Valuing the benefits of Nature-based Solutions for Integrated Urban Flood Management in the Greater Mekong Region

THE SUKHUMVIT GREEN TRIANGLE

CASE STUDY REPORT

February 2022

Prepared for: **AWP, DFAT, World Bank, ONEP**

Prepared by: **CRCWSC and ICEM**

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DISCLAIMER

This document was prepared by the Cooperative Research Centre for Water Sensitive Cities (CRCWSC) and the International Centre for Environmental Management (ICEM) for the project *Valuing the Benefits of Nature-based Solutions for Integrated Urban Flood Management in the Greater Mekong Region* for the Australian Government Department of Foreign Affairs and Trade (DFAT) and the Australian Water Partnership (AWP). The views, conclusions and recommendations in the document are not to be taken to represent the views of DFAT and AWP.

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In Thailand, the project is hosted by the Office of Natural Resources and Environmental Policy and Planning (ONEP) which is the national point of United Nations Framework Convention on Climate Change (UNFCCC). The project team also extends our thanks to the other organizations who guided and informed the project: the Bangkok Metropolitan Administration (BMA), the Office of the National Economic and Social Development Board (NESDC), the Office of National Water Resources (ONWR) and Chulalongkorn University's Urban Design and Development Centre (UddC).

Executive summary

The vision for this case study is a 'green triangle', connecting Benjakitti Park, Lumpini Park and the dense, urban area to the north of Benjakitti Park with a network of multifunctional green space to showcase world class future city solutions in Bangkok, Thailand.

In October 2020, Thailand's Treasury Department and Royal Thai Army initiated Phases 2 and 3 of the Benjakitti Park in Bangkok's Sukhumvit area (located within Khlong Toei District) to transform the site of a former tobacco factory via an innovative ecological design. Alongside this, municipal agencies accelerated renovating a green bridge connecting the park to the nearby Lumpini Park – one of the city's largest and most popular. This case study builds on these plans to propose three main features:

1. **Multifunctional design of Benjakitti Park.** The design incorporates improvements to the open channel in the north of the existing park site, a linear subsurface flow wetland to improve water quality in the channel, retrofitting of the lake for greater flood detention capacity and amenity with a terraced design and wetland species that can withstand inundation, and stormwater harvesting.

2. **The incorporation of precinct and small scale nature-based solutions (NbS) in Sukhumvit to the north of the park.** A network of NbS including green roofs, tree pits, swales and stormwater planter boxes will be installed through partnerships with the private sector and local communities to mitigate flooding, reduce combined sewer overflows into the open canal, and improve human thermal comfort and amenity for local residents and tourists.

3. **A 'green triangle'** that connects the greened urban area to Benjakitti Park and Lumpini Park to the west to create a cool, walkable and ecologically rich central zone in Sukhumvit, which can be traversed using an innovative Internet of Things enabled 'cool lines' platform.

The study recognizes the goal to upscale the Benjakitti Park throughout Thailand and supports this ambition by highlighting the additional value of NbS and decentralized initiatives in supporting large investments. The hybrid-NbS assets would reduce flooding in a critical business and residential area, improve water quality in the park and local area, improve thermal comfort, provide a network of rich urban ecology, and enable new amenity and recreation, boosting the local economy and aligning with Bangkok's world class future city ambitions.

Results indicate a strong overall benefit–cost ratio of 14 over a 20-year period with a net present value of approximately USD 150 million. The largest individual benefit is improvements in amenity along the canal though surface and subsurface flow wetlands on the northern park perimeter, with the benefit largely coming from increased property values near the canal. The greatest individual cost is attributable to installing and maintaining green roofs in the northern urban area. These elements could be implemented though private sector and community partnerships supported by government incentivization schemes (such as an expanded Floor Area Ratio bonus scheme), capacity building initiatives and pilot projects. Engagement with local neighborhoods to install and maintain NbS is also recommended to help to create local champions and community action under a shared vision for a green, prosperous and climate resilient Bangkok.

As a whole, this case study provides an integrated package or portfolio of large and small investments ensuring the whole is greater than the sum of the parts. It also makes the

case for piloting innovative solutions to establish proof-of-concept, and where necessary, updating planning and regulations to create an enabling environment for upscaling successful sites. Finally this study adds to a growing list of practical applications of a 5-step Integrated Urban Flood Management (IUFM) framework in the Greater Mekong region. For information on the IUFM methodology see the IUFM Manual.

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Abbreviations

ARI	average recurrence interval
AWP	Australian Water Partnership
BCA	benefit–cost analysis
BCR	benefit–cost ratio
BMA	Bangkok Metropolitan Administration
CCMC	Climate Change Management and Coordination Division
CRCWSC	Cooperative Research Centre for Water Sensitive Cities
CSR	Corporate Social Responsibility
DFAT	Australian Government Department of Foreign Affairs and Trade
FAR	Floor Area Ratio
GHG	greenhouse gas
GIS	geographic information system
ICEM	International Centre for Environmental Management
INFFEWS	Investment Framework for Economics of Water Sensitive cities
IOT	Internet of Things
IUFM	Integrated Urban Flood Management
NAP	National Climate Adaptation Plan
NCCC	National Committee on Climate Change Policy
NbS	nature-based solutions
NESDC	Office of the National Economic and Social Development Board
NESDP	National Economic and Social Development Plan
NGOs	non-government organizations
NPV	net present value
OECD	Organisation for Economic Cooperation and Development
ONEP	Office of Natural Resources and Environmental Policy
ONWR	Office of National Water Resources
PPP	public–private partnership
UddC	Urban Design and Development Centre
UNFCCC	United Nations Framework Convention on Climate Change

Project background

Now and in the future, cities need integrated solutions to complex challenges. Floods are the most frequent natural disaster globally, and cause more damage than any other weather or non-weather-related event. And flood-related damages are expected to grow, driven by urbanization, land use changes and climate uncertainty. Compared with conventional 'gray' infrastructure by itself, nature-based solutions (NbS) such as wetland parks, raingardens, bioswales, green roofs and walls, can involve less upfront investment, can be more scalable and flexible and generate a range of environmental, economic and social co-benefits beyond flood management.

A range of innovative hybrid approaches to integrated urban water management are already operational across the Asia–Pacific region. The increasing recognition of hybrid approaches that integrate NbS reflects the changing nature of societies across Asia and the increasing aspirations for improved environmental quality, community health and economic prosperity. However, sometimes it can be difficult for decision makers to justify using NbS, or hybrid solutions compared with conventional measures.

Responding to this challenge, the Cooperative Research Centre for Water Sensitive Cities (CRCWSC) and the International Centre for Environmental Management (ICEM) have been working closely with national government agencies in Thailand and Vietnam to identify and evaluate the full range of market and non-market benefits of NbS, as well as considering appropriate financing and investment models.

The CRCWSC has developed and trialed the innovative Investment Framework For Economics of Water Sensitive cities (INFFEWS) which comprises a Benefit–Cost Analysis (BCA) Tool and a Value Tool that adjusts existing non-market values for application in new contexts. These tools have been trialed extensively in Australia as well as in several cities in China. The current project now applies them to the Mekong region, focusing on Thailand and Vietnam. Four detailed case studies across Thailand and Vietnam demonstrate the Integrated Urban Flood Management process and the assessment including quantifying market and non-market benefits of NbS in monetary terms.

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Case study methodology

Each case study follows the 5-step IUFM process for identifying, valuing and choosing an appropriate mix of flood management interventions for a particular context.

Benefit–cost analysis (BCA) was adopted because it is a rigorous and accepted methodology for comparing the value to the community of different options. BCA can be used for a range of purposes including initial scoping of strategic concepts, detailed comparison of options, and review of whether a project, program or regulation has delivered the promised benefits. This analysis assesses the proposed strategic concepts.

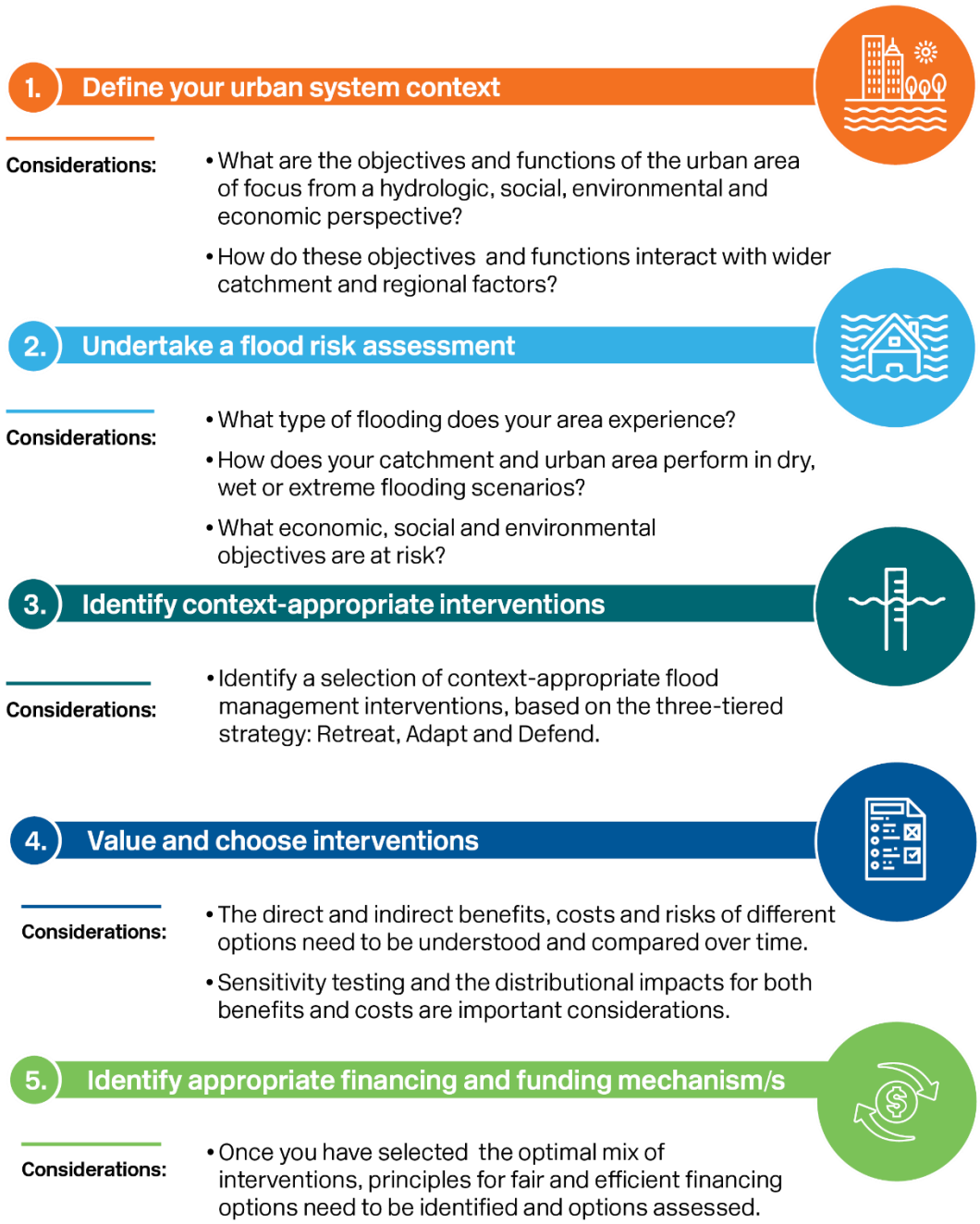


Figure 1: IUFM process.
Source: Project team.

The case study began with detailed scoping and geospatial analysis with GIS and the Fulcrum surveying tool to define the case study site and understand the potential for NbS. Additional contextual information was provided by national experts and from reviewing existing good practice.

Much of the hydrological information and hazard risk analysis for Step 2 was drawn from the comprehensive IHE Delft Studies (2017 and 2019)[1] which mapped flooding impact in Sukhumvit and analyzed the potential of various NbS. This research provided a strong foundation for the team to build on. Context-appropriate interventions were developed based on national and international best practice and the expertise of the project team. Onsite investigations also took place, with the team noting all the possible locations for the NbS.

Cost estimates of the hybrid solutions were developed, based on national data and cost norms, supplemented where there were gaps by data from other countries in Asia. A previous study on valuing the benefits of NbS for IUFM in Kunshan, China was a key resource.[2] Next, the benefits were estimated. In this case, the majority of benefits were calculated based on market values – i.e. avoided costs of cleaning up after flooding to establish the value of the water retention from the lake. This was supplemented by the INFFEWS Value Tool for benefits such as recreational value to visitors. The Value Tool provides a way of transferring values from similar studies into the modelling tool for the study in question.

Another important consideration in the methodology is how benefits and cost change over time. Some benefits may be one-off, such as increases in property values. Other benefits will build over time, such as avoided flood damage. It is also important to build local technical and financial capacity to maintain assets so they continue to deliver value, as well as defining who will be responsible for maintenance. Additionally, the model recognizes benefits are more valuable now than in say 5, 20 or 40 years' time. The time value of money – or the 'discount rate' is usually set according to national standards, and commonly ranges from 2–6%. In this case, we assumed a discount rate of 4%, but the range adopted for sensitivity testing includes the current government bond yield of 2.4%.

After the cost and benefit information was added to the model, an important final stage was sensitivity testing. This stage asks how strong the conclusions are when significant changes are made to the assumptions. In cases such as these where the BCA is strategic, without precise costs and benefits, undertaking this step is important for establishing the validity of findings. In this case study, sensitivity testing involved increasing and decreasing costs and benefits by 30%, running the model 1,000 times and building a distribution of probabilities. Similar sensitivity analysis was done for different discount rates and key assumptions such as the take up rate of small scale NbS by private parties and the period of analysis. Results of the sensitivity testing are presented in Chapter 4.

Financing and funding recommendations were formulated based on international and national good practice and innovation. In particular, this study considered the existing national Floor Area Ratio (FAR) bonus scheme, as well as information on the distribution of costs and benefits from the BCA model, to support discussions about efficient and fair ways to distribute costs.

