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The Gray, Green, Blue Continuum

Valuing the Benefits of Nature-Based Solutions for Integrated Urban Flood Management in China

Marcus Wishart, Tony Wong, Ben Furmage,
Xiawei Liao, David Pannell, and Jianbin Wang

Contributors

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A series of case studies were prepared to validate the methodology within the local context, highlight the change in values within different social, cultural and economic conditions and support the valuation of benefits associated with China's Sponge Cities. These case studies include the Futian River in Shenzhen (Annex D) conducted by a team from the Shenzhen Water Planning and Design Institute Co. Ltd led by Xiang Sun (Project Manager, Senior Engineer) and including Hang Song (Assistant Engineer) and Penghui Du (Engineer); the Kunshan Forest Park (Annex E) conducted by a team led by Bin Jiang (Principal Investigator, Researcher) from the Jiangsu Institute of Urban Planning and Design and including Jianguo Zhu (Professor-level Senior Engineer), Yongzhou Huang (Professor-level Senior Engineer), Sufang Shenz (Senior Engineer), Yun Kong (Engineer), Bo Feng (Engineer), Yanyan Zhou (Assistant Engineer) and Kun Xie (Assistant Engineer).

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The Role of NbS in IUFM

Nature-based solutions (NbS) are increasingly recognized as important tools to build resilience, develop sustainable adaptations, and improve disaster risk management.

Such solutions have the potential to integrate natural habitats, processes, and services as part of a coherent and holistic approach to water management, particularly in the urban context. They can provide multiple functions beyond conventional flood mitigation, generating a range of benefits by restoring and conserving natural capital, improving the liveability of urban spaces, increasing resilience and contributing to more sustainable outcomes. In doing so, they can enhance overall water security by improving water availability and water quality while simultaneously reducing water-related risks and generating additional social, economic, and environmental cobenefits.

Achieving these outcomes requires hybrid urban infrastructure city-wide. Such infrastructure optimizes a mix of blue, green and gray corridors that can integrate NbS into the built urban form at a range of scales and in varying proportions. While the design and implementation of these hybrid assets are relatively well considered, their implementation at scale has been limited. This is due in part to the challenges in realizing the values associated with the full range of market and non-market benefits and comprehending the distribution of these among diverse beneficiaries. This situation makes it difficult to secure sustainable revenue streams and to internalize future returns that can be aggregated to leverage sufficient financing. As a result, improved approaches are required to identify the benefits derived from NbS, evaluate the value of these benefits and to identify the range of potential beneficiaries, to provide a framework that can facilitate co-investment in hybrid infrastructure and ultimately suitable financing models.

There are a range of innovative hybrid approaches to building resilience within the context of integrated urban flood management (IUFM). The increasing recognition of hybrid approaches that integrate NbS reflects the changing nature of societies and the increasing aspirations for better environmental quality. This is particularly true of the world's large megalopolises and rapidly urbanizing cities across Asia, where there is growing recognition of the need to enhance inclusive and sustainable urbanization, improve resilience to floods, and to increase access to safe, inclusive, and accessible green public spaces. Such approaches are needed to foster more positive and sustainable economic, social, and environmental outcomes. Achieving these outcomes requires integrated, participatory, and sustainable planning and management, which are embodied in the Sustainable Development Goals (SDGs), specifically SDG 11, which calls for making cities and human settlements inclusive, safe, resilient, and sustainable. Similarly, the United Nations World Water Development Report 2018: Nature-Based Solutions for Water called on countries to scale up the adoption of NbS to mitigate water-related risks, especially with the prospects of a changing climate. The Global Commission on Adaptation's landmark report, Adapt Now: A Global Call for Leadership on Climate Resilience, also calls for governments and companies to significantly accelerate action and investment in NbS.

Many global practices have emerged in support of hybrid city-wide infrastructure and the concept of integrated urban water management.[1] These practices share a common element: the integration and adoption of NbS to complement conventional engineering approaches within a landscape-level planning framework. Such integrated approaches to urban flood management take a whole catchment perspective that considers a broad range of social, economic, and environmental objectives. This idea of positioning urban resilience within a catchment-to-coast framework acknowledges the importance of landscape-level hydrological processes along with the integrated solutions required to manage them. Thus, it values the full range of direct and indirect costs and benefits from blue, green, and gray corridors and balances actions before, during, and after flood events across an array of retreat, adapt, and defend strategies to improve the resilience of urban environments to the effects of floods (figure 1).

