and policymakers.

Toxopeus and Polzin (2021), in a systematic review on financing barriers and strategies for urban NbS, illustrate barriers including coordination between private and public financiers and integrating NbS benefits into valuation and accounting methods. Strategies proposed include an integrated accounting and valuation framework for NbS and coordinating public/private finance to encourage specific actors to co-finance.

To assess NbS effectiveness, available data sets from site monitoring are crucial, considering various time scales (Ferreira et al., 2022; Kabisch et al., 2016; Pan et al., 2020). Environmental concerns, such as allergies from urban weeds (Katz et al., 2014) and infectious diseases associated with poor management of open stormwater and urban wetlands (Ferreira et al., 2022; Haase, 2017; Hwang & Roscoe, 2017) link health issues to NbS conditions and management. Threlfall and Kendal (2018) highlight that global environmental

change can lead to unpredictable ecosystem responses in urban wild spaces, which are spatially and temporally diverse, making the complexity of urban ecosystems challenging to understand and manage in the context of urban landscapes. The different social and ecological roles of wild urban spaces add to this complexity.

While implementing NbS in an urban park provides opportunities for tackling multiple challenges, the barriers remaining ranged from political will, to legal challenges, financing support, large space consumption, ecosystem disservice, and public awareness. These will be the main challenges for operating and managing the NbS landscape.

3.3 Implementing the concept of NbS in Benchakitti Forest Park

The third part of this paper focuses on the design process of landscape architecture concerning the concept of integrating Nature-based Solutions (NbS) to address some of the urban challenges in the city of Bangkok. Categorized by Eggermont et al. (2015), the landscape architectural design of Benchakitti Forest Park could be matched and defined as solutions for designing new ecosystems. Building on the old Tobacco Factory, the park transforms the former industrial landscape into an urban forest and artificial wetland. The design process of Benchakitti Forest Park will be explained, covering design concepts and strategies, construction, and landscape maintenance (Sung, 2023).

3.3.1 Design concept and strategy

The design concept and strategy were inspired by Queen Sirikit's speech: "If His Majesty is regarded as 'Water', I will be the 'Forest' and the 'Forest' will always be supportive and loyal to 'Water'." The park was designed to incorporate the forest and water to mimic the ecological balance of nature. Four sub-concepts were proposed for the forest park: Water + Forest Ecological Park, Living Learning Center, Urban Ecological Infrastructure, and Urban Forest Model (Table 1).

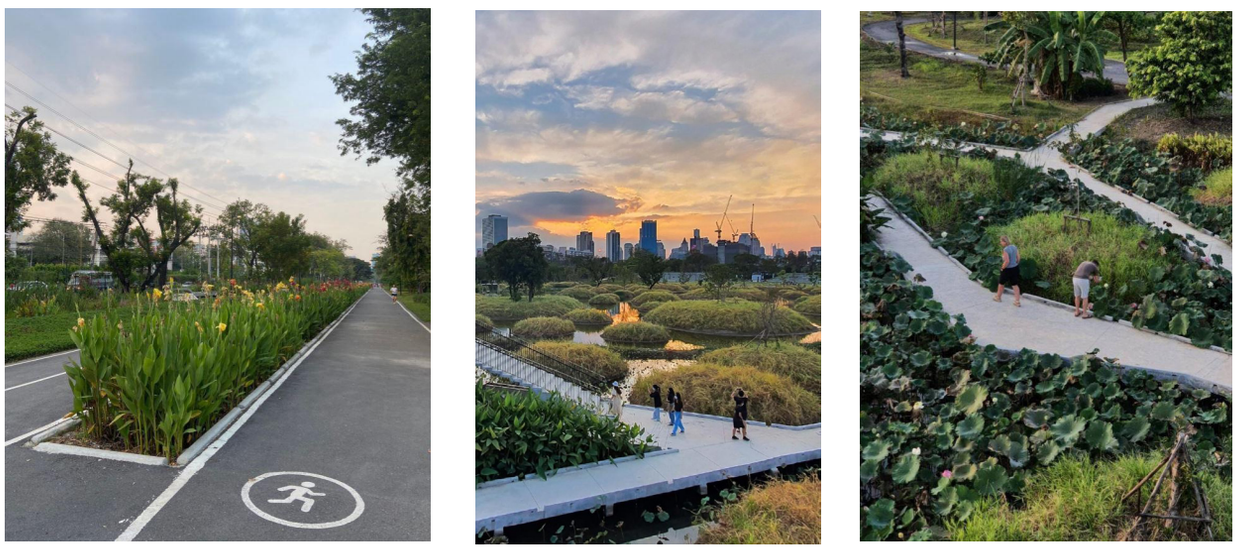
Table 1. Design concepts related to NbS for Benchakitti Forest Park.

