Valuing the benefits of nature-based solutions to integrated urban flood management in the Mekong Region

An overview – January 2021

Contents

At a glance

Already the world's most common natural disaster, flooding is forecast to occur more frequently and cause more damage in future years. Rapid urbanization and industrialization, and the effects of climate change, are increasing the number of people and assets at risk of flooding. There is mounting evidence to suggest that flood management approaches that have served communities well in the past may not be a sufficient or an affordable response to the challenges of the future.

Countries in the Mekong region, such as Vietnam and Thailand, are among the world's most exposed to flood risks. Within these countries, disadvantaged groups including women, children, the elderly, people with disabilities and homeless people are often disproportionately affected.

Integrated urban flood management (IUFM) offers a broad range of solutions that can respond to the unique needs of a given catchment and community. These solutions can include conventional 'gray' infrastructure (e.g. dams, dikes, levees), nature-based or 'green' solutions (e.g. constructed wetlands, raingardens, bioswales) and non-structural solutions (e.g. behavior change programs, land use planning and building requirements, emergency planning and management).

The question becomes which combination of flood management interventions is appropriate for a given community or catchment?

This document summarises a detailed IUFM guide and supporting tools which have been developed around a 5 step process for selecting the best portfolio of gray, green and non-structural solutions, based on leading international research, established valuation and comparison methodologies and local expertise:

1. Define your urban system context
2. Undertake a flood risk assessment
3. Identify context-appropriate interventions
4. Value and choose interventions
5. Identify appropriate financing and funding mechanisms.

The guide includes 4 case studies from Vietnam and Thailand, to demonstrate how the tools and processes are applied in practice.

The global challenge

Floods are our most prevalent natural disaster, and they cause the most damage (Figure 1). The impacts associated with floods have significant social consequences as well as substantial economic effects—loss of human life and livelihoods, damage to property, destruction of crops, loss of livestock, disruption of services, and deterioration of health conditions owing to waterborne diseases.

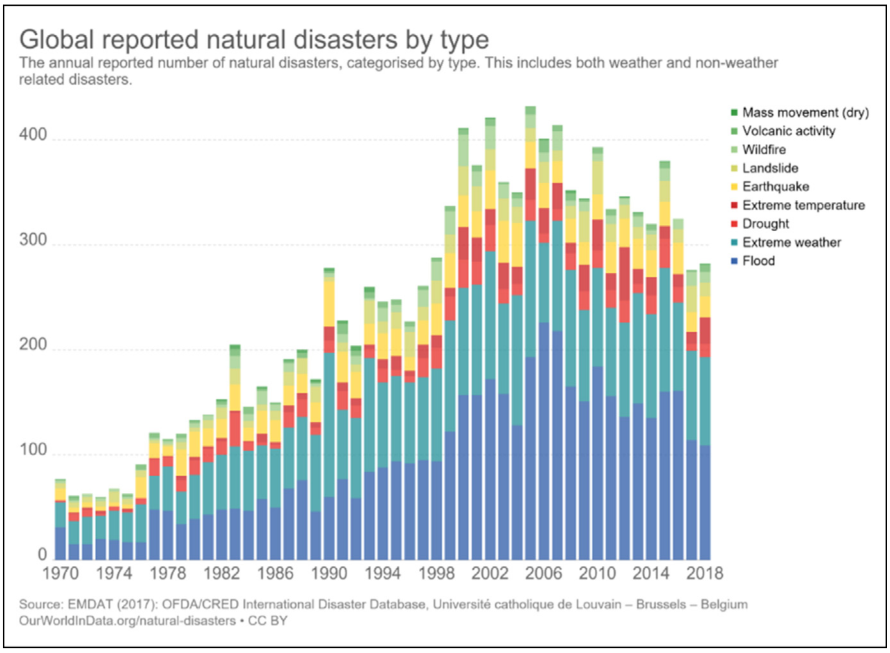

Figure 1. Global reported natural disasters by type. In 2018, 109 flooding disasters were reported, the most of any disaster type reported in 2018.[1]

Globally, floods are estimated to have affected more than 2 billion people between 1995 and 2015, 95 percent of whom live in Asia.[2] Floods accounted for 45 percent of all people affected by disasters during this period with an estimated 142,088 fatalities. The economic losses caused by flooding over the past decade are estimated at US$656 billion. However, the direct economic costs are systematically under-reported and the actual losses are likely to be much higher.

In addition, these costs are expected to grow. Rapid urbanization and economic development have exposed larger numbers of people and assets to flood hazards, increasing the levels of risks and vulnerabilities. By 2050, an estimated 1.3 billion people (or 15 percent of the global population) will live in flood-prone areas.[3] Projections indicate the extent of urban areas exposed to flood hazards will increase 2.7 times by 2030 (2000 base year).[4]

For several reasons, poor and marginalized people often bear the disproportionate brunt of flooding. First, they face greater exposure by living in marginal or unsafe areas, such as on flood plains or along riverbanks. Second, they are more likely to live in substandard housing and be affected by uncertain land ownership rights that provide no incentives for investments in risk reduction. Third, they are less able to absorb and recover from the impact of hazard events and rely on a range of sub-optimal coping mechanisms following a disaster with little savings, limited assets, support networks and a lack of access to formal credit mechanisms.

[1] Ritchie H and Roser M 2019. *Natural disasters*. Oxford: Our World in Data. Available from: https://ourworldindata.org/natural-disasters.
CRED and UNISDR 2015. *The human cost of weather related disasters: 1995-2015*, Brussels: CRED. Available from: https://www.unisdr.org/files/46796_cop21weatherdisastersreport2015.pdf.

[2] Verwey A, Kerblat Y, and Brendan C 2017. *Flood risk management at river basin scale: the need to adopt a proactive approach*, Washington, DC: World Bank. Available from: https://www.alnap.org/system/files/content/resource/files/main/ufcop-flood-risk-management-at-river-basin-scale-kn-final.pdf.

[3] Güneralp B, Güneralp I and Liu Y 2015. 'Changing global patterns of urban exposure to flood and drought hazards'. *Global Environmental Change*. 31: 217–225. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0959378015000047.

The challenge for Mekong countries

The Mekong River flows through six countries in Asia: China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam. Seasonal flooding is a natural part of life in Mekong countries, playing an important role in sustaining agricultural production in delta areas.[5] The communities living in floodplains rely on traditional knowledge and experience to manage and benefit from these seasonal floods.[6] However, the nature of floods in countries like Vietnam and Thailand has become less predictable in recent years. There is more flash flooding, and acute riverine and coastal flooding, and floodwaters are deeper and longer lasting than in the past.[7] As a result, losses from flooding are also rising, particularly in peri-urban areas on the edge of built-up areas. These areas are undergoing rapid residential, commercial and industrial development, yet often lack drainage infrastructure (Box 1).