figure 1 / **CITY WATER RESILIENCE APPROACH**

Sources: Arup (2014). Design with Water. https://www.arup.com/perspectives/publications/promotional-materials/section/design-with-water

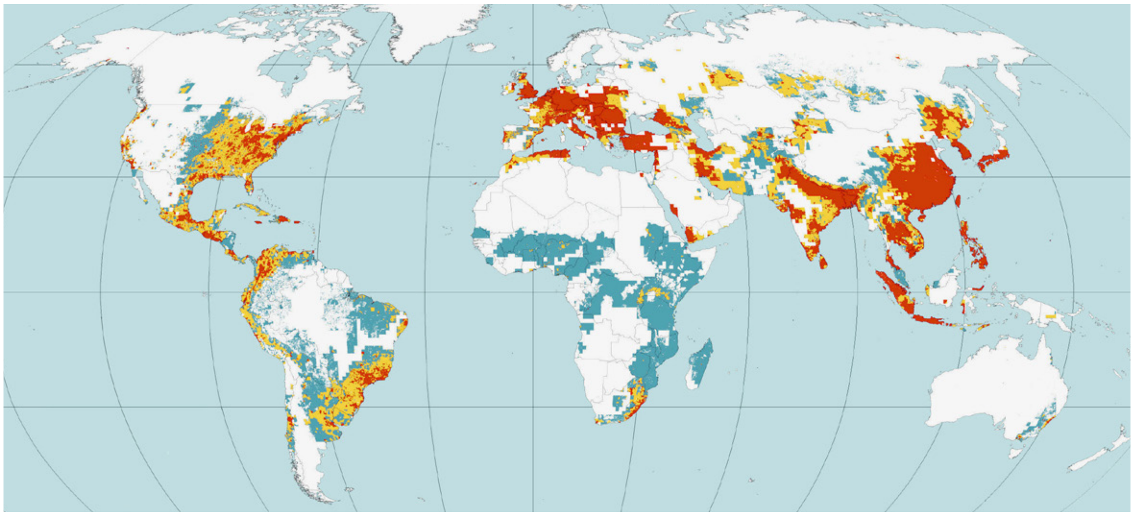
[1] These include water sensitive cities (WSCs) in Australia; low-impact development (LID) in the United States and Canada; sustainable drainage systems (SuDS) and blue-green cities (BGCs) in the United Kingdom; the Active, Beautiful, Clean Waters (ABC Waters) Programme in Singapore; and Room for the River in the Netherlands, among others.

Floods are the Most Frequent of Natural Hazards and Cause More Damage than any Other Disaster

Globally, floods are estimated to have affected more than 2 billion people between 1998 and 2018, accounting for about 45 percent of all people affected by disasters during that period and an estimated 142,088 fatalities (CRED and UNISDR, 2015). Immediate effects of flooding include loss of human life, demise of livelihoods, damage to property, destruction of crops, devastation of livestock, disruption of services, and deterioration of health conditions because of waterborne diseases, among others. Flooding led to an estimated US$656 billion in direct economic losses during that same 10-year period, but these figures suffer from systematic underreporting, and actual values are likely much higher. Considering indirect effects on human well-being, natural disasters are thought to cost the global economy more than US$520 billion per year (Kundzewicz et al. 2013; World Bank 2017).

Increasing exposure to floods and changing climate conditions are expected to escalate economic effects. This increase in exposure stems from continued population growth and urbanization as well as sustained economic growth and growing prosperity, compounded by the effects of a changing climate. Changes in climate are expected to alter water regimes, both in terms of availability and variability, as well as many of the factors that affect the frequency and severity of flood events, such as precipitation and runoff and sea levels. It is estimated that approximately 1.3 billion people (or 15 percent of the global population) will live in flood-prone areas by 2050 (Verwey, Kerblat and Brendan 2017). Given the substantial uncertainties embodied in climate change projections, there is increasing recognition of the need to have more robust approaches. This has led to an increased use of scenario planning and more holistic, resilient approaches to flood management that incorporate NbS and the range of cobenefits they can deliver.

map 1 / **GLOBAL FLOOD TOTAL ECONOMIC LOSS RISK DISTRIBUTION**



Risk Deciles: 1st - 4th 5th - 7th 8th - 10th

Source: Diley et al. 2005.
Note: Total Economic Loss is found by weighting the value of GDP to floods for each grid cell by a vulnerability coefficient to obtain an estimate of risk. The vulnerability weights are based on historical economic losses in previous disasters. The economic loss risks are applied to GDP per unit area exposure to obtain economic loss risks. The weights are an aggregate index relative to losses within each region and country wealth class (classification based on 2000 GDP) over the 20-year period from 1981 to 2000.