Sub-concept	Project's aim, goal and highlight
1) Water + Forest Ecological Park	Restore native habitat, create a large water storage area in the city center of Bangkok
2) Living Learning Center	Provide outdoor learning space emphasizing the value of the forest and environment
3) Urban Ecological Infrastructure	Recreate a new 'urban lifestyle' embracing urban-nature activities
4) Urban Forest Model	Design an ecological park to maximize the city's benefit, promote sustainable management and urban forest to other urbanized areas

These sub-concepts are linked to eight design strategies inspired by the power of nature to address urban challenges and enhance the functionality of public parks. These strategies respond to various urban challenges, including habitat preservation, stormwater management in flood and drought conditions, urban wastewater, and limited natural resources and energies, limited human resources and budget, poor connectivity and accessibility, and lack of open green space and other social issues. The overarching goal is to promote NbS in the urban area of Bangkok (Table 2).

Table 2. Urban challenges and design strategies and NbS for Benchakitti Forest Park.

Urban challenges	Design strategies related to NbS
Stormwater management; flood and drought	1) Managing the monsoon climate; The park is envisioned as a 'sponge,' capable of retaining and discharging water during both rainy and dry seasons. The wetland area has a storage capacity of 128,000 cubic meters, designed to respond to floods and droughts throughout the years.
Urban wastewater	2) Using natural systems for wastewater treatment; This strategy involves the use of a constructed wetland and an artificial pond system to treat wastewater from Khlong Phai Singto, located north of the park. Approximately 1,600 cubic meters of wastewater can be effectively treated, particularly during the dry season.
Habitat preservation	3) Preserving existing trees in the project area; Existing trees within the project area were deliberately preserved to maximize the utilization of natural resources. Simultaneously, this approach helps in cost savings associated with transplanting new trees to the park.
Limited natural resources and energies	4) Reusing and recycling material onsite; A balanced approach to cutting and filling the soil onsite was calculated and designed to minimize energy consumption during transportation. Demolished concrete waste from previous buildings was repurposed onsite, serving as concrete stone in the eco-canal (Figure 4 (a)). Additionally, some buildings and warehouses were retrofitted into museum and sports facility spaces with a focus on sustainability and energy efficiency.
Limited human resources and budget	5) Reducing long-term maintenance; The design of the wetland park incorporates local knowledge from traditional raised bed gardens. This technique facilitates the tree roots in absorbing both air and water efficiently, consequently reducing the need for long-term landscape maintenance on the trees.
Poor connectivity and accessibility	6) Opening access to the public; The park is designed to establish connections with other public parks and surrounding communities through pedestrian pathways and skywalks, enhancing accessibility for the public.
Habitat preservation	7) Creating an ecological forest park; Developed from a former industrial site, the design of the forest park establishes a new habitat with over 400 species of the local plant community. Approximately 5,600 new saplings of rare native species have been introduced, transforming the park into an outdoor learning space for local plant species and the community (Figure 4 (b), (c)).
Lack of open green space	8) Providing recreational space for all; The park serves as a space for the community and urban residents to engage in recreational activities. Simultaneously, it acts as a home for urban wildlife and creatures, creating an ecological space that seamlessly incorporates both urban activity and urban nature into the city.