Box 1. Costs of natural disasters in Vietnam and Thailand

Over the past 2 decades, natural disasters in Vietnam have caused more than 13,000 deaths and property damage in excess of US$6.4 billion.[8] The World Bank (2019) estimated that economic losses from flooding currently account for around 1.5 percent of Vietnam's gross domestic product each year. These costs are expected to increase to 3 percent of GDP by 2050, and to as much as 7 percent by 2100.[9]

McKinsey Global Institute (2020) estimated that the economic impact of flooding in Ho Chi Minh City could increase by 5 to 10 times over the next 30 years. The report estimated that a 100-year flood event occurring today would cause US$1.5 billion damage to real estate, US$200–300 million damage to infrastructure and US$100–400 million in knock-on effects. The same flood in 30 years would cause US$8.4 billion damage to real estate, US$500 million–1 billion damage to infrastructure, and US$1.6–8.4 billion of knock-on effects.[10]

Thailand experienced its worst floods in almost 50 years in 2011. Between late July and early December of that year, 65 of the country's 77 provinces were affected by flooding. The floods were a combination of natural factors—excessive rainfall from multiple tropical storms, high tides and the general slope of the land—and man-made factors—urbanization, insufficient drainage and flood protection, land subsidence (caused by over-extraction of groundwater) and the sudden release of waters from upstream dams.

More than 880 people died during the floods, and millions more were left homeless or displaced. An estimated 20 percent of Bangkok's population was affected by flooding, for example. As many as 1.5 million homes and other structures were affected, including 300,000 in Bangkok. The World Bank estimated economic losses of US$45.7 billion, making these floods one of the top five costliest natural disasters in modern history. These losses reflected disruptions in many sectors of the Thai economy, particularly agriculture, tourism and manufacturing.[11]

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[5] Park, E., Loc, H. H., Dung, T. D., Yang, X., Alcantara, E., Merino, E., & Son, V. H. (2020). *Dramatic decrease of flood frequency in the Mekong Delta due to river-bed mining and dyke construction*. Science of The Total Environment, 138066.
[6] Boyland M 2019. *In pursuit of effective flood risk management in the Mekong Region*. Discussion Brief. Stockholm: Stockholm Environment Institute. Available from: https://www.sei.org/wp-content/uploads/2019/03/sn-briefings-mb-8mar.pdf.
[7] Verwey A, Kerblat Y, and Brendan C 2017. *Flood risk management at river basin scale: the need to adopt a proactive approach*, Washington, DC: World Bank. Available from: https://www.alnap.org/system/files/content/resource/files/main/ufcop-flood-risk-management-at-river-basin-scale-kn-final.pdf.
[8] Government of Vietnam 2017. *Rapid flood damage and needs assessment—Vietnam 2016*. Washington DC: World Bank. Available from: http://documents1.worldbank.org/curated/pt/935391503548807702/pdf/119060-WP-PUBLIC-Rapid-Flood-Damage.pdf.
[9] World Bank 2019. *Vietnam: toward a safe, clean, and resilient water system*. Washington DC: World Bank. Available from: https://openknowledge.worldbank.org/handle/10986/31770.
[10] McKinsey Global Institute 2020. *Can coastal cities turn the tide on rising flood risk?* Available from: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/Can%20coastal%20cities%20turn%20the%20tide%20on%20rising%20flood%20risk/MGI-Can-coastal-cities-turn-the-tide-on-rising-flood-risk.pdf.
[11] Aon Benfield 2012. 2011 *Thailand floods event recap report*. Available from: http://thoughtleadership.aonbenfield.com/Documents/20120314_impact_forecasting_thailand_flood_event_recap.pdf.

Water management in Vietnam and Thailand

Water management in countries like Vietnam and Thailand is complex because river basins often overlay different administrative zones, both within and between countries, increasing the number of parties involved in managing them. This requires a coordinated approach to water management. Uncoordinated activities not only affect sustainable water use and the health of natural resources, but can exacerbate the risks posed by floods and storms, especially in downstream locations.

At the international level, the lower Mekong countries (Vietnam, Thailand, Cambodia and Lao PDR) formed the Mekong River Commission (MRC) in 1995, to manage the shared water resources and sustainable development of the river. The countries cooperate in all fields of sustainable development, utilization, management and conservation of the water and related resources in the Lower Mekong River Basin. This includes cooperating on activities such as irrigation, hydropower, navigation, fisheries and flood control.

Like many other countries, water management within Thailand and Vietnam can be complicated by multiple levels of decision making with overlapping and competing tasks, policies and responsibilities. Further, policy makers, planners and service delivery agencies may lack the legal authority, institutional capacity, and financial and physical resources to plan and ensure plans are implemented.

At the same time, urban planning guidelines can sometimes be prescriptive, detailing technical requirements, rather than looking at performance. They may not specify long-term outcomes or criteria for determining priorities or making tradeoffs.

Nature-based flooding solutions in Vietnam and Thailand

The use of nature-based solutions (NbS) to manage flooding in cities is growing in popularity in the Mekong region. For example, with assistance from the Asian Development Bank, the Vietnamese cities of Vinh Yen, Hue, Ha Giang, and Ho Chi Minh City will integrate NbS by rehabilitating their ponds, parks, and rivers. One proposal is to use Go Vap Cultural Park in Ho Chi Minh City as a community park as well as a floodplain park that stores and treats water during storm events.

Similarly, a planning committee in Dong Ha has proposed several options to improve the city's flood management. For example, the committee proposed redeveloping the Le Loi box canal and drainage basin as a green multifunctional zone: a drainage corridor, a water retention facility, a landscaped recreation area, and a water and air purifier. The committee also proposed using Le Duan Park to help manage pluvial flooding by linking it to the river. The city's adaptation plan also includes expanded green space, footpaths and riverside recreation facilities. It increases permeable surfaces and retrofits the city market to recycle stormwater and treat wastewater on site.