China is Among the Most Exposed Countries to Floods

According to the Global Climate Risk Index for 2017, China is the world's 31st country most affected by climate-related disasters, with more than 67 percent of people living in flood-prone areas (Ding 2018). Flooding occurs regularly in 641 of China's 654 largest cities, and recorded flood losses have more than tripled—from about US$7 billion per year in the 1980s to US$24 billion per year in the 2000s, with the largest annual damage recorded in 2010, amounting to a total loss of US$51 billion. A survey by the National Bureau of Statistics of China shows that 62 percent of Chinese cities experienced floods from 2011–14 and the direct economic losses amounted to as much as US$100 billion (National Bureau of Statistics of China 2015). On average, floods annually result in losses estimated to equal 1 percent of the Chinese gross domestic product (GDP) with the losses due to floods in 2020 estimated at US$25.87 billion (Kobayashi and Porter 2012) (see box 1).

Rapid urbanization, shifts in land use patterns, and climate change are driving the increase in risks of urban floods in China. Urbanization typically increases areas of impermeable land surface, which reduces infiltration and increases surface runoff and peak discharges during storm events. Urban microclimates and urban heat island effects are likely to cause more thunderstorms. Meanwhile, increasing numbers of people and assets are facing exposure to flood risks because of continued migration to densely concentrated urban areas. From 1978 to 2018, China's urbanization rate increased from 17.9 percent to 59.6 percent and the number of people living in urban areas grew from 172.45 million to 831.37 million. By 2030, the urban population is expected to account for 70 percent of the total population. Different climate change scenarios project precipitation increases associated with the maximum five-day rainfall in the central, southern, and eastern regions of China. Without large-scale structural adaptation and improved resilience, China is expected to suffer the highest direct economic losses around the world, increasing by 82 percent by 2040 (Willner, Otto, and Levermann 2018).

box 1 / **FLOODS IN SOUTHERN CHINA, 2020**

In 2020, China experienced extreme rainfall and flood events comparable to the major floods in 1998. From early June to mid-August, accumulated precipitation was estimated to be 1.7 times the long-term average and the highest on record since 1961. Intense rains resulted in unusually high-water levels of major rivers and lakes, concentrated in the Yangtze River Basin, Huai River Basin, Lake Tai Basin, Lake Dongting Basin and Lake Poyang Basin in the southern China. The Three Georges Dam in the Yangtze River received 76,000 cubic meters per second at its peak level, the highest ever inflow since the dam was built and at its maximum capacity (Sohu News 2020). By mid-August, floods in 27 provinces had reportedly disrupted the lives of over 63.5 million people, with more than four million residents having to evacuate from their homes, and 219 people had been reported missing or dead. The number of casualties was considered relatively modest considering the severity and magnitude of rains and subsequent flooding (State Council Information Office 2020a) owing to the comprehensive and integrated flood management system developed over the past few decades. This approach is built on an infrastructure platform with improvements in flood forecasting and early warning, coupled with improved coordination and flood response mechanisms. According to the State Council Policy Briefing on August 13 (State Council Information Office 2020b), the floods caused direct economic losses of US$25.87 billion (RMB178.96 billion) (People's Daily 2020), which does not account for the secondary cascading effects on the economic flows and outputs.

The Sponge City Program Was Initiated to Improve Urban Resilience through Integration of Nature-Based Solutions

To improve the resilience of China's urban environments, the Sponge City Initiative was introduced in 2014. This builds on earlier concepts of flood risk management and was launched following the 2010 floods in southern China during which exceptionally heavy summer rains caused major rivers, including the Songhua, Yangtze, and Yellow, to reach catastrophic levels. The Sponge City Initiative reflects a global transition toward IUFM approaches, combining both structural and nonstructural solutions that leverage gray, green, and blue infrastructure to mitigate risks of urban flooding and inundation. The approach addresses flooding by integrating several ideas and practices—such as NbS, community and environmental well-being, and adaptation to climate change—within urban land use planning processes. By leveraging NbS and using natural or seminatural measures to mimic natural water cycles, the Sponge City Initiative addresses surface-water flooding, attenuation of peak runoff, improved purification of urban runoff, and enhancement of water conservation. Through a unique blend of structural and nonstructural initiatives, sponge cities have the potential to strengthen resilience to the many challenges of urban water security and urban liveability, creating recreational spaces around urban water sources, fostering the development of a water culture, promoting greater awareness, and improving water conservation.