[1] Majidi, A. N., Vojinovic, Z., Alves, A., Weesakul, S., Sanchez, A., Boogaard, F. & Kluck, J. (2019). 'Planning nature-based solutions for urban flood reduction and thermal comfort enhancement', *Sustainability*, 11(22), 6361 (p 3); Hilly, G., Vojinovic, Z., Weesakul, S., Sanchez, A., Hoang, D. N., Djordjevic, S. & Evans, B. (2018). 'Methodological framework for analysing cascading effects from flood events: the case of Sukhumvit Area, Bangkok, Thailand', *Water*, 10(1), 81.

[2] Wishart, M., Wong, T., Furmage, B., Liao, X., Pannell, D. & Wang, J. (2021). *Valuing the benefits of nature-based solutions*. Washington DC: World Bank.

Stakeholder engagement

Strong stakeholder engagement and co-creation of solutions was critical to the case study approach. As well as promoting IUFM approaches, the project's parallel goal was to build capacity and create a community of practice of national champions who have the necessary tools and knowledge to identify, evaluate and quantify NbS within a robust economic framework.

A key initial action was forming a high-level Steering Committee with relevant Thai government stakeholder agencies. The Committee was chaired by the Office of Natural Resources and Environmental Policy and Planning (ONEP) with a core mandate of climate adaptation policy. Other agencies involved were the Bangkok Metropolitan Administration (BMA), the Office of the National Economic and Social Development Board (NESDC) and the Office of National Water Resources (ONWR).

Three workshops were held:

- **1. Foundational training for national stakeholders (8–9 February 2021):** This 2-day event provided a high-level overview and introduction of the topics, including examples of NbS as multifunctional water infrastructure in Australia, China and Thailand. The session also introduced the case studies, covering Steps 1 and 2 of the IUFM process and seeking feedback on whether the project team had adequately understood the local context and issues faced. The event covered both Rayong and Sukhumvit case studies.

- **2. Identifying Integrated IUFM and NbS Interventions (22–23 March 2021):** The second session focused on the Step 3 of the IUFM process, presenting the hybrid solutions and the anticipated benefits. Key questions put to stakeholders focused on local feasibility, whether the solutions adequately responded to the issues identified in the previous phase, and whether the benefits were accurately described. The event covered both Rayong and Sukhumvit case studies.

- **3. Valuing and comparing IUFM solutions (11 June 2021):** The final session focused on Steps 4 and 5 of the IUFM process, presenting the results of the BCA analysis, and outlining potential modalities for funding and financing. A key goal was to test the assumptions in the model with participants to ensure their appropriateness. While supportive of the overall direction and results, key feedback from that event reduced the period of analysis from 40 to 20 years. Two separate workshops were held for each of the 2 case study locations, although participants from Rayong joined the Sukhumvit workshop and vice versa.

To ensure continuity of learning outcomes and to support the development of a community of practice, the same participants were invited to each event. However, as the case progressed, the project team broadened engagement, reaching out to non-governmental organizations involved with NbS in Thailand. This led to consultation with Chulalongkorn University's Urban Design and Development Centre (UddC) who lent critical insights and perspectives, as well as facilitated stronger networks for current and future implementation of NbS.

1. Define your urban system context

“History taught us that Bangkok is a city of water with lush forests and verdant nature. We used to live under Bangkok’s green canopy, but 70 years ago many old trees were replaced by buildings. The fertile soil is now covered by concrete, and our lives left the water behind. We can co-exist with nature in the city centre. We must understand that forest resources are important to us. Humans, forest and wildlife are deeply interconnected, and no one element can be missing.”[3]

1.1 Bangkok leading the way for nature-based solutions in Southeast Asia

Bangkok is a pioneer in Southeast Asia for its use of NbS as part of future city and climate resilient thinking. Opened in 2017, the visionary Chulalongkorn University Centenary Park was one of the first to demonstrate the full benefits of multifunctional green space. The park contains the largest green roof in Thailand and harnesses the power of gravity to collect, treat and detain water to reduce flooding in the surrounding area and protect against a 50-year average recurrence interval (ARI) flood event. Constructed wetlands containing local species treat water to improve quality, and a large retention pond ensures no water is wasted with rain and roof runoff circulated for park irrigation. Three hundred varieties of plants and trees are grown, and the multifunctional space is integrated with ‘outdoor classrooms’ including a herb garden, meditation area, bamboo garden and children’s areas. Stationary water bikes allow visitors to contribute to the wetland treatment system by aerating the water.[4]

[3] Army Public Relations Center (2020). *The Royal Thai Army joins hands with the Treasury Department to sign an MOU to build a forest plantation* ‘Benjakitti Park’ Phase 2–3. Retrieved 28 May 2021 from https://www.facebook.com/armyprcenter/posts/3430609813671373

[4] Chulalongkorn University Centenary Park. Landprocess. Landezine International Landscape Award. https://landezine-award.com/chulalongkorn-university-centenary-park/

Figure 2: Aerial view of the park (top) and planning (bottom).
Source: https://landezine-award.com/chulalongkorn-university-centenary-park/.

Another example is the Thammasat University Green Roof in Bangkok. As Asia's largest urban rooftop farm, this 22,000 m^2 space mimics traditional rice terraces to deliver public green space, urban organic farming, water management and solar energy.[5]

[5] Homes, D. (2020). Thammasat University – the largest urban rooftop farm in Asia. World Landscape Architecture. https://worldlandscapearchitect.com/thammasat-university-the-largest-urban-rooftop-farm-in-asia/.

1.2 Benjakitti Park: from tobacco factory to green lung of Sukhumvit

To the east of Chulalongkorn Centenary Park, another visionary plan is in the making. In 1991, a large tobacco factory in eastern Bangkok was moved outside the city, leaving the land on Rama IV Road, Khlong Toei District for a public park. This park was opened to the public in 2004 as a tribute to Queen Mother Sirikit. With a total area of 9.8 ha, the park included a large lake surrounded by a forested area, an outdoor recreation space, a steel walkway, bicycle land and a parking area.

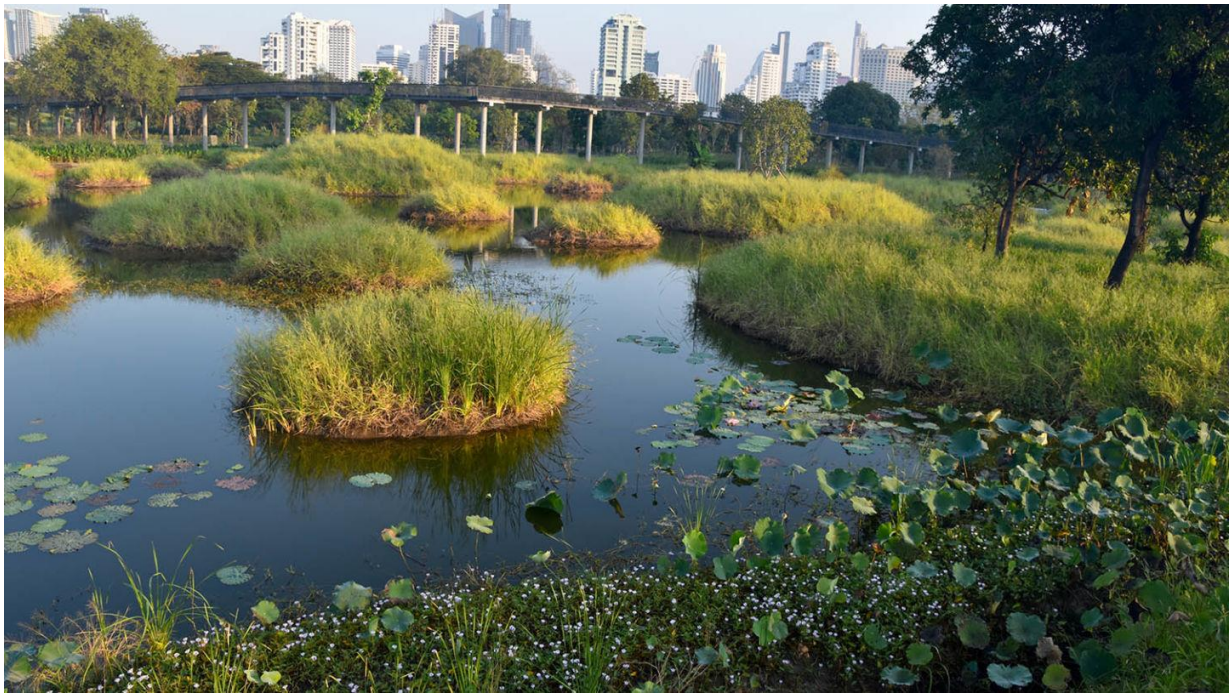


Figure 3: Elevated walkway connecting Benjakitti and Lumpini parks.
Source: Coconuts Bangkok, 2021, 'Take a peek inside Bangkok's massive downtown park upgrade, https://coconuts.co/bangkok/lifestyle/take-a-peek-inside-bangkoks-massive-downtown-park-upgrade-photos/.
Photo: Phoebe Storm.

In October 2020, the Thailand Tobacco Monopoly handed over the remaining land and the Treasury Department and the Royal Thai Army signed a memorandum of understanding for Phase 2 and 3 of the Benjakitti Park with a budget of 652 million Thai Baht (approximately USD 20 million). The aim was to transform the landscape and disused space into a green zone fitting with Bangkok's original habitat. The design includes water in every area, with the park intended to be a 'giant sponge' in the city centre, absorbing up to 120,000 m^3 of water during the rainy season and providing moisture in the dry season. In this way it will help to mitigate both flood and drought problems.

The plan proposes keeping the existing 1,733 trees, plus reintroducing a multitude of native species including large and rare trees like Bodhi and Banyan. Landscaping will feature traditional ridging techniques to prevent roots being flooded and reduce park maintenance needs by letting gravity-based flows irrigate plants. The rich ecological zones will provide a habitat for animal species like migratory birds. The plan also includes the renovation of the former warehouse, a herbarium of rare plants, walkways, bicycle paths and learning centres for the public to foster an appreciation of the values of forest, water natural resources and environmental sustainability. In addition, several sustainable solutions for park maintenance are proposed, including solar cells to provide lighting, and a water turbine. Covering a total of 41.4 ha including the original site, the project is expected to be completed by the end of 2021

and open to the public early 2022. This case study considers opportunities to add further value to the significant benefits offered by the measures already planned for Benjakitti Park.

Figure 4: Artistic renderings of the completed Benjakitti Park.
Source: Army Public Relations Center. (2020). The Royal Thai Army joins hands with the Treasury Department to sign an MOU to build a forest plantation 'Benjakitti Park' Phase 2–3. Retrieved 28 May 2021 from https://www.facebook.com/armyprcenter/posts/3430609813671373

1.3 Integrating NbS opportunities beyond Benjakitti Park – the 'northern area'

As well as Benjakitti Park, this case study also focuses on a portion of the urban area between the park and Sukhumvit Road within Klong Toey District (Figure 5). This area is dense and highly urbanized, filled with markets, hotels, shopping malls and high-rise residential buildings. It is bounded by Sukhumvit Road to the north – one of the busiest streets in Bangkok with nightlife and restaurants. The area suffers from flooding, poor water quality and urban heat island problems (see Chapter 2). Runoff from this area flows into the open channel to the north of Benjakitti Park. This area was chosen to fully demonstrate the IUFM process, showing how the park and the surrounding urban area can function together to provide maximal benefits.

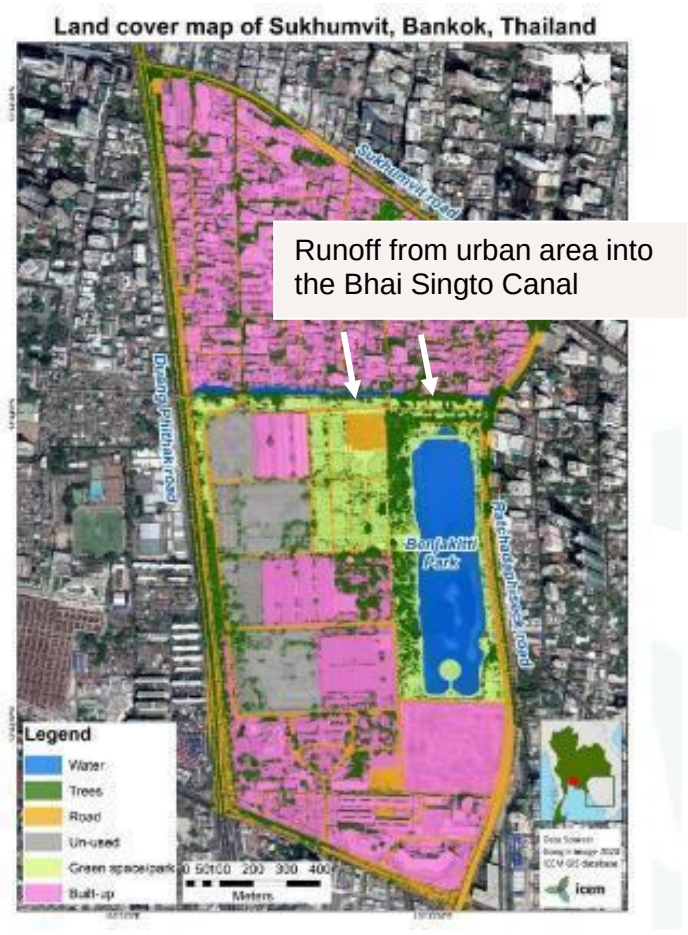


Figure 5: Soi Cowboy street – a famous nightlife location on Sukhumvit road (top left), Asok intersection (bottom left), case study site showing elevation and water flow direction (right).
Sources: Project team, Wikimedia commons.

1.4 Connecting major green assets for more value – Lumpini Park and green bridge

Another well-known park in neighboring Pathum Wan District is the 57.6 Lumpini Park – one of the largest and most frequented green spaces in central Bangkok. A 1,300 m elevated green bridge connecting Lumpini and Benjakitti parks was built in 2000 but has since fallen into disrepair, with damage to the bridge surface, the stainless steel fences and the lighting. The BMA, with key input from UddC, has plans to renovate the bridge as a part of a larger 3 Dimensional Superconnector, seamlessly linking the 2 main parks. With a budget of

approximately USD 1.2 million, this initiative will provide mobility for people, act as a bridge for plants and animals, and improve public safety for the formerly rundown and often dangerous site.

Figure 6: Aerial view of Lumpini Park and Benjakitti Park with proposed green bridge.
Source: UddC.