(a) (b) (c)

Figure 4. Design transformation of Benchakitti Forest Park; (a) the design transforms the existing street into a shared space with a pedestrian walkway and an eco-canal; (b) and (c) it converts the old factory area into a wetland forest park, overlaid with connected boardwalks.

3.3.2 Construction with NbS

The park showcases landscape innovation with a modular system constructed wetland that can be matched and explored as a nature-based and nature-driven solution, providing multi-benefits to ecosystem services (Sung, 2023; Kongjian & Dong, 2023). The construction of the new phase of Benchakitti Forest Park was limited to 18 months, emphasizing time efficiency and cost-effectiveness.

For the construction part, the new topography was designed to mimic the character of a raised bed garden for a traditional orchard (Figure 5 (b)). Landforms of circular mounds were created (Figure 5 (a)). The construction was done practically, as the rounded mounds were repeated as a modular system.

(a) (b)

Figure 5. Comparison of construction techniques, (a) Benchakitti Forest Park's construction technique using the raised bed method; (b) a raised bed orchard in the central plain of the Chao Phraya River Basin.

The newly designed planting communities were divided into seven zones. Plants from each zone were selected to suit the conditions of the newly developed topography, including freshwater wetland plants, swamp forest plants, mangrove trees, lower montane evergreen and dry evergreen forest plants, as well as edible species from agroforestry. The project also advocated using seedlings to grow sapling trees, allowing plants to adapt to the new site conditions and saving on transplanting costs. Some mature trees were transplanted where needed. In total, 347 new species with 5,600 small trees were planted in the park.

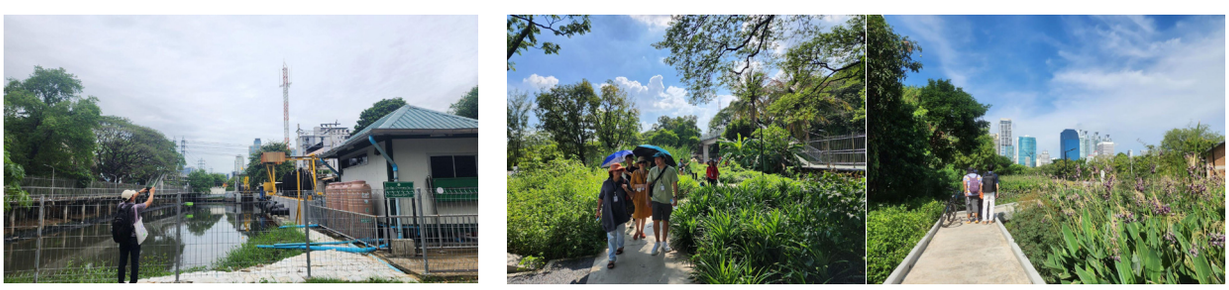
3.3.3 Landscape management related to NbS

From a landscape management perspective, the original proposal introduces concepts such as pollution remediation management, low-maintenance landscapes, and the preservation of urban wildlife biodiversity.

Pollution remediation management

The design of the constructed wetland aims to bring water from Khlong Phai Singto (Figure 6 (a)) to improve water quality, especially during the dry season. Due to the high BOD characteristic of the khlong water, the original design of the constructed treatment wetland is supposed to cleanse the water with the maximum capacity of a long and linear system before getting to the wetland ponds. However, challenges in connectivity and engagement between different stakeholders within government agencies arose initially when the park was already opened. These challenges include reengineering and connecting water systems, as well as the absence of the planned water pumping station. The hydrological flow in the constructed wetland needs to be redesigned and readjusted to address these challenges after the negotiation process among multiple stakeholders. This variation to design also might affect the performance of the constructed wetland and water quality in the wetland ponds.