China aims to have 80 percent of urban areas across the country sponge-like by 2030. Thirty cities were selected in 2015 and 2016 to pilot the construction of sponge cities by a working group made up of the ministries of Finance (MoF); Housing, and Urban-Rural Development (MoHURD); and Water Resources (MWR) (map 1.2). Funding was an estimated US$29 billion (RMB 200 billion), of which central government financing accounted for only 20 percent. For the first 16 pilot cities, the investment requirements were estimated at US$985 million (RMB 6.9 billion), and about US$12.26 billion (RMB 86.5 billion) would be required to meet the national target of having 20 percent of the urban areas "sponge-like" by 2020 (Zevenbergen, Fu, and Pathirana 2018). The unit costs have been estimated as much as US$15 million to US$22 million (RMB 100 million to 150 million) per square kilometer or higher in more economically developed areas, such as Beijing and Shanghai.

Investments to develop China's sponge cities have come primarily from public funding. Each pilot received a central budget allocation, estimated between US$57 million and US$86 million per year for three consecutive years. The investment needed to scale up the program is an estimated US$1 trillion by 2030, with the financing gap expected to be covered by provincial and local governments and financial institutions together with the private sector and local communities. As such, a range of innovative financing options are required that can incorporate more holistic approaches for identifying benefits derived from NbS, evaluating these benefits, and monetizing revenues streams to leverage sustainable sources of financing.

There are a number of challenges to integrating NbS for urban flood management. Facilitating the transition from conventional to hybrid approaches requires accounting for technical and physical concerns, legal and regulatory issues, and social and institutional considerations, among other issues. However, financial challenges have been identified as one of the main constraints because of the substantial costs in implementing NbS for IUFM. Despite broad acknowledgment of the range of market and nonmarket benefits, complex interrelationships exist among the values of those benefits associated with water and flood management measures.

While there have been improvements in integrated planning approaches, these benefits are often coincidental and not optimized within design considerations. It is therefore important to have strategies for ensuring that:

- a broad range of possible financing sources are considered
- the chosen financing approach responds to the unique attributes of nature-based and nonstructural solutions
- benefits and costs are allocated equitably, and activities are funded fairly
- the decision-making process is transparent
- funding is efficient and effective, and it delivers project benefits over time