In Bangkok, the city's administration established 'Monkey Cheeks' on privately owned lands as part of its flood management strategy. (A Monkey Cheek project is a retention pond in which part of the runoff is stored for a while and then gradually drained into the waterways. This is similar to a monkey holding banana pieces in its cheeks.) Similarly, the recently constructed Chulalongkorn Centenary Park in Bangkok provides onsite water management, collecting, treating and holding up to 1 million gallons of water, and so alleviating pressure on the overwhelmed public sewerage network during heavy rainfall.

A study of flooding solutions for Koh Mueng in Thailand considered both conventional and green infrastructure options, examining the impacts of various options on flood hazards, physical and economic vulnerability, and ecosystem benefits.[17]

[12] Mekong River Commission 2020. *About MRC*. Available from: http://www.mrcmekong.org/about-mrc/.
[13] Asian Development Bank 2019. *Nature-based solutions for cities in Vietnam: water sensitive urban design*. Manila, Philippines: Asian Development Bank. Available from: https://www.adb.org/sites/default/files/publication/535016/nature-based-solutions-cities-viet-nam.pdf.
[14] Asian Development Bank 2016. *Nature-based solutions for building resilience in towns and cities: case studies from the Greater Mekong Subregion*. Manila, Philippines: Asian Development Bank. Available from: https://reliefweb.int/sites/reliefweb.int/files/resources/nature-based-solutions.pdf.
[15] Chiplankar A *et al*. 2012. *Good practices in urban water management: decoding good practices for a successful future*. Philippines: ADB. Available from: https://www.researchgate.net/publication/295073833_Good_Practices_in_Urban_Water_Management_Bangkok_Thailand/link/56c6dd5108ae408dfe4f0f31/download.
[16] Preventionweb 2020. Nature-based solutions to increase urban adaptability—Thailand. Available from: https://www.preventionweb.net/news/view/74371
[17] World Bank 2017. *Implementing nature-based flood protection: principles and implementation guidance*. Washington DC: World Bank. Available from: http://documents1.worldbank.org/curated/en/739421509427698706/pdf/Implementing-nature-based-flood-protection-principles-and-implementation-guidance.pdf.

Despite these examples, what is lacking—in the Mekong region and more broadly—is a consistent framework for valuing the relative economic benefit/cost of NbS; this has impeded the development of a rigorous financial and economic business case for their implementation and upscaling.

As well as encouraging wider adoption of NbS, a consistent framework may also open up a wider range of financing and funding options for flood management options.

Integrated urban flood management

Globally a range of approaches have emerged in which water management (including increasing resilience to floods and droughts) has a central role in shaping a city.

For example, in Australia, the vision of the Water Sensitive City (WSC) describes a place where people are not disrupted by flooding, and can enjoy reliable water supplies, effective sanitation, healthy ecosystems, cool green landscapes, efficient use of resources, and beautiful urban spaces that feature water and bring the community together. Similar initiatives have been introduced in the United States, Canada, the United Kingdom, Singapore and the Netherlands. All of these initiatives reflect the increasing recognition that a broader range of benefits can be derived from integrating water management with urban development. Such approaches are increasingly focused on combining built infrastructure with solutions that harness natural systems to deliver a range of co-benefits beyond conventional flood measures.

The evolution of urban water management in many countries follows the conceptual framework for urban water transition which identifies six distinct developmental states that cities may move through on their path toward increased water sensitivity (Figure 2). In the early phases, flood protection generally relies on large-scale flood control infrastructure. But the later phases apply a more integrated, systems approach to deal with flooding, combining 'hard' engineering solutions with 'soft' institutional interventions at a variety of scales.

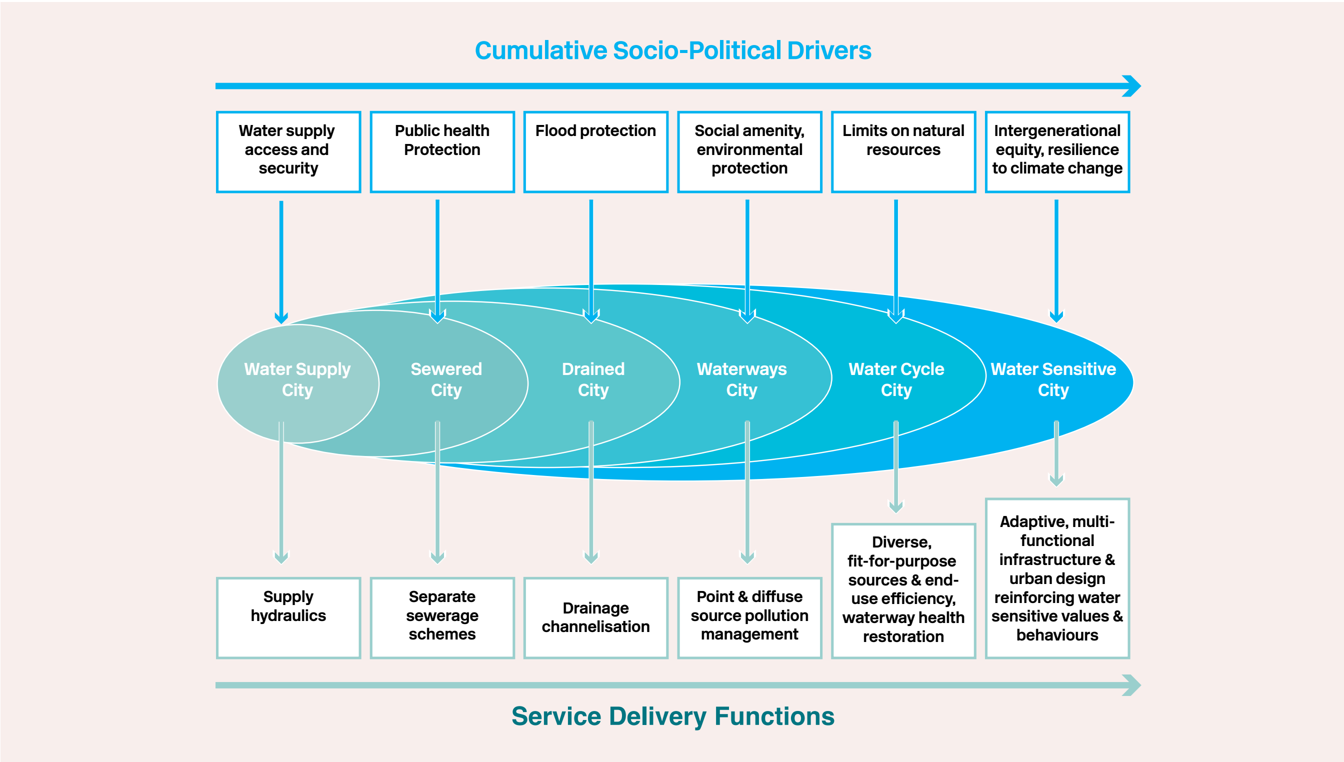


Figure 2. Urban Water Transitions Framework.[19]

[18] Brown R, Keath N and Wong T 2009, 'Urban water management in cities: historical, current and future regimes', *Water Science and Technology*, 59(5).
[19] Brown R, Keath N and Wong T 2009, 'Urban water management in cities: historical, current and future regimes', *Water Science and Technology*, 59(5).