The performance of the constructed wetland (Figure 6 (b)) needs further study and review over time. Water treatment performance will be linked to the method of harvesting and controlling the plants in each constructed wetland cell. The process of collecting and composting plant waste needs to be monitored and properly managed (Koottatep & Panuvatvanich, 2010; Kennen & Kirkwood, 2015; Likitswat et al., 2023). Both the quality and quantity of water will serve as crucial elements to nourish and provide sufficient water budget to the four main wetland ponds. The proposed water level in each pond is designed to be at least 10 centimeters during the drought period, allowing plant communities to root well in the wetlands.



(a) (b)

Figure 6. The constructed wetland is designed to infiltrate and cleanse the water from the canal; (a) is Khlong Phai Singto, located north of the park, and (b) designed constructed wetland.

Many wetland plants and trees also are edible, requiring careful consideration and management. Despite regulations prohibiting public foraging in public urban parks, the design proposes a seasonal urban paddy farm for educational purposes. This needs to be discussed further considering regulations, landscape programming, and safety concerns regarding public consumption.

Low-maintenance landscape

Following the park's construction, the landscape management program is operated by the Bangkok Metropolitan Administration (BMA) under the Environment Department. The preservation of urban wild space is a key concern in landscape maintenance practice. The low-maintenance landscape practice should be aligned with the ecological perception and aesthetic understanding among stakeholders to promote and maximize the benefits of NbS on ecosystem service values.

For vegetation management, the plant communities in the wetland will need to withstand extreme drought and flood conditions. As mentioned, irrigation can be reduced since the plant communities can take advantage of being surrounded by water seasonally to absorb both air and moisture. This dynamic needs to be carefully understood as a process of ecological succession, which could occur naturally in the urban wild space. Unlike traditional vegetation management that clears ground cover and harvests plants on a schedule, this new method of understanding and altering plant communities requires readjustment and redesign of the landscape maintenance process and practice.

Erosion control and sediment management are other points to be addressed with the new typographic design. If the plant communities can root well to protect the topsoil and are not overly maintained by cutting too short, this can slow down the erosion process and reduce sediment management. Biomass and landscape waste are decomposed and turned into fertilizer onsite and offsite. Sufficient and low-maintenance landscape management will be linked to biodiversity gain and preservation.

Urban wildlife and biodiversity preservation

Biodiversity gain is observed and monitored. New species have been found after the park opened in 2022 (Figure 7 (a), (b)). Bird species found in the park include the 'Anastomus oscitans' (Asian Openbill), 'Merops philippinus' (Blue-tailed bee-eater), 'Muscicapa dauurica' (Asian brown flycatcher), 'Coracias benghalensis' (Indian Roller), and 'Athene brama' (Spotted owlet). A more complete food web and food chain study should be conducted in this new urban forest habitat. However, concerns over some species still need to be managed and controlled, such as the public safety concern over the urban wildlife big snake 'Boa constrictor' (Boas) in the wetlands and non-native predators like 'Felis catus' (Cat), which often come to the park area as stray cats. Species monitoring should be linked to public understanding and acceptance as well.

(a) (b)

Figure 7. The aerial photograph of Benchakitti Park; (a) shows the four wetland ponds connected by the boardwalk; and (b) the biodiversity found in preserved forest and the new wetland habitat.

Reducing noise from traffic can be another point to promote urban wildlife and biodiversity. The question of using some internal streets as shortcuts to reduce city traffic or preserving the park as a large green patch of urban biodiversity still is debated. The linkage between pollution remediation management, low-maintenance landscape, and urban wildlife and biodiversity preservation and control are interconnected. From landscape management within the design related to NbS, there will be lessons learned and linkages between the understanding of scientific conditions and changes in environmental issues (water quality, soil quality, air pollution, etc.), plant communities and habitat, and urban wildlife biodiversity. This also will strongly support public debates and policy directions on other related issues, such as new framework guidelines on landscape maintenance with NbS, biodiversity control, the possibility of opening some streets as traffic passages, and other related issues. To maximize the benefits of NbS, the forest park will be an educational platform to demonstrate performance related to multiple challenges and public perception. For landscape management related to NbS in Benchakitti Forest Park, it cannot be seen only in the short term but needs to have a long-term monitoring program and practice.