map 2 / **CHINA'S THIRTY SPONGE CITY PILOTS**

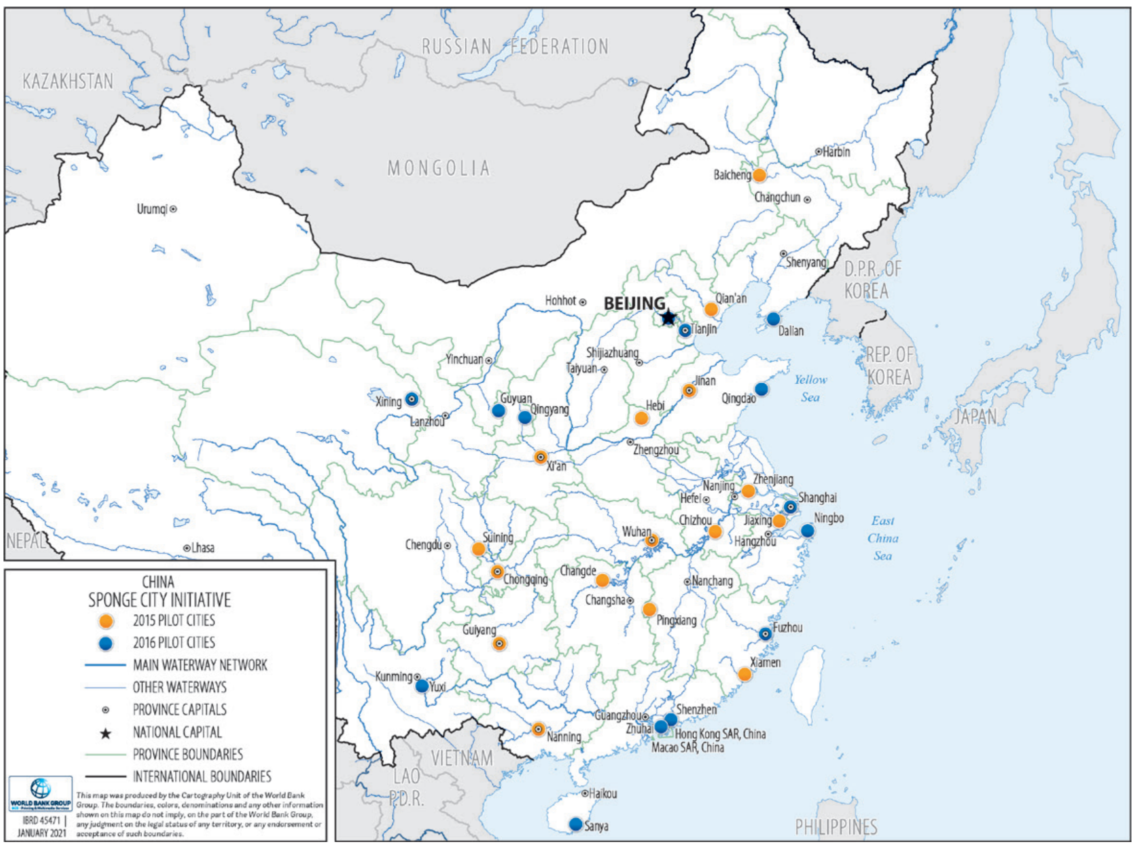


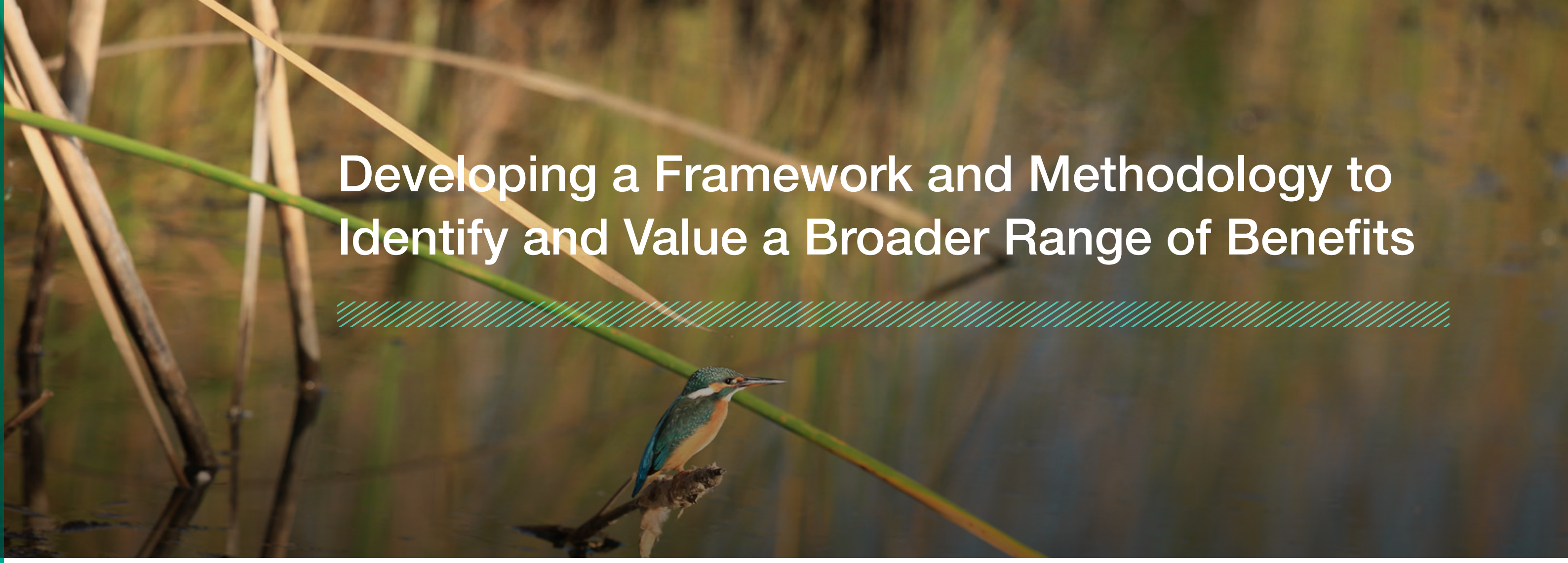
photo 1 / **EIGHT BENEFITS ASSOCIATED WITH A NATURE-BASED PROJECT IN URBAN FLOOD MANAGEMENT**

In addition to flood protection, this site provides:

1. Access to green space increasing local property value and encouraging new investing
2. Water for parks and agriculture
3. Improved water quality and road runoff
4. Improved biodiversity
5. More actively connected communities
6. Improved well-being through access to green spaces
7. Improved local multimodal transport
8. Improved air quality

Source: Original to this publication, using photo from Kunshan Urban Development Investment Company.