Progression through the states does not have to be linear. As Mekong countries industrialize and urbanize, cities have an opportunity to 'leapfrog' transition stages, by implementing multi-functional, integrated and sustainable approaches to water management, including flood management. Central to leapfrogging is integrating NbS with conventional urban water infrastructure. A good example is using public open spaces and wetlands to manage stormwater. These areas can treat and store stormwater during storm events, support ecological biodiversity and—if effectively landscaped—can be used for recreation and commercial activity. At scale, they can also influence the local microclimate.

Integrated urban flood management (IUFM) applies water sensitive city principles to the specific challenge of flood management. A range of interventions are available to manage floods—conventional structural solutions, nature-based solutions and non-structural solutions. But, flood management is context-specific, so what works in one location may not work in another.

So how do we decide what combination of flood management interventions is appropriate?

A collaborative project by the Australian Water Partnership, the World Bank, the CRC for Water Sensitive Cities and the International Centre for Environmental Management has developed a draft guide (along with supporting materials and tools) that provides:

- High level guidance for **policy makers** in the form of an overarching framework and overview of strategic issues to consider in evaluating flood management options
- Practical information for **managers** reviewing the results of benefit cost analysis (BCA) and assuring a fit for purpose approach
- A consistent methodology for **practitioners** wishing to undertake a BCA, together with worked examples, more technical references and access to supporting tools, guidelines, and templates.

The framework outlines 5 steps for identifying, valuing and choosing an appropriate mix of flood management interventions for a particular context (Figure 3):

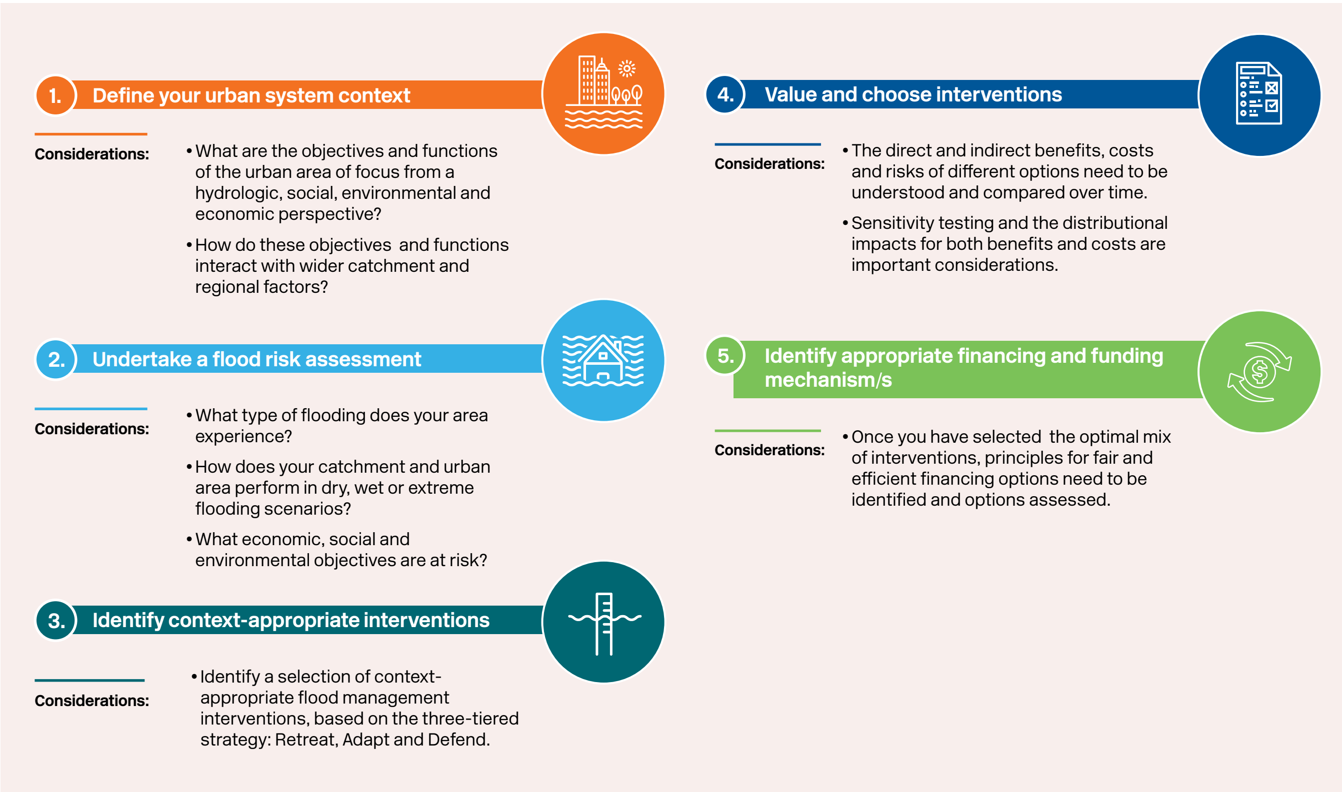


Figure 3. 5 steps for identifying, valuing and choosing appropriate flood management interventions

Steps 1 and 2 are key to understanding the nature of the problem and the size of potential impacts, but the guide focuses primarily on Steps 3, 4 and 5. These steps are critical to ensuring on-ground delivery results in lasting community benefits through a range of tools and guidance to comprehensively value, finance and fund the desired solution.

Step 1 — Define your urban system context

Urban systems often include:

- **the catchment area**, where rain falls and/or is collected
- **the urban context**, where most urban development occurs.
- **the coast**, which is the boundary between the land and a large body of water. The coastal zone can exist along a river, and is also a zone for urban development.

Flooding can occur at any point in the system. To determine the appropriate flood management interventions, decision makers must consider the desired social, economic and environmental objectives for the catchment. These may include economic growth in particular industries or locations, protection of environmentally important locations, or improved conditions for low income or at risk members of the community. Decision makers also need to understand how actions in one part of the system may affect another location or different groups of people or future generations. Maximizing an outcome for one urban center in the short term may not be optimal for the region and catchment as a whole over the long term.