2. Undertake a flood risk assessment

In Bangkok, annual rainfall is 1,651 mm which takes place mainly in the wet season from May to October. Over the past 30 years, rainy days have increased from an average of 90 to 110, and average mean temperature has increased by 0.6°Celsius over roughly the same period.[6] The OECD found that by 2070, Bangkok will be among the top 10 cities in the world exposed to flooding, affecting half of its 10 million residents.[7]

Elevation along Sukhumvit Road is approximately equal to sea level which makes it vulnerable to fluvial and coastal flooding due to overtopping of embankments along the Chao Phraya River. Flooding is further aggravated by inadequate local drainage. The lack of storage areas and rapid urbanization and a decrease in vegetated, permeable areas since the early 1990s. Land subsidence is also a challenge caused by over extraction of groundwater, with some areas sinking by up to 15 cm. BMA divides Bangkok's flood protection into polders – an approach that prevents discharge from upstream areas during high tide – and local drainage that aims to prevent pluvial flooding.

A 2018 study on flooding impact in Sukhumvit led by IHE Delft Institute found widespread losses from flood events, with most notable impacts being to drivers of vehicles and motorbikes. Around 82% of respondents reported failure of transportation services due to flooding.[8] These effects are 'cascading', with transport disruption causing lost business hours, additional fuel consumption and additional CO_2 emissions. Another key impact of flooding was stormwater intrusion into the water supply system and contamination by *E. coli* and other waterborne pathogens, which threaten public health.

A later 2019 study led by IHE Delft analyzed NbS for urban flood reduction and thermal comfort enhancement in Sukhumvit. Figure 7 shows flood hazard overlaid with height of buildings. The study found heat stress was more likely to occur in the dense upstream in A1 which contains more high-rise buildings, while flooding was worse in the low-rise area of A2, due to the runoff from the impervious surfaces in A1 flowing downstream to A2. The study also found urban parks can be up to 1.4°Celsius cooler than the surrounding urban area.

[6] Majidi, A. N., Vojinovic, Z., Alves, A., Weesakul, S., Sanchez, A., Boogaard, F. & Kluck, J. (2019). 'Planning nature-based solutions for urban flood reduction and thermal comfort enhancement', *Sustainability*, 11(22), 6361 (p 3).

[7] Nicholls, R.J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot, J., Château, J. & Muir-Wood, R. (2008). *Ranking port cities with high exposure and vulnerability to climate extremes: exposure estimates.*

[8] Hilly, G., Vojinovic, Z., Weesakul, S., Sanchez, A., Hoang, D. N., Djordjevic, S. & Evans, B. (2018). 'Methodological framework for analysing cascading effects from flood events: the case of Sukhumvit Area, Bangkok, Thailand', *Water*, 10(1), 81.

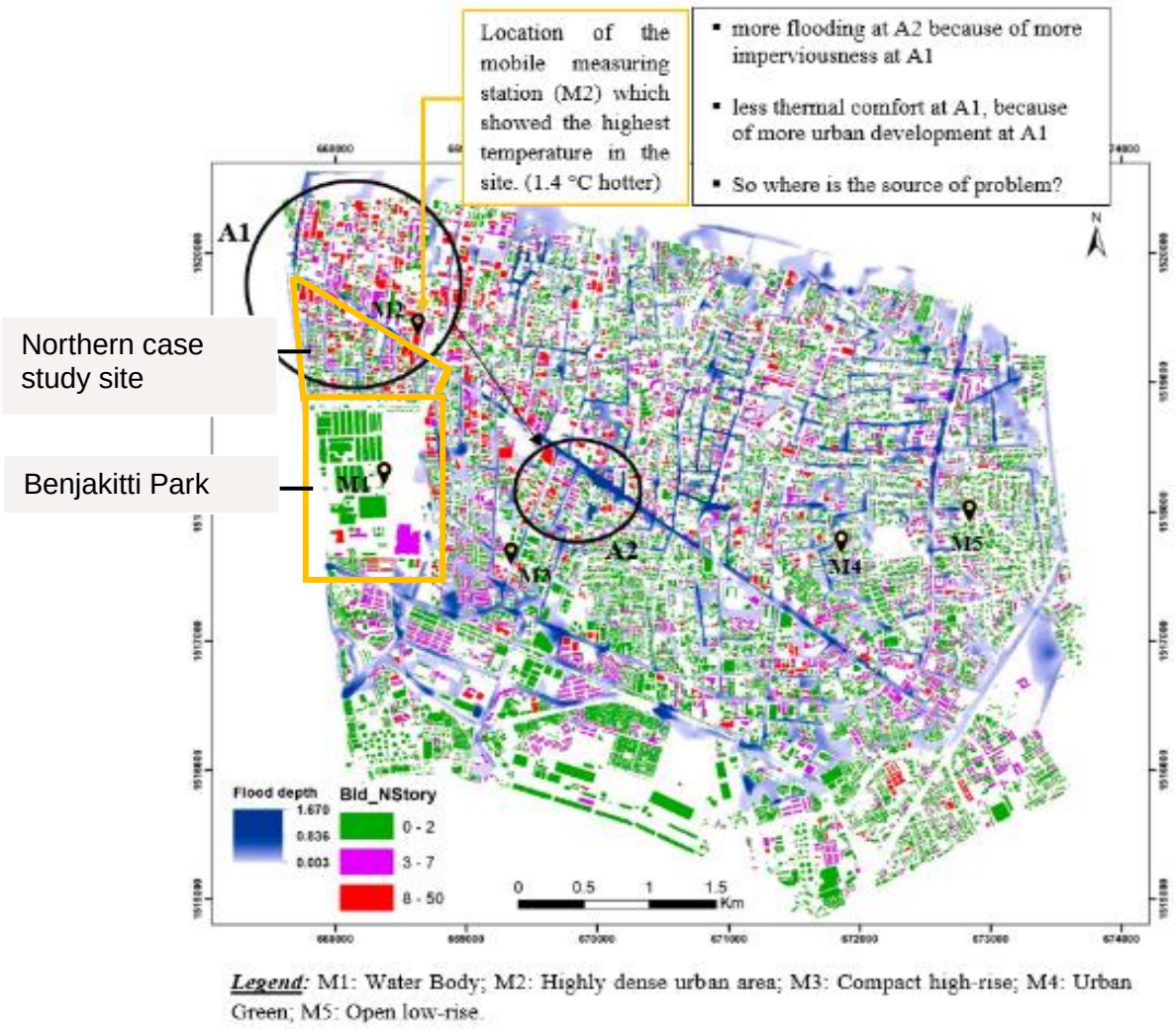


Figure 7: Flood inundation map of Sukhumvit (20 year ARI) and building height.
Source: Majidi, A. N., Vojinovic, Z., Alves, A., Weesakul, S., Sanchez, A., Boogaard, F. & Kluck, J. (2019). 'Planning nature-based solutions for urban flood reduction and thermal comfort enhancement', Sustainability, 11(22), 6361 (p 9).

That study analyzed the potential effectiveness of 4 NbS in Sukhumvit: green roofs, pervious pavements, bioretention with shrubs (height of 1.2 m), and raingardens (trees of 6 m height). It concluded green roofs are the most efficient NbS type for the case study area, reducing total runoff volume by up to 39% and reducing peak discharges for a 2-year ARI rainfall event by up to 40%. Green roofs were also particularly promising due to the relatively large suitable area for implementation, with the study finding around 27% of the area suitable for green roof implementation. Raingardens had the most significant effect on urban heat, but only in low-rise areas where trees prevented sunlight reaching paved areas. (In high-rise areas, the shadows of tall buildings did not allow trees for further decrease temperature.) However, in the night time, when urban heat island is at its peak, raingardens were more effective, counteracting the release of heat stored by high-rise buildings during the day. Raingardens can also reduce flooding by improving infiltration. The study proposed a combination of raingardens and green roofs to address both urban challenges.

3. Identify context-appropriate solutions

The hybrid approach

The baseline scenario in this case is taken as the Phase 2 and 3 of the Benjakitti Park works led by the Treasury Department and Royal Thai Army and the Green Bridge from BMA and UddC. The visionary ecological design of the park and green bridge plan is recognized, as well as the goal of scaling up the model and expanding it across Thailand. However, while the park will deliver strong benefits in terms of recreation, aesthetics, and flood mitigation, it may not be enough to fully respond to significant flooding events.

This case study proposes additional large and small scale initiatives as part of a package of actions to maximize multifunctionality and improve the flood protection level, providing the economic evidence base to support further upscaling. The solution focuses not just on the park, but also builds on the findings of the IHE Delft study. Specifically, it proposes installing precinct and small scale NbS in the northern urban area to mitigate local flooding problems, and enhancing the precinct-scale approach by connecting the green bridge to the northern urban area to further enhance mobility and multifunctionality as part of a 'green triangle'.

1. **Multifunctional design of Benjakitti Park.** The design incorporates improvements to the open channel in the north of the existing park site, a linear subsurface flow wetland to improve water quality in the channel and intercept direct wastewater discharged from the northern area, retrofitting of the lake for greater flood detention capacity and amenity with a terraced design and wetland species that can withstand full or partial inundation, and stormwater harvesting that can be recirculated and used for park irrigation and non-potable water supply for park learning centres.

2. **The incorporation of precinct and small scale NbS in Sukhumvit to the north of the park.** A network of NbS including green roofs, tree pits, swales and stormwater planter boxes will be installed through partnerships with the private sector and local communities to mitigate frequent flooding, reduce combined sewer overflows into the open canal, and improve human thermal comfort and amenity for local residents and tourists.

3. **A 'green triangle'** that connects the greened urban area to Benjakitti Park and Lumpini Park to the west to create a cool, walkable and ecologically rich central zone in Bangkok's Sukhumvit area, which can be traversed using an innovative Internet of Things enabled 'cool lines' platform.

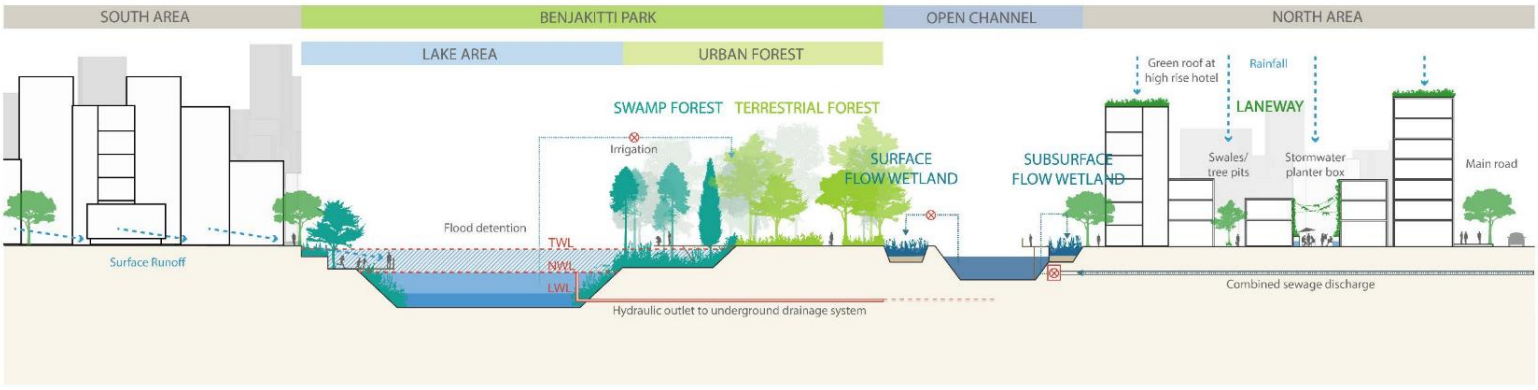


Figure 8: Transect overview of the hybrid approach.
Source: Project team.

Benefits of the hybrid approach

The proposed hybrid approach has a range of additional benefits across the whole case study area:

- flood mitigation
- improved water quality
- improved human thermal comfort
- improved public health
- increased amenity, recreational and leisure opportunities
- enhanced public safety
- reduced costs for park maintenance
- increased tourism and increased spending in the local community
- enhanced urban ecology.

The following section describes each of the 3 components of the hybrid approach in detail.

3.1 Multifunctional design of Benjakitti Park

3.1.1 Bhai Singto Canal subsurface and surface flow wetland

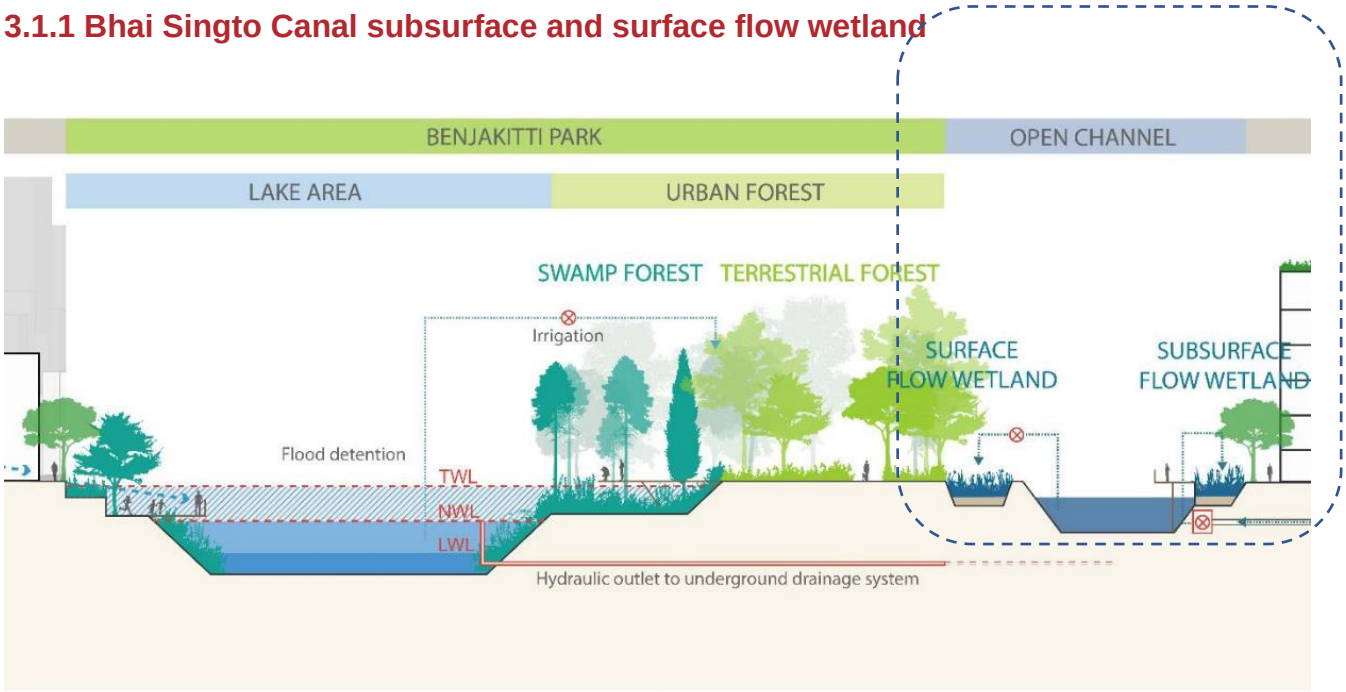


Figure 9: Bhai Singto Canal subsurface and surface flow wetland.
Source: Project team.