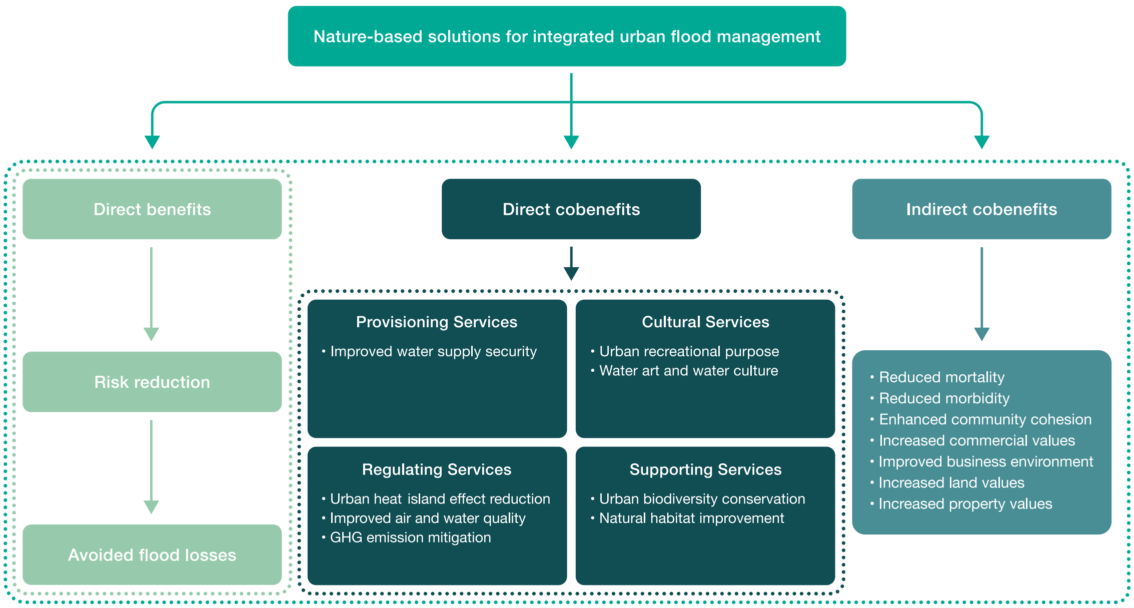
Developing a Framework and Methodology to Identify and Value a Broader Range of Benefits



NbS for IUFM provide a wide range of tangible, market-related benefits along with intangible, nonmarket-related benefits that are typically not accounted for in conventional BCA. By absorbing, filtering, and slowing stormwater runoff, NbS can help mitigate urban floods and improve water quality. Further, NbS provide a range of additional tangible and intangible benefits by enhancing natural ecosystems and improving aesthetics of the urban environment for the people who live and work in them (photo 1 and figure 2). The benefits include, but are not limited to, enhanced resilience to future climate change, increased amenity values, and increased utility and social values by providing urban green spaces and increased asset values. NbS often require lower capital investments than conventional gray infrastructure approaches and have substantially lower operating expenses. Although there are significant uncertainties in predicting future climate changes and their effects in urban landscapes, NbS offer the potential to increase resilience and to cope with future changes in climate through adaptive management. These are considered “no-regret” measures because they provide benefits even without climate change.

Conventional approaches to determining returns on investments in flood management and mitigation projects have largely focused on avoided losses. A benefit to these approaches is that they are simple to calculate and to explain to decision-makers. They can also provide information about the optimal level of flood risk reduction associated with the direct intervention cost. However, such approaches do not reflect the full range and diversity of environmental, social, and economic cobenefits as well as the values of resilience and reversibility that can be realized through integrated approaches to urban water management. Such innovations require new approaches to facilitate the identification and assessment of the full range of benefits to be derived from IUFM.

figure 2 / **TYPOLOGY OF BENEFITS THAT CAN BE DERIVED FROM NBS FOR IUFM**



Note: GHG = greenhouse gas.

The approach described herein builds on the "Principles for Valuing Water" articulated by the High-Level Panel on Water convened by the United Nations and the World Bank Group. It includes three common types of flooding (that is, fluvial, pluvial, and coastal) via a five-step process (figure 3). This is intended to highlight economic efficiency as a precursor to monetizing these benefits. In doing so, it can help identify different funding options and tap into the variety of financing sources. Broader recognition of the full range of benefits and an evaluation of their value under different circumstances provides the foundation for capturing nonmarket values and leveraging private sector and community financing options.