Step 2 — Undertake a flood risk assessment

A flood risk assessment looks at how flooding impacts the catchment. It examines two things:

Flood hazard—This is the amount, extent and location of flooding expected. A flood hazard assessment identifies the types of flooding likely to affect an area (e.g. fluvial, pluvial and coastal).

Flood vulnerability—This is the susceptibility of an area to flooding, quantified as a damage cost assessment. Understanding vulnerability involves quantifying the damage costs of a given hazard. Ideally, assessments include direct costs, indirect costs and intangible costs. Indirect and intangible costs (which are not traded in a market)—such as health impacts and biodiversity—can be difficult to identify and quantify, but excluding them leads to systematic underestimation of the overall costs of flooding.

Vulnerability assessments enable decision makers to create flood risk maps, and identify areas of high flood susceptibility and impact. Identifying a system's most vulnerable elements and prioritizing resources and assistance reduces vulnerability and enhances capacity.

Step 3 — Identify context-appropriate interventions

Conventional flood management—These approaches promote flood defence and mitigation. They often rely on large engineering structures, often referred to as 'hard' engineering or 'gray' infrastructure. Examples include dikes, levees, dams, pumping stations, diversion channels and related infrastructure. Historically, they have been very effective at managing flooding, but the costs of building and maintaining these extensive flood control systems can be significant and continue to increase.

Further, reliance on conventional flood protection infrastructure has resulted in large-scale, centralized systems that have limited capacity to adapt to changing conditions. Increasingly, climate change and other global drivers of change mean we need flexible and adaptive urban water management strategies that can deal effectively with future shocks and uncertainties.

Nature-based solutions (NbS)—These approaches use natural processes and systems to manage floods. Examples include constructed wetlands, mangroves, bioswales, floodable parks green roofs and green walls. NbS have some benefits over gray infrastructure solutions, particularly for flood management. They can be multi-functional, with direct benefits to flood management, as well as ancillary benefits for health, environment and economics. And, they typically involve less initial investment and are more scaleable and flexible than gray infrastructure solutions, so they free up budgetary space for other projects.

Non-structural solutions—These approaches keep people safe from flooding through better planning and management of urban development as well as a more informed and empowered community. They include emergency planning and management (e.g. early warning systems), increased awareness and preparedness, flood avoidance through land use planning, and increased community resilience through improved building design and construction and appropriate risk financing.

Th IUFM guide proposes a 3-tiered framework for designing an integrated flood risk management strategy (see Table 1). The framework outlines 3 complementary approaches to managing flood risk:

- **Retreat**—the re-examination of land use zoning and redefining the use in highly vulnerable areas to transition to more appropriate use, for example, the Dutch concept of 'making room for the river'
- **Adapt**—through urban design, spatial planning and built form adaptation to flood characteristics of the subject city including the establishment of preferential flood pathways (green and gray corridors) and designated flood inundation areas, and flood resilient building designs
- **Defend**—through infrastructure investment in flood defences such as traditional engineering approaches of flood levees, flow diversions, pumps and gates etc.

Table 1. 3-tiered framework (structural and non-structural options) for managing flood risk with examples

Approach	Structural options	Non-structural options
Retreat options reduce exposure to the hazard through land use planning. They involve moving people and associated infrastructure away from vulnerable areas into less exposed areas.	Relocate or abandon threatened assets	Land use restrictions, setbacks, rolling easements, revised settlement patterns, socio-economic transition strategies, cultural needs assessment
Adapt options reduce the impact of the hazard by increasing the flexibility of vulnerable communities so they may cope with change and continue using the land.	Build on pilings, adapt drainage, emergency flood shelters	Anticipatory building codes, early warning and evacuation systems, risk-based hazard insurance
Defend *options* reduce the likelihood of the hazard through preventative or defensive measures.	Construct dikes, levees, floodwalls, seawalls, bulkheads, groynes	Dune restoration, beach nourishment, afforestation

The 3 approaches are not mutually exclusive. A flood management strategy would include a mix of retreat, adapt and defend approaches tailored to the particular outcomes, objectives, context and type of flooding being addressed.

For example, fluvial flooding could be addressed by making room for the river by creating ecological landscapes (***retreat***), adopting new built forms (e.g. raising floor levels) and building social resilience through increased community awareness and preparedness (e.g. insuring infrastructure and other assets against flooding) (***adapt***), and constructing flood protection infrastructure such as levees, dams, pumps etc. (***defend***). Similarly, managing pluvial flooding could involve remediating urban waterways (***retreat***), creating green corridors and dealing with water when and where it falls (source control) through green buildings and smart infrastructure (***adapt***), and pumps (***defend***). Often their combined approach can deliver a broader range of benefits, and greater benefit/cost ratios, while maintaining a core level of flood protection.

Conventional gray solutions, NbS and non-structural solutions can be combined to address different types of flooding, using the retreat–adapt–defend strategy.

Step 4 — Value and choose interventions

Benefit cost analysis (BCA) is a useful tool for comparing different IUFM options, to choose the project or projects that deliver the greatest benefit to the community. It essentially involves describing and assigning a monetary value to the benefits and costs associated with different options, and then comparing them. It has rigorous theoretical foundations, broad practical application and is widely accepted internationally by financing agencies and public authorities. It makes the best use of the available information. And it is transparent about assumptions and uncertainties.

However, putting BCA into practice can be challenging:

Understanding the base case can be difficult. The base case or 'without-project' scenario requires good knowledge of the issue, the context, the proposed management practices and the people whose behavior matters. Importantly, comparing values 'with' and 'without' the project is not the same as comparing values before and after the project.

Some costs and benefits can be difficult to identify and quantify. Some costs and benefits are tangible and easy to identify and quantify, for example infrastructural damage from flood events. But others are not so straightforward. BCA should include information about less tangible benefits such as social and environmental values because (a) the importance to the community of different social and environmental outcomes varies enormously, and (b) ignoring these values will very likely result in poor decisions about how to spend public resources. Some intangible costs and benefits may be valued through pre-existing markets (e.g. markets for houses). Others we may be able to estimate using a benefit transfer method.

The size, timing and certainty of costs and benefits may vary between options. Some options may involve large upfront costs (e.g. a dam or levee), while others may have fewer upfront costs (e.g. a wetland or an education program to build community resilience), but have higher ongoing costs (e.g. operating costs, maintenance costs, compliance and enforcement costs).