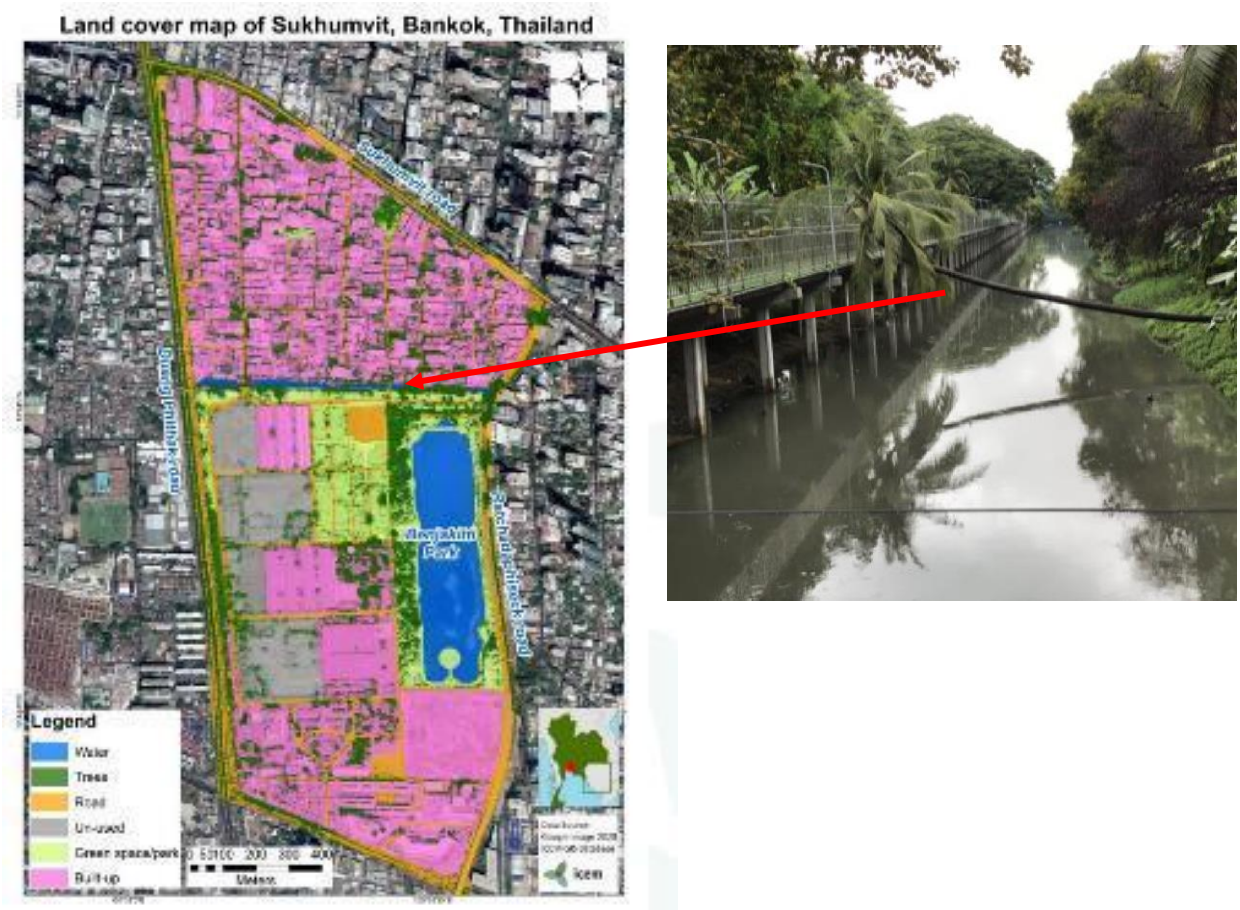


Figure 10: Case study area and location and image of Bhai Singto Canal.
Source: Project team, site visit October 2020.

Just north of the existing park site, an open channel runs from east to west, receiving wastewater and combined sewer overflows from the northern urban area. Along this channel runs the steel walkway that has been targeted for upgrading and renovation. The hybrid NbS solution proposes installing a linear subsurface flow wetland on the northern side of the channel to intercept and treat runoff from the northern area before it reaches the park, and a linear surface flow wetland on the southern side of the channel to improve water circulation for further water cleansing. The combination of both interventions will improve the water environment in the channel and allow the flow of better-quality water into the lake.

This subsurface wetland system will usually consist of an excavated basin containing gravel at a depth of approximately 0.6–1.0 m and emergent aquatic plants. Wastewater is introduced at one end of the basin through interception pump sumps (Figure 11) installed at the drainage outlet of the urban area. It flows horizontally to the effluent end, being treated via microorganisms on the plant root systems that break down the contaminated effluent, discharging clean water at the end. As it passes through the basin, the water is kept below the surface of the gravel so there is no risk of odors, insect vectors or public exposure.[9] The second linear surface flow wetland installed at the southern side of the channel will be used as a recirculation system to constantly treat the water in the open channel. The wetland and the channel will be integrated into the broader Benjakitti Park design with riparian plants and the renovated walkway above the subsurface flow wetland creating an accessible and

[9] Reed, S. C. & Brown, D. (1995). 'Subsurface flow wetlands—a performance evaluation', *Water Environment Research*, 67(2), 244–248.

aesthetic waterfront area. These features will benefit park visitors and create greater opportunities for waterfront recreation and possible commercial activities, such as small cafes with viewing platforms along the channel.

Figure 11: Subsurface wetland design (left) and example from Xuhui, Shanghai (right).
Sources: Project team (left), Sasaki (right).

3.1.2. Retrofitting of the lake edge for greater flood detention capacity and establishment of swamp forest

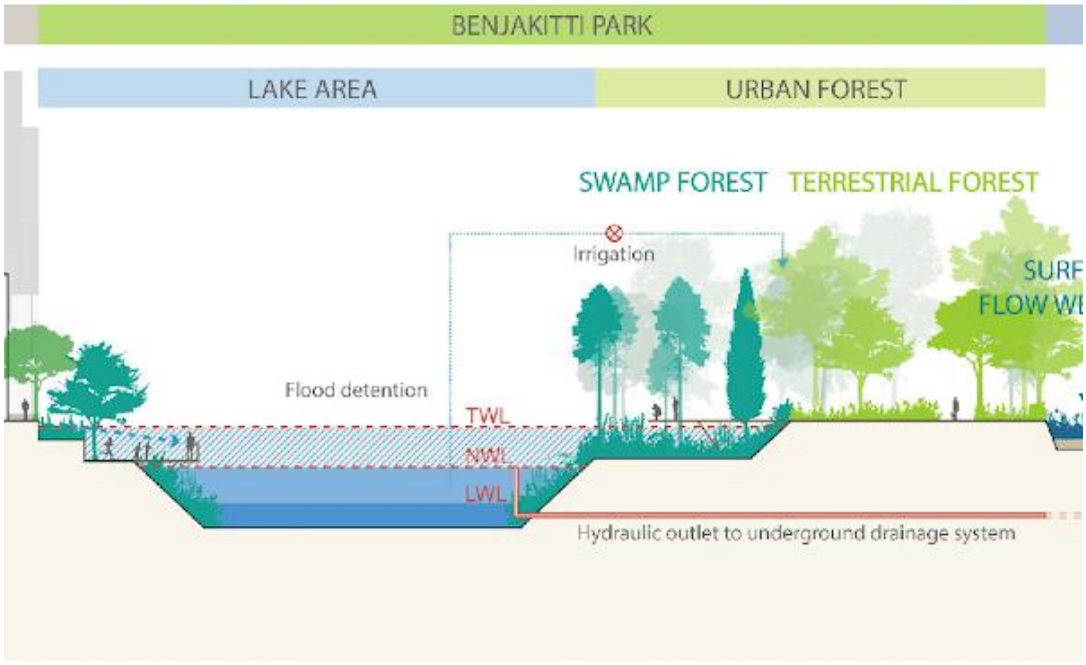


Figure 12: Top, normal and low levels of water in the lake.
Source: Project team.

Retrofitting the lake areas with a terraced edge design and using wetland species that can withstand full or partial inundation allows the riparian zone to function as a critical flood detention area. It receives surface runoff from the southern urban area via either active or passive diversion during flood events, increasing the park's ability to absorb and store water even further. The volume between the normal water level and the top water level is the volume that is available to temporarily detain flood water before it drains to the north (Figure 12). This is achieved by creating a hydraulic outlet that connects to the underground drainage system that manages the maximum flow from the lake to the downstream and thereby controls flooding for the precinct. This design supports distributed flood storage in the polder which can dramatically mitigate extreme flooding downstream. During normal water levels, the riparian area is available for recreational purposes. This design is also exhibited at the Chulalongkorn Centenary Park; during extreme flooding, the retention lake can double in size by expanding into the park's main lawn.

Bangkok lies on former swampland. Planting wetland forest species along the riparian zone restores elements of Bangkok's natural systems. The swamp forest will be highly multifunctional, detaining flood water, improving the water quality in the lake via plant root systems, providing habitat for species and creating canopy shading during summer. The wetland forest will gradually merge with the terrestrial forest of the Benjakitti Park. There should be multiple layers and a mix of vegetation, with shrubs, understory and canopy trees. The forested area in the park should include wetland species to maintain the quality of water in the lake through recirculation between storm events and avoid outcomes such as algae blooms which are unsightly and threaten public health.

Figure 13: Artistic renderings showing the multifunctional design across various levels of inundation and integration of the swamp forest with other park assets.
Sources: Tiange Wu, Water Sensitive Cities Australia.

The design can also incorporate features to minimise the risk of mosquitoes:

- The wetland can be designed with proper hydraulic retention time and a recirculation feature to avoid stagnant water.
- The design can include various habitats to attract and host mosquito predators.
- Maintenance is essential to ensure design features remain functional.

3.1.3 Stormwater harvesting

It is important to showcase the park as fully sustainable, drawing its irrigation needs from stormwater rather than mains supply. A good amount of stormwater can be harvested before discharge to the northern area and stored in the lake using the volume between normal water level and lowest water level, providing significant cost savings for park maintenance. Stormwater harvesting involves intercepting stormwater before it flows down the drain, treating it using biofiltration. Figure 14 provides an overview of a stormwater harvesting system.

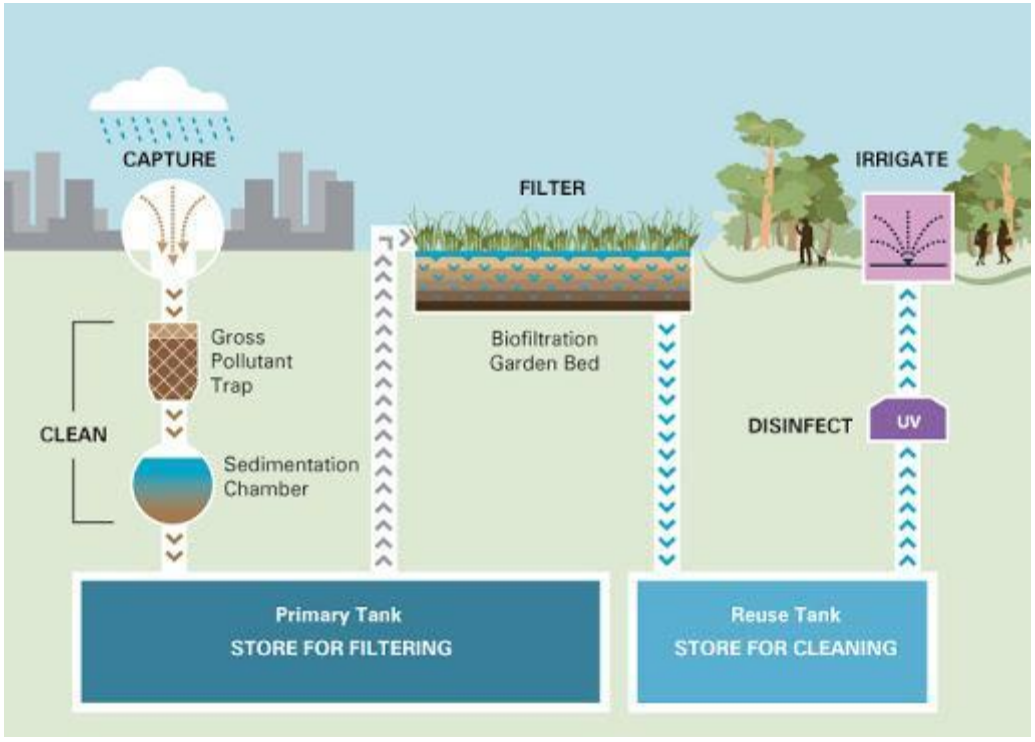


Figure 14: Stormwater harvesting system.
Source: Melbourne Water.

In this case, water will be intercepted from the lake and reticulated for park irrigation, and could also be exported for non-potable water consumption such as toilet flushing in the learning and convention centres included in Phase 2 and 3 of the Benjakitti Park plan. Water will be drawn from the top water level to the lower water level depending on the operating scenarios. This approach involves designing the lake edge to look different, but aesthetically pleasing at any water level in the lake. Figure 13 presents an artistic rendering of such a design.