4. Discussion

Based on the concepts of NbS as defined by Sowińska-Świerkosz and García (2022), Benchakitti Forest Park was designed by adopting NbS within the following characteristics, as summarized in Table 3.

Table 3. NbS characteristics of Benchakitti Forest Park.

NbS characteristics	**Opportunity for the implementation of NbS**		
1) are inspired and powered by nature	Designing series of retention and detention ponds to incorporate with the seasonal changes	Designing to mimic the flow of water for water treatment by using plants	Using the low maintenance concept for promoting the urban forest
2) address (societal) challenges or resolve problems	Addressing climate change issues and challenges on urban water management during wet and dry seasons	Addressing wastewater issues and alternative solution for water treatment	Preserving and adding urban green space
3) provide multiple services/benefits, including biodiversity gain	Providing the provisioning service as well as regulation service	Providing cultural service such as public recreational space for urban residences	Proving supporting services such as educational space both outdoor and indoor for urban dwellers
4) are of high effectiveness and economic efficiency	Balancing cut and fill amount of soil on site for reducing the input energy	Proposing for rounded mound as modular system for efficiency construction	Reusing material on site such as concrete for the construction of eco canal

The design proposal for Benchakitti Park showcases the concept of NbS in landscape and engineering design in the city of Bangkok. It addresses multiple scales of urban challenges, ranging from climate change and poor water quality in urban areas, to a lack of public space for urban residents. The park adopts the concept inspired by the power of nature, designing with water dynamics, addressing seasonal challenges, utilizing sustainable materials and construction techniques at a low cost, and incorporating a diverse plant community for multifunctional purposes. These features could provide various services and benefits, encompassing both provisioning and regulation services, as well as cultural and supporting services.

However, there are a number of questions related to public understanding and the long-term landscape management cost, techniques, and benefits. What are the costs and efforts required for maintaining NbS projects? The question on the park's maintenance in the long term remains unanswered. There needs to be further study and documentation to record and interpret landscape management from a maintenance perspective for NbS projects. Also, there is a knowledge gap and a lack of scientific database to validate the park's performance with respect to ecosystem service benefits/disbenefits in its current state.

To prioritize NbS for a better understanding of long-term landscape management plans and practices, guidelines for maintenance and monitoring, along with a training program for the landscape crew, should be established to deal with the complexity of the forest park. This is especially crucial in the context of a tropical and monsoon climate, which involves managing high and complex biodiversity in urban areas.

Another challenge lies in property ownership complexities for connecting with multi-stakeholders, both in terms of infrastructure and investment. The new design of urban green spaces utilizing NbS water storage retention areas and constructed wetlands to reduce flood risk and water cleansing (Sung, 2023; Kongjian & Dong, 2023) may not effectively respond to the social and ecological benefits due to poor communication and coordination among stakeholders. It is crucial to comprehensively understand the function of these 'Sponge Parks' through both quantitative and qualitative studies and analyses. Chitwatkulsiri et al. (2022) suggest to develop a new forecasting and flood modeling approach and framework to understand the performance of this blue-green infrastructure. Additionally, extensive research is needed on the public understanding and perception of local park users to the new forest and wetland park. The implementation of the NbS project involves a complex process of creatively fostering conversations and collaboration with multiple stakeholders, encompassing government and non-government agencies, private developers, and the public.

Our findings suggest that Benchakitti Forest Park could serve as a valuable lesson on the design concept and strategies related to NbS, as well as construction within a short time period and a limited construction budget. Since the new forest park is still in its early stages, a deeper understanding of the long-term process of landscape maintenance with the dynamics of the forest park is essential.