Different projects can also generate benefits at different times for a range of reasons:

- Some projects take significant time to implement (implementation lags).
- It may take a while for the physical actions implemented in a project to take effect and to start generating benefits (effect lags).
- The project may address a threat that has not yet occurred yet but is expected in future (threat lag).
- A project may require people to change their behaviour, which can take time (adoption lag).
- Benefits from educational programs decay over time if not reinforced or if a new law or regulation is not enforced.

And even when implemented, some risks might stop the project from delivering its intended benefits. These risks include technical risk, socio-political risk, financial risk and management risk. All can be important and should be accounted for.

Understanding the profile of costs, benefits and risks/uncertainties over time is important for comparing options and financing and funding the preferred portfolio of actions. The further in the future a benefit or cost occurs, the smaller its value in present value terms.

Costs and benefits may not be distributed equitably, between different sectors of the community and over time. Traditional BCA focuses on the overall merits of a project or policy, based on whether the total benefits attributable to the project outweigh its costs. However the approach recommended by the IUFM guide also considers the outcome for individual community groups, different locations or across time. It is then up to decision makers to decide whether distributional impacts or equity issues are important and how they should be addressed, financed and funded.

The IUFM guide and supporting INFFEWS tools[20] provide guidance on how to address these and other challenges. It also contains a checklist of general issues for conducting a robust BCA.

[20] The INFFEWS (Investment Framework for Economics of Water Sensitive Cities) tools were developed by the CRC for Water Sensitive Principles, as part of its Integrated Research Project 2 (Comprehensive economic evaluation framework).

Step 5 — Identify appropriate financing and funding mechanisms

Once the desired portfolio of measures has been identified, the next step is to secure financing and funding. Importantly, financing and funding are not the same thing.

Financing is about getting the money upfront to pay for designing, constructing and operating an infrastructure asset or program. Discussions tend to focus on upfront capital costs, but financial decisions should also consider ongoing maintenance and capacity building costs to sustain benefits over time.

Funding is about how investment costs are repaid over time. The party who provides the initial loan (finance) to construct a dam may be different from those who repay (fund) the loan over time. An international bank or private sector organization may fund construction of an asset, but the beneficiaries of the asset may repay the investment through charges, fees or taxes.

Financing and funding for *any* infrastructure project can be challenging:

- Very large (and therefore expensive) projects can find it difficult to secure enough financing and funding.
- Projects that involve many stakeholders can be difficult to coordinate, and sometimes the financing and funding arrangements unravel.
- There are always competing priorities. Often, short-term urgent issues crowd out long-term important actions, and acute events override chronic risks.
- Benefits and therefore funding may be difficult to sustain over time.
- The benefits and costs may not be distributed fairly.

As well as these factors, NbS and non-structural solutions have different cost, risk and benefit profiles, that can affect the cost and appropriateness of different financing and funding options.

Because they are often smaller, NbS may have a lower financing requirement and investments can be staged. This makes them flexible and responsive to changing circumstances but can also mean they may not enjoy the economies of scale associated with a large structural solutions. They may involve less upfront investment, but they require ongoing maintenance. And because they are open systems that involve natural processes, they have different construction and operational risks when compared to conventional approaches.

Non-structural solutions (e.g. behavior change programs or regulations) can also involve lower or no upfront capital investment. However, as they are designed to influence behavior they often involve more uncertainty than structural solutions and require ongoing investment to remain effective. Regulations, such as planning controls and design standards, may not involve direct capital investment but do incur costs to develop and enforce; often these costs are financed and funded via taxes, fees or charges. They can also constrain economic activity that may otherwise occur, which may have a net positive or negative impact on the community (depending on their design and application).

IUFM interventions may have significant public good elements, so government funding may be most appropriate for at least part of the project. But, there is still an important role for the private sector and opportunities for collaboration to deliver both public and private benefits. NbS can include private benefits and provide additional revenue streams that can be privatized and used to offset the project cost. For example, using pluvial flows and wetlands to treat and recharge groundwater can increase the water which is available for agriculture. Rehabilitated flood-affected land can be made available for private property development.

Recognizing these features of NbS and non-structural solutions is important for decision making, so that access to financing and funding does not become a barrier to implementing the best integrated combination of measures for a specific context. And it is possible that the range of financing and funding options will increase over time as technology advances, governments undertake policy, institutional and industry reforms, and local capability increases enabling new forms of finance and new forms of government, private sector and community partnership.

Generally, finance can be equity or debt. Equity secures resources in return for a share in the ownership of the asset and access to the future benefits that ownership affords. Debt secures resources but must be repaid over time with appropriate compensation paid to the lender. Most people are familiar with government and private sector sources (both debt and equity), particularly direct investments in large infrastructure assets, public private partnerships (PPPs), private land developments and green bonds. Community financing (particularly NGO funding) is also a key finance source.

Many people will be familiar with some of the common sources of funding, particularly taxes, fees and charges. Taxes are levied by governments, but governments and private sector operators can levy fees and charges. For example, utilities impose charges on customers for services (such as water use charges), regardless of whether the utility is publicly or privately operated.

Other, perhaps less obvious, sources include:

- asset recycling, which occurs when government sells a public asset and reinvests a portion of the proceeds in an identified new infrastructure investment
- incentives, which reward investment and action by household and businesses that either reduce the cost or increase the actual or perceived benefits of an activity
- regulations, which impose costs on households, businesses and developers.

Different financing and funding options will have pros and cons, and their suitability for different IUFM strategies may also vary. Selecting the right context specific approach can involve trade-offs between issues such as efficiency and equity, sophistication and cost, risk and return. The most appropriate mix of measures may change over time and over the project's planning, construction and operations phases.[21] For example, debt and equity financing options can be used together, but there may be a greater focus on debt in the risky construction phase, relative to the operational phase.[22]

To demonstrate the framework and how NbS can be used to manage floods, the IUFM guide includes 4 detailed case studies—2 in Thailand and 2 in Vietnam (See Appendix 1). These case studies propose suitable NbS in prioritized locations, and demonstrate the application of the INFFEWS economic valuation methodology. They build on a growing catalogue of similar projects, combining international experience with Vietnamese and Thai local knowledge.

Alongside the case studies, a 3-part training programme is available, targeted at government policy makers, senior planners, strategy leaders and managers, as well as civil society and private sector representatives in Thailand and Vietnam. This programme provides a solid grounding in how to use the economic tools for NbS benefit valuation, how to identify effective NbS for specific urban water management needs, and how to develop and evaluate investment options. It draws upon the ongoing case studies as applied examples.