3.2 Precinct and small scale NbS in urban area to the north of Benjakitti Park

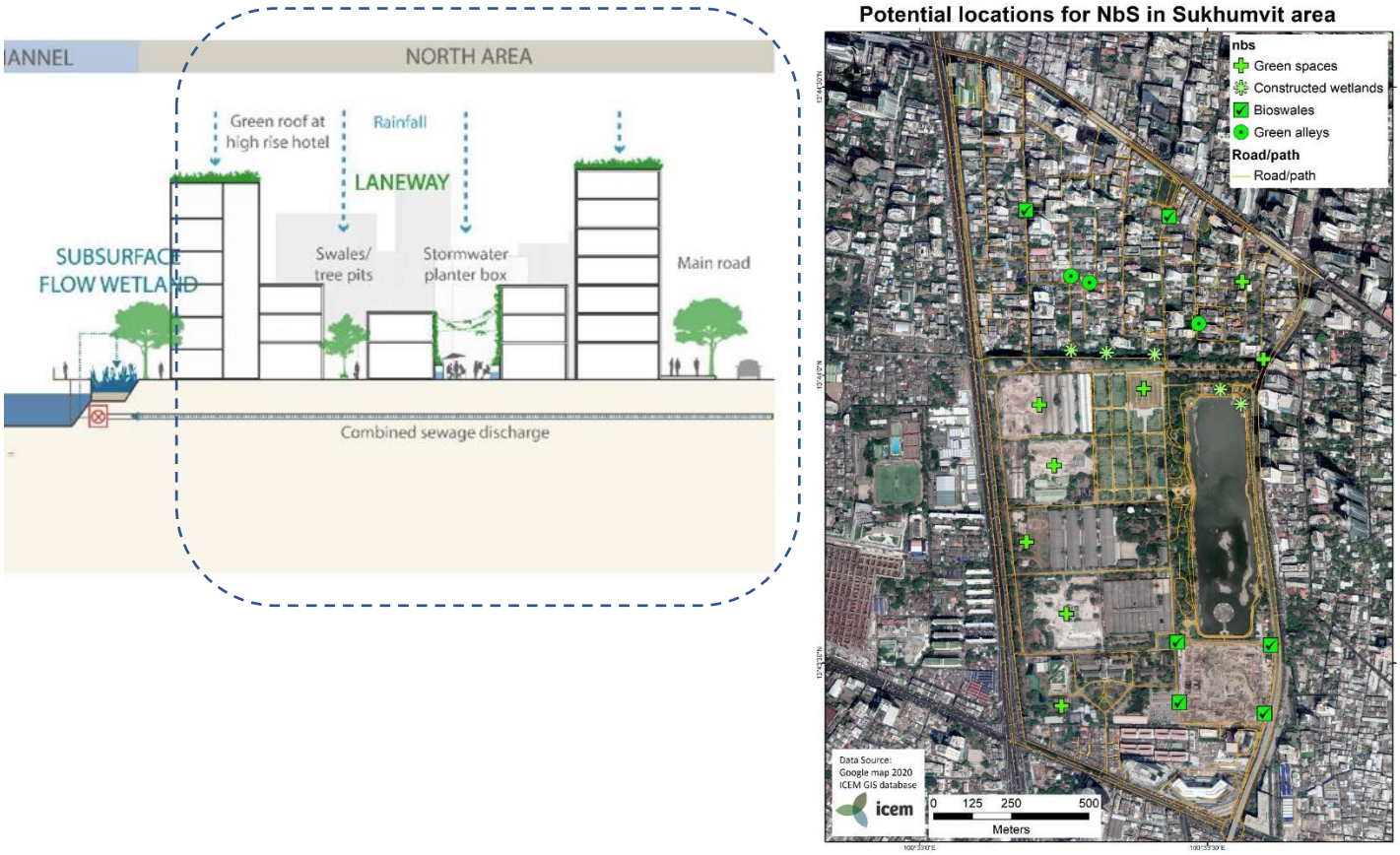


Figure 15: Overview of components for NbS in northern urban area (left), map of potential locations (right).
Source: Project team.

The second part of the hybrid strategy for Sukhumvit builds on the IHE Delft study to recommend a network of precinct and small scale NbS to mitigate flooding, intercept combined sewer overflow discharge, and improve human thermal comfort and amenity for local residents and tourists. These measures comprise green roofs, tree pits, swales and stormwater planter boxes. For this part of the strategy, the project team acknowledges measures may not be fully consistent with BMA and other municipal regulations. For example, currently, private systems cannot connect to the main drainage system, as capacities have been calculated. The proposed NbS would reduce the demand on the drainage system and therefore improve its overall capacity in terms of the total number of communities it services. However, regulatory reform would be required to permit the connection to the drainage system. Maintenance is also important, with clear divisions of responsibilities, demonstration projects and capacity building needed to support municipal agencies and private sector and residential groups.

3.2.1 Green roofs

Green roofs were the leading solution from the IHE Delft study by capturing and detaining roof runoff at the source. A well-designed green roof can capture and detain the majority of roof runoff, easing pressure on the drainage system and reducing both flooding and combined sewer overflow. Figure 16 provides an example of the components of a green roof.

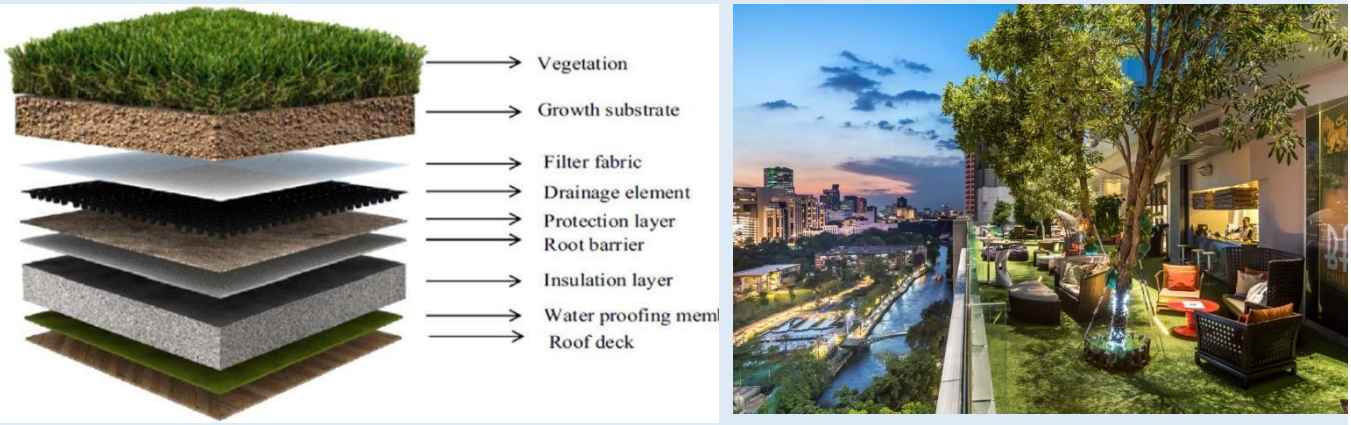
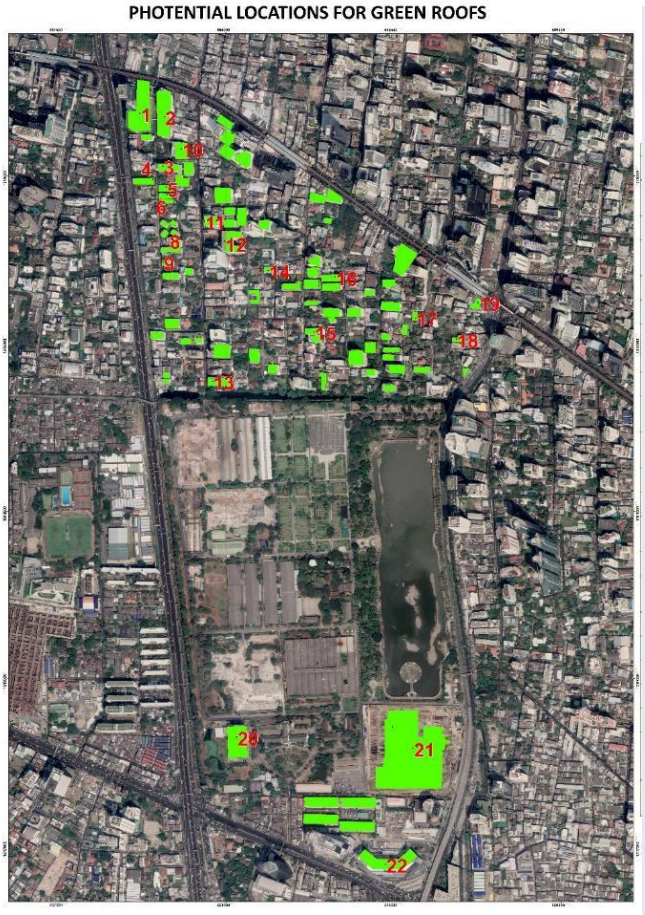


Figure 16: Components of a green roof (left), Novotel Bangkok rooftop bar (right).
Source: Le Trung, N., Khawaja, M., Beyranvand, E., Bucchi, D., Singh, A. & Alam, A. A. (2018). Approaching a nearly zero-energy building in integrated building design by using green roof and double skin façade as major energy saving strategies.

Landscape designed green roofs could be targeted at luxury high rise hotels, which will provide an additional attraction for guests. The green roofs can be integrated with other luxury amenity constructions like infinity pools and sky bars, taking advantage of the views and cumulatively creating a highly aesthetic green view over Sukhumvit. The project team used the Fulcrum surveying tool and GIS analysis to estimate green roof potential in the area at 91 buildings, or 14.2 ha in the northern and southern area (Figure 17). The team adjusted this result to 22 high potential sites, with 19 in the northern area and 2 in the southern area, accounting for limitations in uptake due to private ownership. To encourage uptake, tax incentives can be provided as well as grants, and promotion and technical support made available for construction and maintenance.



ID	Name	Address
1	Ploenchit Center	Duang Phithak Rd, Khlong Toei, Bangkok 10110, Thailand
2	JW Marriott Hotel Bangkok	4 Sukhumvit 2, Khwaeng Khlong Toei, Khet Khlong Toei, Krung Thep Maha Nakhon 10110, Thailand
3	Rajah Hotel	18 Soi Sukhumvit2 & Sukhumvit4 Sukhumvit Road Klongtoey Bangkok 10110, Thailand
4	Focus Ploenchit	Sukhumvit 2, Khwaeng Khlong Toei, Khet Khlong Toei, Krung Thep Maha Nakhon 10110, Thailand
5	Hotel Icon Bangkok	49 Sukhumvit Rd, Khlong Toei, Bangkok 10110, Thailand
6	Green Ville	51 Soi Pha Suk, Khlong Toei, Bangkok 10110, Thailand
7	SureStay Plus Hotel by Best Western Sukhumvit 2	89 Sukhumvit Soi 2 Sukhumvit road, Khlong Toei, Bangkok 10110, Thailand
8	65-65/1 Soi Pha Suk	65-65/1 Soi Pha Suk, Khet Khlong Toei, Krung Thep Maha Nakhon 10110, Thailand
9	iCheck Inn Residence Sukhumvit Soi 2	71 Sukhumvit Soi 2 Sukhumvit road, Klongtoey, Bangkok 10110, Thailand
10	Shama Sukhumvit Bangkok	39/1 Sukhumvit 2, Klongtoey, Watthana, Bangkok 10110, Thailand
11	S.M. Grande Residence	33 Sukhumvit 4 Alley, Khlong Toei, Bangkok 10110, Thailand
12	ibis Bangkok Sukhumvit 4	41 ถนนเทศบาล4 Klongtoey, Watthana, Bangkok 10110, Thailand
13	Nana Tai Mansion Apartments	225 Sukhumvit 4 Alley, Khlong Toei, Bangkok 10110, Thailand
14	129 Sukhumvit 4 Alley	129 Sukhumvit 4 Alley, Khwaeng Khlong Toei, Krung Thep Maha Nakhon 10110, Thailand
15	Citadines Sukhumvit 8 Bangkok	77/7 Sukhumvit 8, Sukhumvit Road, Klongtoey, Bangkok 10110, Thailand
16	Baan Siri Sukhumvit 10	16 Sukhumvit 10 Alley, Khlong Toei, Bangkok 10110, Thailand
17	MSI III GARDEN	49 1 ซอย สุขุมวิท12 Khlong Toei, Bangkok 10110, Thailand
18	Red Planet Bangkok Asoke	7 Sukhumvit 14 Alley, Khlong Toei Nuea, Khlong Toei, Bangkok 10110, Thailand
19	Urban Retreat (Asoke Branch)	348 1 Sukhumvit Rd, Khlong Toei Nuea, Watthana, Bangkok 10110, Thailand
20	Benchakitti Park Hospital	Rama IV Rd, Khlong Toei, Bangkok 10110, Thailand
21	Queen Sirikit National Convention Centre	60 Ratchadaphisek Rd, Khlong Toei, Bangkok 10110, Thailand
22	Minor International PCL	88 The PARQ Building, Ratchadaphisek Rd, Khlong Toei, Bangkok, Thailand

Figure 17: GIS and Fulcrum mapping of potential green roof sites in case study area (left), list of corresponding buildings (right).
Source: Project team.

3.2.2 Tree pits and swales

The IHE Delft study found raingardens or trees around 6 m high are the most effective at improving thermal comfort, as well as having additional flood mitigation benefits by increasing natural drainage into the soil. This case study proposes BMA install tree pits and swales on public pavements and roads to create a ‘pocket’ landscape that receives road runoff, mitigates flooding, and improves thermal comfort from the shade provided by the trees. The vegetation will be passively irrigated by the stormwater.

Figure 18: Potential locations for swales in case study site.
Source: Project team.

3.2.3 Stormwater planter boxes

Another streetscape solution are stormwater planter boxes; this vegetated urban furniture connects to downpipes and detain roof runoff in low-rise areas. Stormwater planter boxes can be integrated with seating to provide additional leisure and amenity benefit. It proposed that the planter boxes be installed by private owners under the same incentivization and support scheme as the green roofs, with grants and technical support available for construction and maintenance to encourage uptake. This measure may be desirable for cafes, e.g. with the boxes providing additional outside seating, as well as in private residential areas. Demonstration sites on public buildings (e.g. schools, hospitals) may also support private uptake.