5. Conclusions

The lessons for planning NbS in cities identify the following requirements and processes (Frantzeskaki, 2020). The planning for NbS requires an aesthetic appeal for urban citizens to appreciate and protect them, the creation of new green urban commons, experimentation to build trust between the city and its citizens, a collaborative governance approach, and design at a scale that facilitates "lessons learned" for their effectiveness. The processes linked to NbS planning also involve co-creating the concept of NbS, learning from urban social innovation and creating an inclusive narrative of a mission for NbS that could bridge knowledge gaps and agendas across different stakeholders. City planning with urban green space and landscape management inspired by nature could be related to sensation, health and well-being (Hwang & Roscoe, 2017; Chitwatkulsiri et al., 2022 Chandrasiri & Arifwidodo, 2017). While the implementation of NbS projects in the Global North could attract attention from local governments, investors, and multi-stakeholders, case studies from the Global South offer different methods for implementing NbS projects due to significant or unclear policy gaps, climatic conditions, and varying levels of financial resources.

The study focused on nonspatial assessments, including park quality, park use, sensorial urban landscape and park benefit, which are usually missing in the assessment of urban parks (Abello & Bernaldez, 1986; Chen

et al., 2022). Landscape aesthetic quality analysis should be crucial to map and assess at a national scale to support policy-making and environmental management decisions (Grahn & Stigsdotter, 2010). Our study suggests the need to consider future practices and an understanding of the long-term operation of NbS (see also Sowińska-Świerkosz & García, 2022; Ramírez-Agudelo et al., 2020). There should be more research and assessment of the relationship between aesthetic preferences and landscape quality of parks, as well as the value of the park's recreational ecosystem service, especially in developing countries (Dinda & Ghosh, 2021). The design of urban parks should reflect the wild and management level of wildness landscape to promote ecological function of the place (Colley & Craig, 2019). The study on user perception, ranging from aesthetic points of appreciation, usages, and benefits, could be linked to NbS performance questions.

Future research could explore and integrate the urban challenges, landscape architectural design with NbS, implications on health and well-being, and public understanding and perception. These aspects should be developed contextually and extensively with new methodologies. This article, using a simple narrative review, could serve as a case study for the early stages of NbS projects in the context of Southeast Asia.

Benchakitti Forest Park adopted NbS concepts to introduce and mimic the wetland environment back to the city of Bangkok within the context of a tropic climate. Further research involving the new phase of the park can expand on NbS from a number of perspectives. The question on blue and green park infrastructure being implemented to manage urban runoff in Bangkok (Chitwatkulsiri et al., 2022) should be understood in both scientific and aesthetic ways. The design intention to bring in NbS as the main concept to the park infrastructure also should be a case study for tropical climate NbS in terms of park performance, long-term landscape management, and cost and benefit. The question of scaling up NbS should be approached critically, considering contextualized site conditions and addressing multi-scale challenges posed by urban environments.

Our study concludes the following lessons learned from theory to practice based on the case study of Benchakitti Forest Park in the context of a tropical monsoon climate.

- Benchakitti Forest Park provides valuable insights into landscape architectural design concepts and strategies related to NbS, effectively addressing multiple urban challenges such as climate change, poor water quality in urban areas, and the lack of public space for urban residents.
- The construction method could be adapted to local construction techniques, promoting efficiency and lower construction costs.
- A site monitoring program should be established to gain a deeper understanding of the scientific performance of NbS, necessitating further research and study.
- A landscape management framework and guidelines need to be generated to understand and ensure the long-term management of the urban wetland forest over time.
- Involving multiple stakeholders in the process is crucial for understanding and envisioning the multifunctionality and benefits of the forest park, as well as addressing trade-offs and ecosystem disservices.
- Educational programs related to NbS should be proposed, covering various issues ranging from urban wetland habitat and urban wildlife to the preservation of urban wild spaces. These topics are essential for promoting environmental stewardship and effective urban wild space management.
- The question of scaling up NbS should be approached critically, considering contextualized site conditions and addressing multi-scale challenges posed by urban environments.

Author Contributions

Conceptualization, F.L., C.S..; methodology, F.L., C.S.; reviewing and formal analysis, F.L., C.S..; writing-original draft preparation, F.L.; writing-review and editing, F.L.; visualization, F.L.,C.S. All authors have read and agreed to the published version of the manuscript.

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