[21] Ehlers T 2014. *Understanding the challenges for infrastructure finance*. Working Paper No. 454. Basel, Switzerland: Bank for International Settlements,. Available from: https://ssrn.com/abstract=2494992.
[22] Poole E, Toohey C and Harris P 2014. 'Public infrastructure: a framework for decision-making', in Heath A and Read M (eds). *Financial flows and infrastructure financing*. Proceedings of a conference. Sydney, Australia: Reserve Bank of Australia. Available from: https://www.rba.gov.au/publications/confs/2014/pdf/poole-toohey-harris.pdf.

Attachment 1: Case study introductions

Vietnam: Phu Quoc

Scale of analysis: Catchment

Urban context: Low density, urban, peri-urban

Type of flooding: Pluvial

With a population of about 146,000, Phu Quoc is the largest island of Vietnam. Its long sandy coastlines, tropical rainforests and vibrant towns have contributed to the island's reputation as a key domestic and international tourism destination. More than 5 million tourists visited in 2019, an increase of 27% compared to 2018.

The key water challenges facing the island are:

- **Flooding:** In August 2019, unprecedented heavy rain caused extensive flooding of up to 1m in depth. Only the towns of Duong Dong and An Thoi have formal drainage and flood management systems, but even these are overwhelmed each rainy season.
- **Inadequate supply:** The existing water supply system serves less than half of the island's current demands. Storage is inadequate with district administration reporting in 2020 that water levels in Duong Dong reservoir was less than 20% capacity. Many tourist resorts have constructed their own independent supplies which has led to poorly regulated groundwater abstraction from sensitive coastal aquifers.
- **Quality:** There is no centralized wastewater collection and treatment system. Wastewater from towns, hotels and industry frequently spills into public spaces or open drains to the beaches and the ocean. Together with plastic pollution, this threatens the tourism industry and poses a risk to public health.

Opportunities for NbS: As the island ramps up efforts for sustainable water management, notably with the WB funded Sustainable Water Management Project (2021-2027) and Construction Master Plan of Phu Quoc Economic Zone to 2040, vision to 2050, there is significant potential to "leapfrog", utilizing nature-based and non-structural measures to address several, interrelated water challenges and reaping the environmental and social co-benefits in terms of increased amenity value for tourism and local communities.

Vietnam: HCMC

Scale of analysis: Precinct

Urban context: High density urban

Type of flooding: Pluvial, fluvial, coastal (storm surge)

As the largest city and economic and financial centre of Vietnam, HCMC is of prime strategic national importance. Green space is relatively low and population growth rates are high at around 3.2% with sustained rural to urban migration.

The key water challenges facing the island are:

- **Flooding:** A delta city, HCMC regularly experiences flooding events. Urban development has also increased coverage of impervious surfaces, leading to inadequate drainage and infiltration. Future climate change impacts may mean HCMC's extreme flood risk increases by 5-10 times by 2050, exacerbated by land subsidence.
- **Water quality:** Drainage systems are affected by flooding, resulting in overflows of polluted water in the open drainage system, as well as damage from saline intrusion.

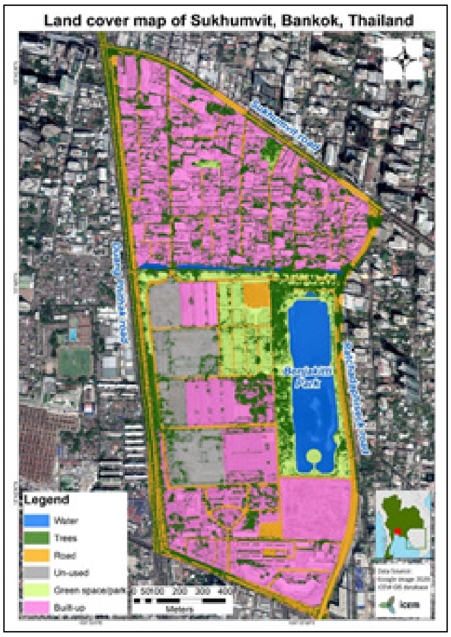
Opportunities for NbS: Nbs are already at the forefront of the urban agenda in HCMC. The current WB supported updated Masterplan for Drainage and Wastewater is a key government priority to improve sanitation on a broad scale. In addition, a new Highly Interactive and Innovative District (New Thủ Đức City) is planned, merging several districts in the east of the city. This area will have a focus on innovation, "smart" initiatives, ecological considerations and tourism. More generally, the goal looking to 2050 for master planning is for broad urban greening including increasing park coverage and permeable areas in the city. A priority for municipal authorities is the need for mobilization of private investment for green areas to reduce upfront government costs.

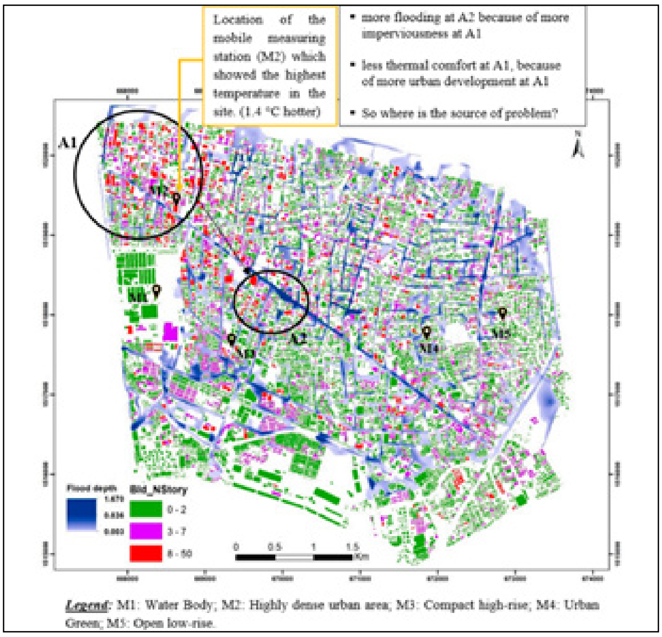
Thailand: Sukhumvit

Scale of analysis: Precinct

Urban context: High density urban

Type of flooding: Pluvial, fluvial





Sukhumvit district is a highly urbanized, commercial centre of Bangkok which is a hub for shopping, dining and nightlife.