Figure 19: Artistic rendering of stormwater planter box.
Source: CRCWSC.

3.3 'Green triangle' connecting the greened northern urban area to Benjakitti Park and Lumpini Park

Figure 20: Artistic rendering of the Green Bridge.
Source: UddC.

This third concept builds upon the existing plan to renovate the walkway through Benjakitti Park to Lumpini Park. The green triangle would extend the bridge, connecting it to the northern urban area. The existing Benjakitti Park includes a large parking area. The hybrid plan instead encourages walking and cycling, allowing visitors easy connection through a large geographical area. Currently, visitors to Benjakitti Park may be different to those who visit, live or work in the northern urban area. Connecting the areas via an aesthetic, ecologically designed walking and cycle path creates a dynamic space for social and neighborhood

interaction. Green space is well known to have a positive impact on social cohesion, provided it remains accessible and non-privatized. A 2001 study of the Chicago Robert Taylor Homes (the largest public housing development in the world) found residents with an increased number of trees and amount of grass in the neighborhood socialized with their neighbors more and felt safer than those in treeless blocks.[10] Opened officially in 2009, the High Line project in New York transformed a former railway into a public park and multi-events space. It was widely lauded for bringing the community together and reducing local crime rates.[11]

Figure 21: The New York High Line.
Source: Wikimedia commons.

A similar initiative was undertaken in Bangkok with the Chao Phraya Sky Bridge, designed by UddC, N7A and Landprocess. Commissioned by BMA and costing around USD 3.9 million, this project transformed a portion of an abandoned electric train track into a green pedestrian bridge. This bridge connects the King Prajadhipok Park at the Phra Nakon side of the river with the Chaloem Prakiat Forest Park in Thon Buri. The sky park has been described as linking old communities in the area and creating an alternative for the over-the-river commute.[12]

[10] Arup (2014). *Cities Alive: Rethinking green infrastructure*. London: Arup.
[11] Arup (2014). *Cities Alive: Rethinking green infrastructure*. London: Arup.
[12] Bangkok Post (2020). *Sky park bridges old Chao Phraya communities*. https://www.chula.ac.th/en/clipping/31942/

Figure 22: Chao Phraya Sky Bridge.

Source: UddC.

The hybrid approach also proposes an innovative 'cool lines' platform for the green triangle via a digitally available map of the whole area (e.g. on a mobile app). An Internet of Things based smart system that monitors urban heat would guide residents and visitors to the coolest and most shaded path in real time. Attractions including viewpoints and places to sit would be marked, e.g. the stormwater planter boxes, viewpoints along the green bridge, and publicly accessible rooftop gardens. Aligning with the existing vision of the green bridge to attract tourism and boost the local economy, this system would provide a novel attraction for people to explore Sukhumvit, as well as give local businesses an incentive to participate in the greening by including them in the cool lines map.

What is the 'Internet of Things'?

The Internet of Things, or IOT, refers to the billions of devices that are now connected to the internet, all collecting and sharing data. Connecting all these 'things' and adding sensors enables them to communicate real-time data to each other as part of 'smart' platforms.

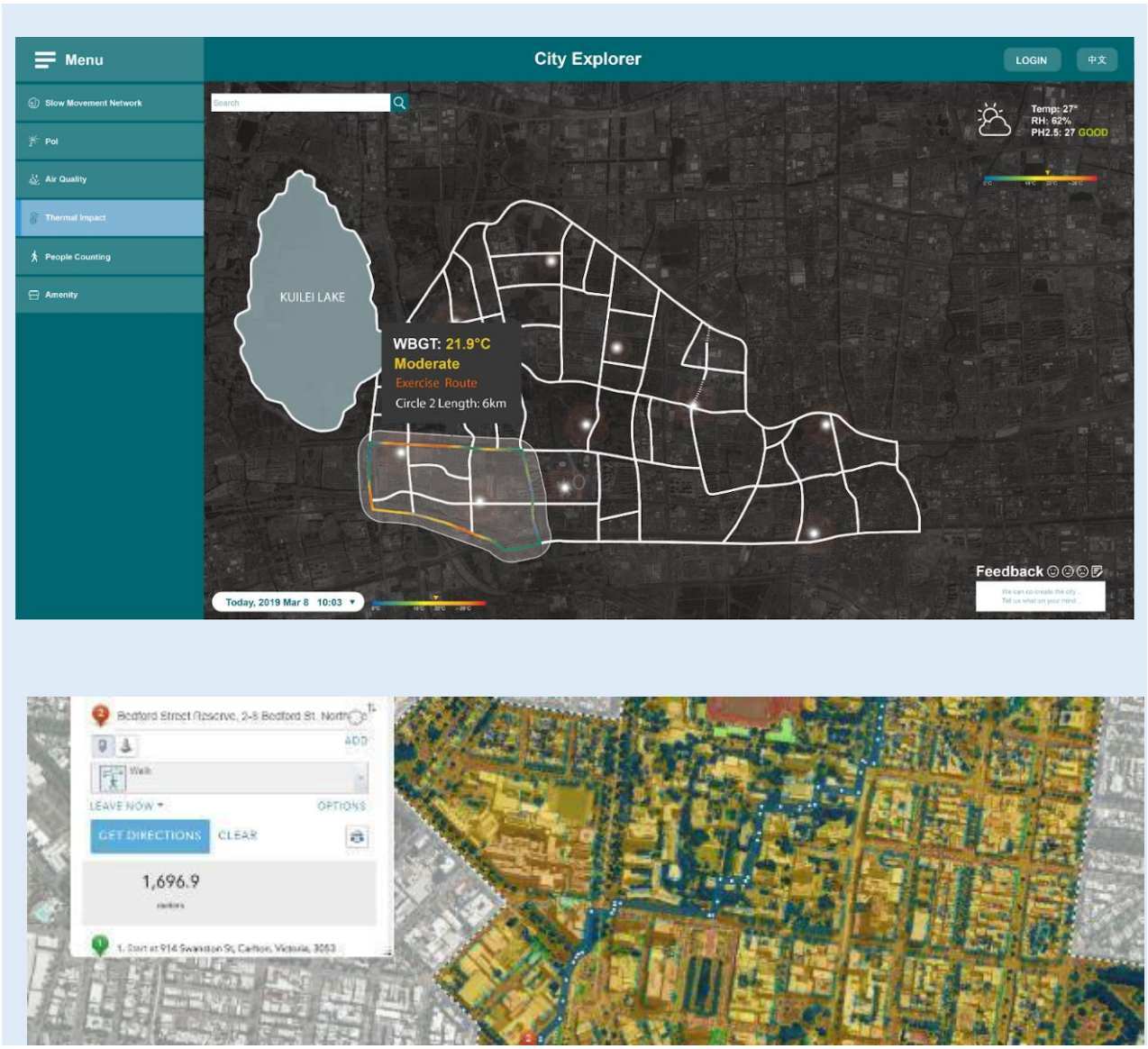


Figure 23: Cool lines platform in Australia.
Source: CRCWSC.

A strong precedent for such a system is already being piloted in Bangkok by UddC as part of the 'GoodWalk' project to promote walkability. That project integrates open data under a smart platform measuring safety, convenience and livability. This platform could incorporate additional parameters, such as flood and temperature forecast and monitoring, showing escape paths for least inundation in Sukhumvit to minimize travel disruptions, exposure to water-based pollution or cool pathways to a particular destination.[13]

[13] This component of the solution is aspirational and has not been included in the BCA, but is described here as part of the overall vision and strategy.

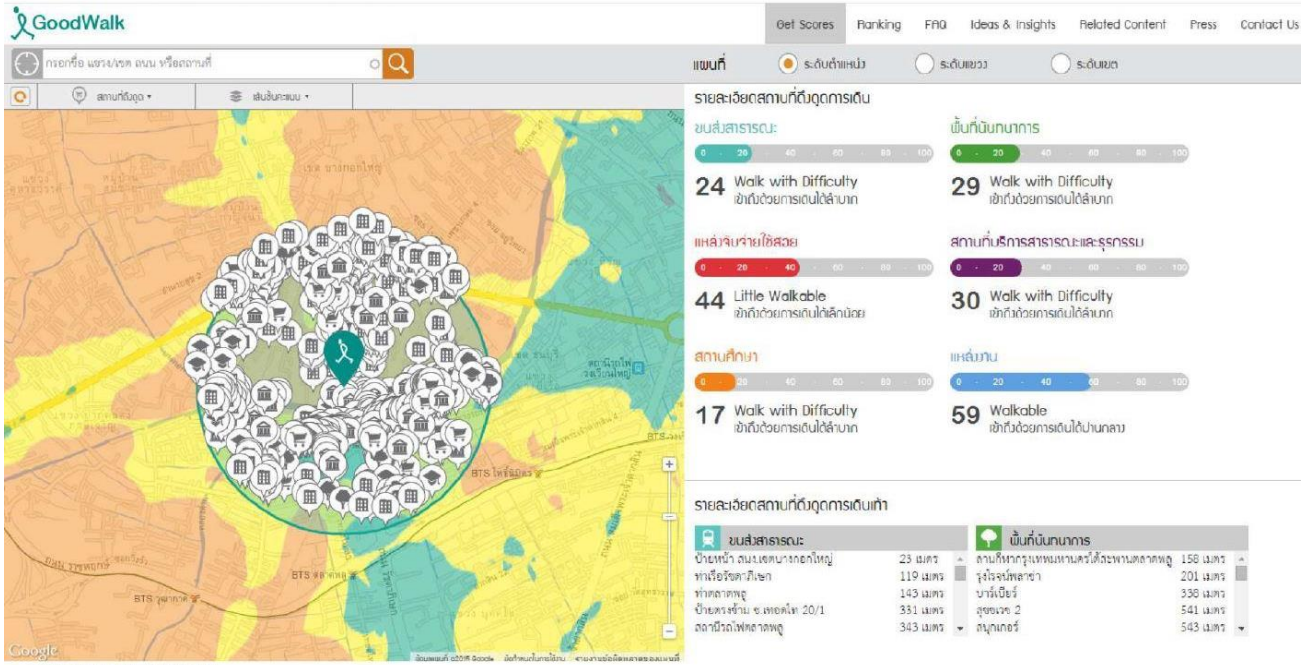


Figure 24: GoodWalk Platform.
Source: UddC.

4. value and choose interventions

This section provides an overview of the results of the BCA. Benjakitti Park already delivers significant value. The BCA did not estimate that existing value, instead concentrating on the costs and benefits of the additional measures to establish whether NbS at different scales can add even more value as part of a precinct-wide approach.

Costs were estimated in Thai Baht, and converted to USD for the economic model. Assumptions were adjusted where necessary – for instance, green roofs benefits assumed uptake in only 70% of the areas identified in the GIS and Fulcrum analysis due to expected limitations in private sector uptake. Similarly, the benefit of improved visitor recreation claimed only 20% of the benefit from the Value Tool because the base case will already increase amenity for visitors; the BCA captures only the *extra* value added by the hybrid scenario.

It is also important to note this study is a high-level strategic assessment with data limitations. The main purpose is to ask, given the information that we have available, whether the strategy is worth further investigation. The results can also help to prioritize measures, by examining which BCR is the strongest of the different components, and formulate fair funding and financing arrangements based on the distribution of costs and benefits. Detailed assessment, e.g. regarding precise volume and water flow, is outside of the scope of this project and should follow as part of a pre-feasibility and pilot stage.

4.1 Overall BCR

For Sukhumvit, the results show a strong overall BCR of around **14** over a 20-year period. This result shows NbS assets can create significant value to a broad range of stakeholder groups, including local communities, downstream communities, visitors and commuters, as well as government service providers such as BMA.

The typical time period of 40 years for a BCA was adjusted according to feedback during the third consultation session. This change reflects Bangkok being very dynamic and prone to change. In fact, adjusting the model to 20 years actually *raised* the BCR from the original result of 13. This is likely due to the cost of ongoing maintenance, compared with the one-off benefits such as increased property prices occurring at the start of the project. Proving the project can deliver strong results in a shorter timeframe is a strong supporting factor for taking the study further.

Breaking down the overall BCR, the net benefits to the community for every dollar of BMA investment is approximately **54** with a total NPV of almost **USD 150 million**. For the project organization (BMA) the BCR is **1.03,** with an NPV of **$74,752**. Although this result represents a lesser return on investment, the benefits still cover the costs and highlight the importance of taking a whole-of-community (rather than an organizational) perspective when considering community infrastructure. There is also potential to investigate methods to more fairly distribute costs. More information about potential funding and financing strategies is provided in Chapter 5.

Sensitivity testing was applied to the results, with a simulation run over 1,000 times with costs and benefits reduced and increased by up to 30%. The results showed the probability that the overall BCR is greater than 1 is 1, or **100%,** with a

Key economic terms

Net present value:
Calculates today's value of a future stream of payments over the entire life cycle including costs and benefits

Benefit–cost ratio:
Compares the present value of all benefits with the cost. For every dollar spent, the BCR gives you how much you will get back in benefits

minimum BCR of 18.66 and a maximum of 105.35. The results for the project organization were not as strong, with a 50% probability that the overall BCR is greater than 1**,** with a minimum BCR of 57 and a maximum of 1.74.

4.2 Costs summary

Figure 25 summarizes the investment costs. Importantly these costs include both the upfront installation/construction and ongoing maintenance over the 20-year period, with the value displayed as the NPV. By far the largest cost are the green roofs, which would be borne largely by the private sector. Notably, the surface and subsurface flow wetland represent a very small total cost at only $128,567 over the 20-year period. The costs for additional improvements to Benjakitti Park represent 22% of the total (to be borne by municipal agencies), compared with 78% for works in the northern urban area (to be shared between municipal agencies and the private sector).