STEP 1

Understand the broader urban socioeconomic context within which the flooding occurs, including the objectives and challenges presented by the specific location.

Decision-makers need to consider social, economic, and environmental effects at multiple scales, including local, urban, and catchment. A flood risk assessment, combining both flood hazard assessment and flood vulnerability assessment, is first used to determine the effects. The primary outputs of a flood hazard assessment are the probability or frequency of occurrence, the magnitude and intensity of occurrence, and the average time between occurrences. An assessment of flood vulnerability is characterized as exposure and damage, quantifying the degree to which a system (in this case, a system consists of people or assets) is susceptible to the adverse effects of floods and quantifying the resultant cost of damages. Based on the flood risk assessment, a three-tiered IUFM framework is used based on three strategies: retreat, adapt, and defend.

STEP 2

Systematically identify the full range of flood management and mitigation interventions in urban landscapes across the spectrum of "gray" to "green" to "blue" infrastructure solutions, along with other nonstructural measures.

Conventional approaches to flood management promote flood defence and mitigation. They primarily address flood hazards through flood control infrastructure that largely involves conventional engineering structures, often referred to as "hard" engineering or "gray" infrastructure. Examples include dikes, levees, dams, pumping stations, diversion channels, stormwater sewer and drainage, and related infrastructure. Complementing gray infrastructure, IUFM increasingly leverages a wide range of green infrastructure or NbS, together with nonstructural measures, including land use zoning, water sensitive urban planning, flood management capacity building, community flood awareness raising, flood preparedness, early warning and response systems, and so on.

STEP 3

Systematically identify the full range of potential social, economic, and environmental benefits associated with identified interventions.

Twenty broad categories covering a wide range of environmental, social, and economic benefits derived from NbS for IUFM have been identified. Among these, environmental cobenefits of NbS include improvements in natural habitat, enhancement of urban biodiversity, improved water and air quality, reduction of heat island effects, and reductions in sediment and nutrient transport, as well as eutrophication. Social cobenefits can include more active and connected communities, control of noise pollution, psychological benefits and improved mental well-being, and increased employment opportunities, including jobs directly linked to the implementation of NbS. Economic cobenefits include improved local land and property values, increased tourism, avoided losses, and so forth. NbS can also contribute to the reduction of social inequalities because, similar to other natural disasters, urban floods often disproportionately affect women, disadvantaged groups, and the poor because of their locations, the ways floods disrupt their normal lives, and the level of resiliency they need to recover.

figure 3

Framework to Identify, Value, and Realize Comprehensive Values of NbS for IUFM

1. Define your urban system context

Considerations:

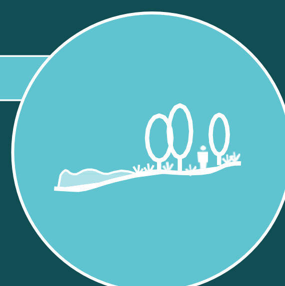
- What are the objectives and functions of the urban area of focus from a hydrologic, social, environmental and economic perspective?
- How do these objectives and functions interact with wider catchment and regional factors?
- Assess flood vulnerability and degree to which a system is susceptible to the adverse effects of different types of flooding.

2. Consider full range of solutions

Considerations:

- Identify a selection of context-appropriate flood management interventions, based on the three-tiered strategy: Retreat, Adapt and Defend
- Consider full spectrum of green, grey and blue interventions as well as non-structural solutions.

3. Identify and value benefits and costs



Considerations:

- The direct and indirect benefits, costs and risks of different options need to be identified and quantified
- Consider the distribution of benefits, costs and risks across time, stakeholders and location.

4. Evaluate and compare options

Considerations:

- Benefit cost analysis provides a rigorous method to compare different options
- Sensitivity testing and transparent assumptions build understanding and support better decisions
- distributional impacts for both benefits and costs are important considerations.