The key water challenges are:

- **Flooding:** Flooding is a severe problem in Bangkok. Between 2994 and 2009 the metropolitan area increased by almost three times, while at the same time there was a 40% decrease in vegetated area. In addition to pluvial flooding, there is also fluvial flooding from overtopping of embankments due to high water level in the Chao Phraya River. Flooding is aggravated by over extraction of groundwater which has caused land subsidence. In Sukhumvit, flooding is worse in the less dense and lower-rise area to the east side of the site (A2) due to decreased perviousness in the dense, high-rise area to the west side (A1).
- **Urban heat island:** In addition to water challenges, Bangkok also suffers from a growing urban heat island problem, particularly in highly dense areas like Sukhumvit, and at night time when roads, buildings and other concrete infrastructure absorb solar radiation during the day and release it at night. In 2012, one study found the maximum temperature difference between Bangkok metropolitan area and surrounding rural area to be 7 degrees Celsius.

Opportunities for Nbs: A previous study conducted in the area assessed the potential for small scale NbS to reduce flooding and the urban heat island effect, applying numerical modelling to assess their effectiveness . Green roofs and pervious pavements emerged from the study as particularly effective options. In addition, the conversion of a lake and adjacent undeveloped area into a large wetland park (Benjakitti Park) is already planned by the Bangkok Metropolitan Authority. The pioneering Chulalongkorn University Centenary Park, also constructed in a dense, central Bangkok location paved the way – demonstrating the value of multi-functional wetland spaces

This presents a unique opportunity to build upon this momentum and optimize design and implementation of current plans to address both flooding, and the related challenge of urban heat island effect.

[23] 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.

Thailand: Rayong

Scale of analysis: Catchment, City

Urban context: Industrial/urban, medium density

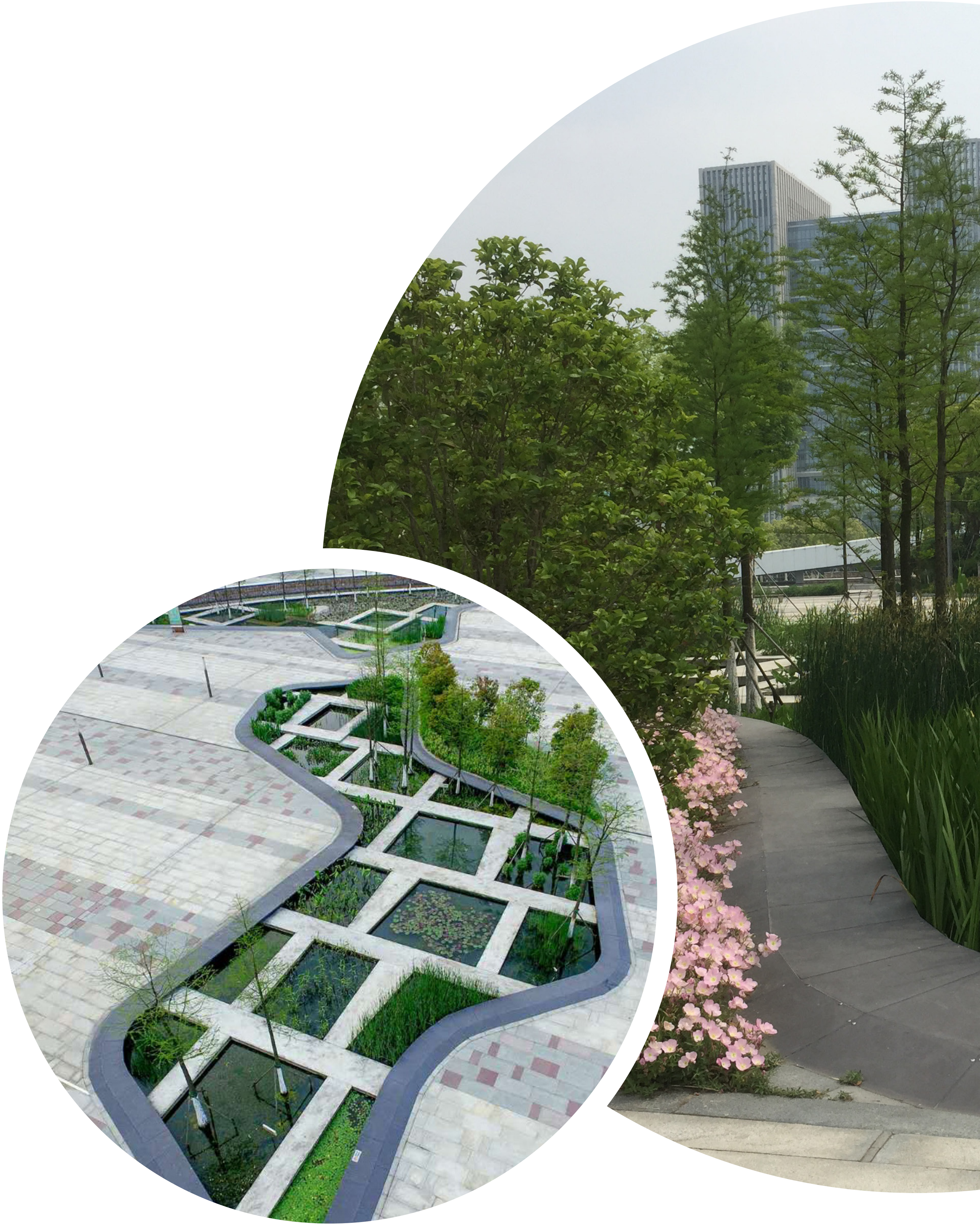
Type of flooding: Pluvial, coastal

Rayong province, to the east of Bangkok has the highest per capita GDP in Thailand. That wealth reflects the rapid development of the province as an industrial and energy hub of the country. Yet, urban growth has been largely unplanned and uncontrolled leading to poor water management and environmental quality.

The key water challenges are:

- **Flooding:** Rayong City, which is in the early stages of development, is affected by pluvial and fluvial flooding with coastal influences. Surfaces have been hardened and drainage is inadequate and poorly maintained.
- **Water quality:** Storm water and sewage are mixed and enter the environment untreated. There are challenges with managing pollutants and runoff from industrial estates.

Opportunities for Nbs: The main road – Sukhumvit road – runs west to east dissecting the city central business district. It and the development zone either side have been developed largely without a view to landscaping or the potential role of NbS in water management and amenity. Many plots either side of the road are still to be developed and, along with relatively wide pavement areas, provide an opportunity for rehabilitation and renewal.



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