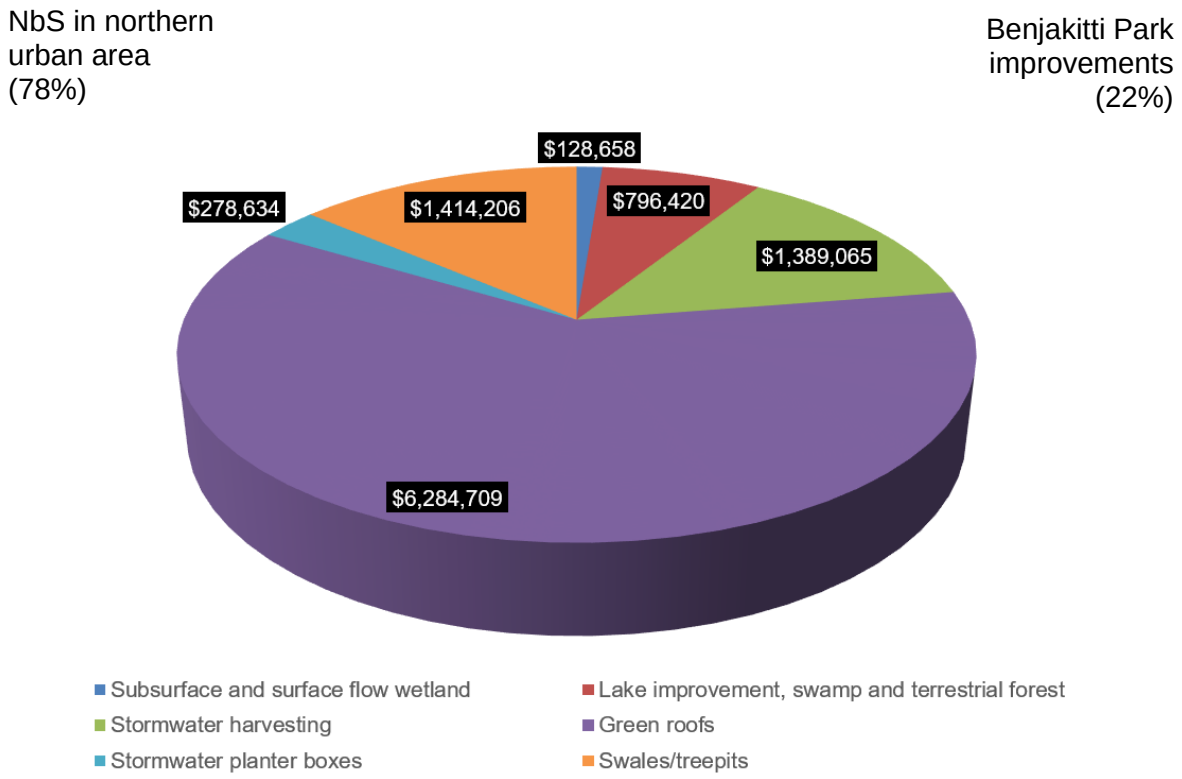


Figure 25: Expenditure costs summary.[14]
Source: Project team.

4.3 Benefits summary

A range of methods were used to estimate project benefits. Identifying specific damage costs was used for northern area initiatives such as green roofs, whereas impact on property values was used for canal improvements.

Figure 26 shows the main benefits and their NPV. This figure shows some benefits are far more significant than others. For example, although the interventions likely to improve the microclimate in the area, the benefit will probably be slight, calculated as a total saving of $52,709 over 20 years. On the other hand, the largest benefit by far, constituting 55% of total

[14] These are the direct costs associated with each strategy. The total cost also includes the costs associated with raising taxes which the government then uses to finance its expenditure on the strategies.

benefits, is improvement in amenity along the canal which has been estimated through a one-off rise in already high property values 2 years after the project start date. Considering improvements to the canal (surface and subsurface flow wetland) is one of the lowest cost interventions, the BCR for this component of the strategy by itself is **686**, with the costs borne by municipal agencies, and the benefits flowing to local residents. This result reflects the low costs for wetland construction and the high property values which mean a small percentage improvement can result in a large value. Despite this, sensitivity testing adjusted the costs and benefits of each component including the wetland intervention by up to 100 times, and did not materially impact overall findings.

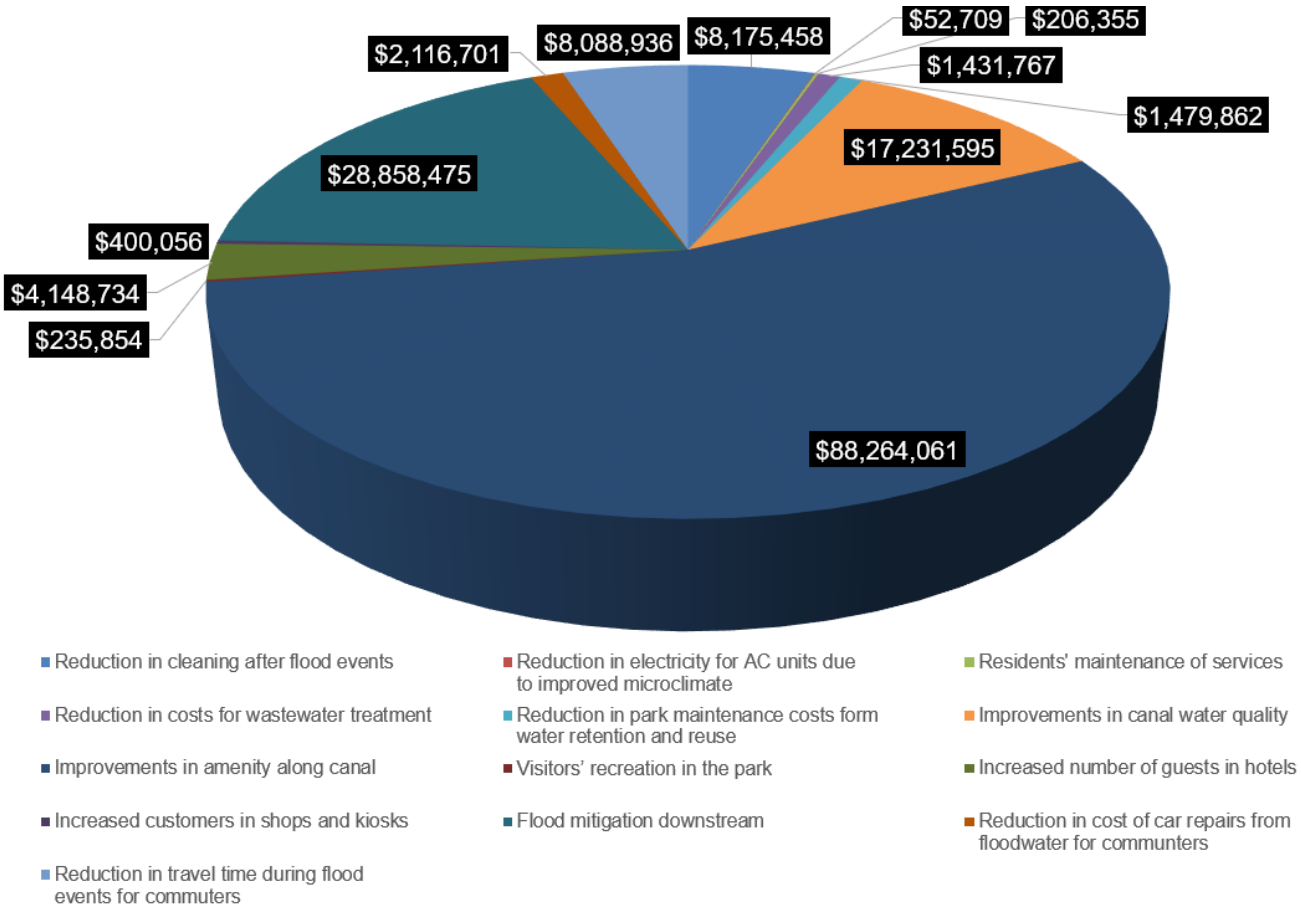


Figure 26: Main benefits and their value.
Source: Project team.

In this case study, the value of benefits were estimated separately. However, connecting hybrid assets via this green triangle approach is likely to produce positive multiplier effects. This effect applies to improved flood protection levels as well as other non-market benefits such as improved thermal comfort, greater walkability and better public safety.

4.4 Distribution of costs and benefits

After analyzing the breakdown of costs and benefits, the next question is determining their distribution between stakeholders; i.e. who pays and who benefits. This breakdown can be particularly relevant for sharing the costs via taxation, tariffs or transfers.

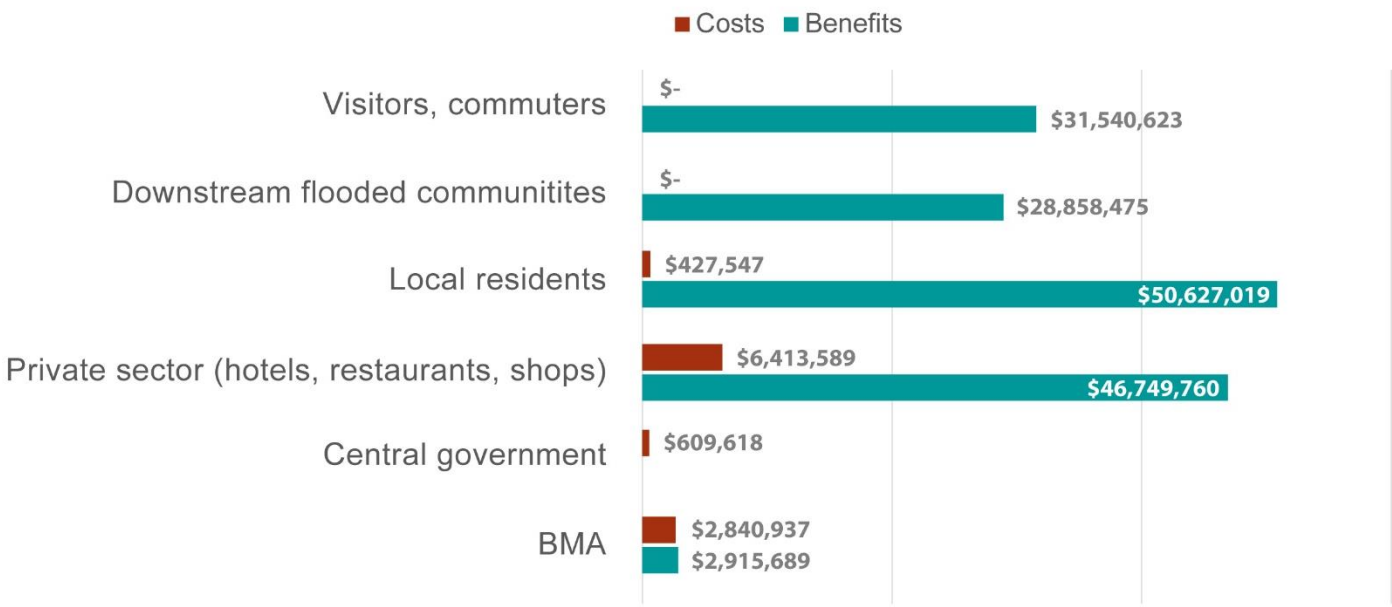


Figure 27: Distribution of costs and benefits.[15]
Source: Project team.

Figure 27 shows the private sector bears the largest proportion of costs, assuming they will bear the majority of costs for the NbS in the northern urban area. However, the benefits coming back to the private sector compared with the costs are significant, with a BCR of around **55.** This result provides persuasive evidence for BMA to work with the private sector to implement this component of the strategy. For BMA, the cost to benefit ratio is smaller at around 1. For the public, which covers a broad population from local residents, downstream flooded communities, to visitors and commuters, the potential benefits are very high – particularly compared with costs, providing a strong case for recovery of these costs through existing broad-based taxes and tariffs or new more targeted measures focusing on flooding.

[15] In October 2020, the Thailand Tobacco Monopoly handed over the remaining land and the Treasury Department and the Royal Thai Army signed a memorandum of understanding for Phase 2 and 3 of the Benjakitti Park. This case study has assumed that future park related constructions costs will continue be shared among central government agencies while park maintenance will paid for by BMA

5. identify appropriate funding and financing mechanisms

Thailand has grown rapidly since the 1960s supported by significant infrastructure investment. Most infrastructure has been funded by government through taxation. Government also remains the largest source of finance with growth in private sector finance stagnating in recent years. However, the growing infrastructure gap driven by climate change, population growth and urbanization means previous approaches to funding and financing may not be sufficient for future needs. Sustainable and equitable investment also needs to increase to achieve future policy and national strategy goals.

Redeveloping Benjakitti Park has seen collaboration across several government agencies with the result that the park will provide significant value to the local community and city overall. Collaboration with public agencies, the private sector and local communities could unlock even more value as we move from a green park to a green precinct that enhances liveability and helps the city respond to emerging climate and economic challenges.

As noted above, and like many countries and large cities, Thailand and Bangkok face an infrastructure funding gap. This case study assumed a similar gap applies for meeting the future water, flood protection and sanitation needs in the Sukhumvit area. The proposed solutions illustrate opportunities to bridge this gap noting many of the ingredients needed to fund and finance sustainable green growth are already in place but need further evolution.

5.1 Enabling policy and strategy

Thailand's vision for national development is articulated in the Twelfth National Economic and Social Development Plan (12th NESDP). This 12th NESDP was recently complemented by the 20-Year National Strategy which outlines a long term vision for sustainable development and was introduced to drive implementation of the 5 year NESDPs. The 12th NESDP focuses on:

- reducing poverty and inequality
- improving the competitiveness of the local economy including restructuring towards a digital economy
- green growth including an increase of total forested areas to 40% and a net reduction in GHG emissions to 7%.

The 12th NESDP is supported by:[16]

- **Thailand 4.0** presents a new economic model for the country and cuts across the 12th NESDP and 20-year National Strategy. Its key contents are economic prosperity driven by innovation and technology, social wellbeing, and environmental protection with a low carbon society and an economic system capable of adjusting to climate change.
- **National Climate Adaptation Plan (NAP) 2019** is built on the 6 priority sectors identified in the Climate Change Master Plan (2015–2050): water management, public health, human settlements and security, tourism, natural resources management, agriculture and food security.

[16] UNDP. *Development Finance Assessment Snapshot – Thailand. 2021*. Retrieved from https://www.th.undp.org/content/thailand/en/home/library/development-finance-assessment-snapshot---thailand-.html

The solutions set out in this case study strongly align with these national strategies, particularly because they promote climate resilience, innovation and increased urban liveability through a walkable, green and prosperous precinct. Achieving the vision will require mobilizing the right scale and mix of funding and financing, from both public and private, and domestic and international sources.

OECD 2021 noted:

Green growth and green investment will be key to meeting the vision for Thailand 4.0, especially in the context of COVID-19 recovery. A green growth pathway allows Thailand to grow and develop while ensuring that natural assets continue to provide resources and environmental services for future generations, and that growth pathways remain resilient to global shocks such as climate change or future pandemics. A key step in pursuing green growth is to catalyze investment and innovation in environmentally sound technologies and infrastructure which helps to sustain growth, gives rise to new economic opportunities and promotes green jobs.[17]

Certain government agencies could play a key role in implementing NbS because their mandates align with these high-level strategies. BMA is a committee member of the National Committee on Climate Change Policy (NCCC) of Thailand which works to define national climate policies and establish guidelines and mechanisms for international collaboration regarding conventions and protocols on climate change. This case study assumed BMA as the implementing agency (project organization).

In addition, ONEP, particularly its Climate Change Management and Coordination Division (CCMC), is highly influential in driving policy for implementing NbS at scale. ONEP's mandate aligns with the NAP 2019, particularly its target strategy for ecosystem-based adaptation.

At a municipal level, an important entry point for mainstreaming NbS and IUFM approaches could be the **Bangkok Masterplan on Climate Change (2013–2023**). The current Masterplan focuses on environmentally sustainable transport (including considerations for liveability and mobility), energy efficiency, wastewater and solid waste management, green urban planning and climate adaptation planning. For the last 2 areas, BMA aims to expand green areas including via incentivization for public and private lands, and by introducing hard and soft measures for disaster resilience.[18] The strategies in this case study were designed with these priorities in mind. Discussions around planning for the decade post-2023 presents an opportunity to introduce new ideas and concepts.

5.2 Recognition and valuation of investment options that support policy objectives

Improving access to financing requires a robust approach to project proposal development and evaluation, acknowledging all relevant costs over the project lifecycle, considering broader value adding opportunities, and valuing both economies of *scale* and economies of *scope*. As illustrated by the case study, the IUFM approach can balance centralized and decentralized solutions as well as green, gray and non-structural solutions that reduce the overall cost to be financed. The Sukhumvit case study highlights the additional value of NbS and decentralized initiatives (such as those proposed for the northern area) in supporting large

[17] OECD (2021). *OECD investment policy reviews: Thailand*. Paris: OECD. Retrieved from https://www.oecd-ilibrary.org/sites/6091762f-en/index.html?itemId=/content/component/6091762f-en

[18] See *Bangkok Masterplan on Climate Change 2013–2023* for more information. (Retrieved from http://copjapan.env.go.jp/cop/cop21/program/151202/1515-1645/pdf/cop21-jp-151202-1515-1645-presentation-02.pdf)

investment (such as the canal and Benjakitti Park). It is important for public authorities to include these values in their investment decisions as a business-as-usual activity.

A stronger business case clearly aligned to government policy objectives can increase the likelihood of public funding support. Information on the size and distribution of benefits can also be used in community education and engagement to mobilize private action for public good.

5.3 Demonstration projects and programs

Standalone projects can demonstrate the value of a particular technology or approach. However, a program linked to strategy and made up of a number of projects is sometimes easier to finance. By bundling diverse initiatives (ranging from large scale park investment by government to works on private land), this case study provides an integrated package or portfolio of investments ensuring the whole is greater than the sum of the parts and increasing the likelihood of funding and finance relative to separate disconnected initiatives. Staging (as already done for Benjakitti Park) also helps manage risk and budget constraints. However, staging that is linked to a clear and inspiring vision for Sukhumvit (such as a *green triangle* linking Lumpini and Benjakitti parks with a decentralized green network in the northern area of Sukhumvit) can also encourage local community engagement and private action.

As a high-profile initiative, Benjakitti Park presents an opportunity to leverage this investment from a project to a precinct through a public–private partnership (PPP), as done by the City of Kunshan and the CRCWSC in developing the Cool Lines platform.

However, feedback from Expert Exchange sessions raised concerns that the time and transaction costs associated with formal arrangements like PPPs may be challenging to implement. Less formal or simpler arrangements such as Memoranda of Understanding (MoUs), joint ventures, incentive programs, accreditation schemes or joint branding of initiatives could be a more practical way to engage businesses as part of their Corporate Social Responsibility (CSR) initiatives. These arrangements may be most suited to larger businesses. A CSR campaign could be a good way for public agencies to encourage uptake of the these arrangements, encouraging businesses to incorporate sustainability into their brand identity, and capitalizing on the agility of the private sector and the need for competitive advantage. Engagement as part of the ‘green triangle’ scheme may be a promising way to foster this collaboration, particularly because it represents a draw for visitors and tourists.

In addition to the private sector, a number of publicly funded planter boxes in the area north of Benjakitti Park could be delivered in partnership with local schools, community groups or NGOs supported by future technical and financial assistance for privately installed units. A network of community champions as part of the shared vision for the area would also help to maintain and protect the assets.

Box 1 presents an example from Australia of effective private and community sector engagement and investment to improve stormwater management.

Box 1: Harnessing private action for public benefit

Melbourne Water's 10,000 Raingardens Program demonstrates is it possible to engage the community and encourage them to take actions that have public benefits.

The program encouraged private landowners to establish raingardens on their own properties. These specially prepared gardens are designed to receive, slow down and filter rain runoff from roofs or impervious surfaces such as driveways or paving. This stormwater runoff can significantly affect the health of our rivers and creeks, carrying harmful pollutants such as litter, chemicals, animal droppings and oil. Raingardens help by reducing the quantity and improving the quality of stormwater runoff entering local waterways.

The program promoted this simple and effective form of stormwater treatment by raising people's awareness of:

- how stormwater fits into the water cycle
- how good management of stormwater contributes to healthy waterways, and
- what can easily be done at home to manage stormwater.

Melbourne Water did not provide financial incentives for landowners to build raingardens. Rather, the focus was on encouragement through education. Integral to the program's success was addressing common barriers to installing raingardens:

- Limited awareness that stormwater is a problem – Melbourne Water established a website and prepared brochures explaining how stormwater runoff affects waterways and how raingardens can help.
- Limited community understanding of raingardens – Melbourne Water provided technical support for landowners about how to build raingardens, via brochures and the website. It also worked with councils on demonstration projects to create raingardens in public places such as streets, parks and schools.
- Lack of industry knowledge at the residential scale – Melbourne Water also provided technical training for plumbers and landscapers.

The number – 10,000 – was intended to raise interest, generate discussion and spur grass roots community interest. Competitions for hardware vouchers successfully encouraged landowners to register their raingarden. The program, which started in 2008, achieved its target of 10,000 raingardens across Melbourne in 2016. The program has now been incorporated into Melbourne Water's stormwater program.

Sources: Milenkovic, K., Potter, M. & Morison, P. (2012). Community engagement: the story of the 10,000 Raingardens Program. Paper presented at the Stormwater '12 Conference, 15–19 October, Melbourne; Melbourne Water (2016). Melbourne's Water Future Green Paper, Melbourne Water's Submission. Melbourne.

5.4 Leveraging private investment and social capital

Public finance and funding will continue to play an important role in promoting green growth and IUFM. The IUFM process also seeks to help bridge the public infrastructure gap by identifying and monetizing additional revenue streams (e.g. stormwater capture and sale) reducing the need for public funding and increasing financability and scalability. An example could be the sale of stormwater to Benjakitti Convention Centre, as was done in Hunan, China (Figure 28).

Incentivization schemes can also play a strong role. The Bangkok Comprehensive Plan (2013) includes restrictions on floor area ratios (FARs) for developments. Currently, the maximum FAR is 10:1 but bonuses up to 20% are available if certain features are included in the building design including low-income housing, green space, stormwater storage and participation in the Thai Green Build Institute certification program. Greater inclusion of NbS such as green roofs, tree pits and swales together with training and capacity building programs could aid uptake by developers.

The FAR Bonus provides a positive incentive. The *Planning Guidelines of Rainwater Utilization System in Shenzhen* illustrates an alternative or additional measure requiring the retention and use of all rainwater in residential areas. Residential areas that do not invest in facilities to use rainwater or fail to meet targets for usage will be charged a 'rainwater discharge fee'. Residential areas that exceed the requirement may be granted rainwater credits which can be sold to residential areas that fail to fully meet the requirements.

Where land developers are identified as major beneficiaries, specific requirements can be used to encourage investments in NbS, such as linking higher floor area ratios to commitments by developers to invest in NbS. Such regulations can promote NbS by enabling property owners or developers to meet a portion of their obligations by buying or selling volume-based 'credits' generated through blue and green investments in offsite NbS.

To succeed, such initiatives require a strong regulatory foundation, as well as sufficient local development to drive demand for credits informed by guidelines developed according to local conditions, clearly defined program boundaries and an independent oversight body.

THE FIRST STORMWATER PURCHASE AGREEMENT IN CHINA

On September 25 2020, Changsha Gaoxin District Park Company and the Hunan Yuchuang Environmental Protection Company signed the first stormwater purchase agreement in China at the Hunan Province Green Development Exhibition Sponge City Forum.

According to the agreement, the Changsha Gaoxin District Park Company will purchase stormwater from the Hunan Yuchuang Environmental Protection Company at a 20 percent of the piped water price for landscaping and cleaning purposes. The Hunan Yuchuang Environmental Protection Company has worked on rainwater retention and utilization from 2014 and has utilized 0.5 million cubic meters of rainwater, which amounts to 2 percent of the total rainwater during the last 6 years, which means there is still large potential for rainwater utilization.

Source: Changsha Evening News 2020

5.5. A growing green finance system

Benjakitti Park provides an important demonstration project. Financing could reinforce messaging around green growth. For example, future stages of Benjakitti, Lumpini and the northern area could be included a diversified green bond issue or a revolving fund.

6. Recommendations and next steps

The following high-level recommendations and next steps have emerged from the case study development. As a basis for all the points below, a multi-sectoral approach with cooperation across public agencies representing the implementers (BMA), policy makers (ONEP), planners and strategy makers (NESDC, ONWR), as well as the lenders (Treasury Department) together with private and community groups will be needed to make the vision a reality – both as a pilot site, and with a view to upscaling across Bangkok and beyond.

- **Further investigation and experimentation.** This case study represents an initial, strategic assessment, aiming to provide evidence for further action. The next step should include detailed assessment of stormwater flows *and* quality as part of an onsite piloting stage to demonstrate proof-of-concept. Small and large scale demonstration initiatives are also important in building local capacity and confidence and attracting private investment.

- **Further refinement of benefits and costs:** The strategic assessment provided by this case study illustrates the significant potential merits of a hybrid approach. Different methodologies were used to estimate different costs and benefits to make the most of available data and illustrate the range of methods open to practitioners. For example:
    - Identification of specific damage costs was used for northern area initiatives such as green roofs, whereas impact on property values were used for canal improvements. The INFFEWS Value Tool enabled application of research from other locations to inform estimates of local benefits. Sensitivity testing suggests the overarching conclusion remains sound even with a range of high-level assumptions.

    - Further refining the key inputs is recommended particularly examining the potential cost of green roofs given their potential significance. A local revealed or stated preference study of amenity and recreational values benefits should also be considered. Further developing the costs and benefits not only increases confidence in the proposed approach but also provides relevant local research to inform scaling hybrid approaches to other parts of Bangkok and Thailand.

- **Monitoring performance of NbS:** NbS are a central element of the benefits offered by the hybrid solution. Developing and maintaining the interventions should include appropriate monitoring and analysis of the performance of NbS elements to support local adaption and inform guideline and regulation development and assist training. This could also include private sector and community engagement and citizen science opportunities.

- **Policy and regulatory reform.** At present in Bangkok, certain building regulations present a challenge for rolling out and upscaling NbS (e.g. prohibition of private linkages to the main drainage system, and restrictions on altering road construction), which would limit the installation of green roofs, stormwater planter boxes and swales.

    - Some reform would be required to construct and maintain NbS in the urban area at scale. Changes in legislation could be enacted under national strategies

such as Thailand 4.0 which promotes innovation, urban livability and climate resilience as a national priority, as well as municipal strategies such as the Bangkok Masterplan for Climate Change, which has green urban planning, and climate adaptation planning as 2 key focal areas.

- BMA is currently drafting a new Bangkok City Plan, which will include 8 FAR bonus measures (up from 5 originally). One measure that may support the project is providing public use areas or parks along public water bodies. The new plan is not yet enacted into law.

- **Partnerships under a shared vision.** The overarching finding of the BCA is that the NbS interventions represent a strong public good. As well as greater inter-agency cooperation, implementing bodies should seek to form partnerships with private and community groups to deliver hybrid solutions under a common vision for a green, prosperous and climate resilient Bangkok. Engagement strategies can leverage CSR policies, the FAR bonus, and include working directly with school, community group and NGOs. Another option for incentivizing private sector participation is for the government to offer tax rebates or refunds for investments. There was a request for guidelines on such measures.

- **A precinct-scale approach.** This case study aimed to demonstrate the significant additional value that comes from connecting green and hybrid assets across a precinct. One park or stormwater planter box on its own will not deliver as much benefit a network of connected large and small scale NbS through a neighborhood. While the benefits of individual NbS have been estimated it is likely that there will be a reasonable amount of overlap and the total value of the integrated package of measures will be greater than the simple sum of the parts. This impact grows even larger when NbS planning is connected with existing infrastructure (water sewerage, drainage, road, urban redevelopment assets and projects).

- **Separating rainwater and waste water.** The benefits and costs examined in this case study report illustrate the value of Bangkok of separating and beneficially reusing rainwater and wastewater. The case study also suggests the broader value transitioning to separated stormwater and wastewater systems over time. In the short to medium term this should include using distributed NbS (such as those outlined in this report) to assist water quality and peak flow management and beneficial reuse in established areas as well as fitting separated systems in new developments. Over the longer term retrofitting opportunities should pursued as assets are renewed and the system upgraded. Further investigation is required to better map and quantify the potential contributions of NbS across Bangkok, but the analysis undertaken by this initial strategic case study and experience in other locations suggest the gains may be significant.

- **Maintaining momentum and building local successes.** This case study highlighted international examples of good practices including from China and Australia. But, local examples have already demonstrated success in applying NbS as well as smart city solutions, including the Chulalongkorn Centenary Park and GoodWalk initiative. Collaboration and continued learning from these projects and further international knowledge exchange should inform future hybrid-NbS development and scaling up of their benefits.