5. Identify appropriate financing and funding

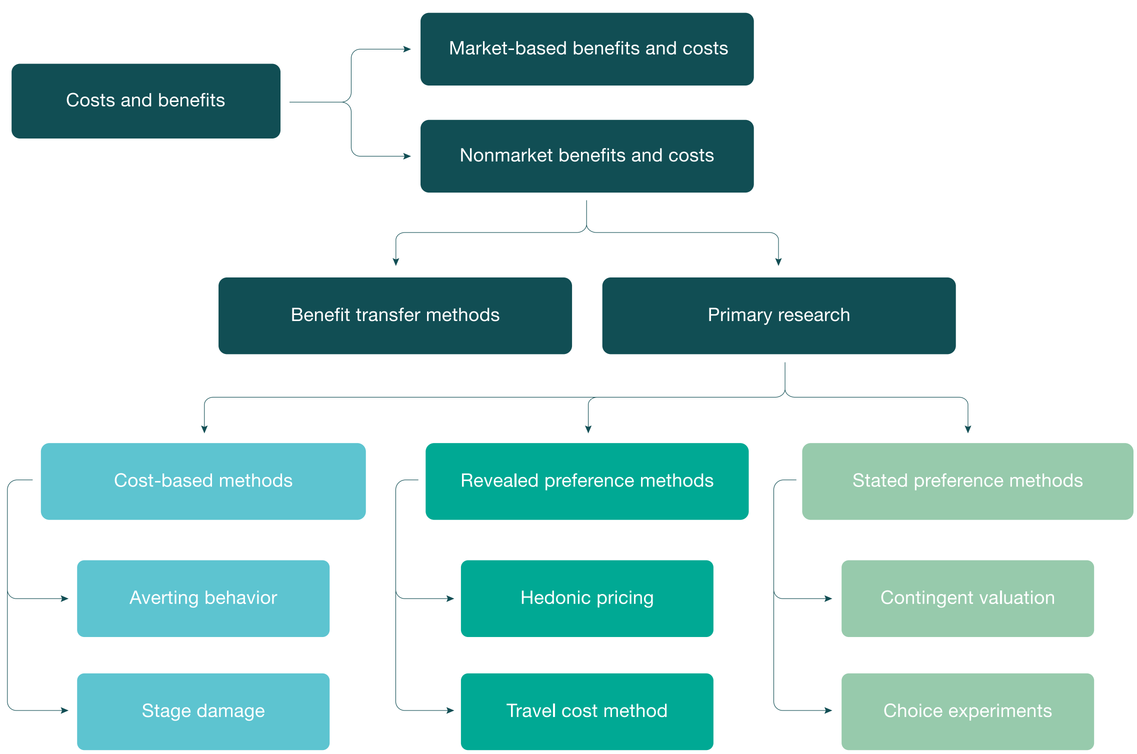
Considerations:

- Once you have selected the optimal mix of interventions, principles for fair and efficient financing options need to be identified and options assessed.

STEP 4

Evaluate values associated with benefits from NbS through a more comprehensive benefit-cost analysis. Practices associated with IUFM provide tangible benefits that are easy to quantify (for example, losses avoided from floods). However, IUFM practices also produce tangible and intangible effects that can be difficult to quantify or monetize (for example, biodiversity and the amenity benefits of having access to public green space). While many studies have attempted to quantify a wide range of nonmarket values, these studies can be both expensive and time consuming. An alternative strategy applies the benefit transfer method to reasonably approximate values associated with benefits based on literature (figure 4). The valuation tool of the Investment Framework for Economics of Water-Sensitive Cities (INFFEWS) draws on a database of values to generate monetary values for nonmarket benefits. The current version of the tool contains more than 2,000 nonmarket benefit values across 20 types of benefits. The INFFEWS tool for BCA provides a robust evaluation based on sound economics, transparency, consistency, and quality assurance mechanisms.

figure 4 / **EXAMPLES OF METHODOLOGIES FOR VALUING BENEFITS ASSOCIATED WITH NBS FOR IUFM**



STEP 5

Identify appropriate financing options to realize values associated with NbS for IUFM.

Three principle sources of funding exist: tariffs, taxes, and transfers. Government has traditionally played a key role in providing economic and social infrastructure by serving as financier and by establishing the enabling polices and regulations. However, public investments often do not suffice because of the need to meet future challenges intrinsic to managing urban floods. By facilitating the identification and valuation of a broader range of benefits—beyond conventional flood management measures—the tools can better capture improvements in the urban landscape and provide opportunities to leverage a wider array of financing options to help promote the application of NbS and continuous improvements in the quality of life and urban landscape. Private sector partners and community co-investment have the potential to unlock additional project value and revenue streams, increase the pool of potentially available funding options, and improve project efficiency. Boxes 2, 3 and 4 demonstrate the application of the framework and approach to case studies in Australia and China.

Valuing the Benefits of NbS for IUFM: Worked Examples

photo 2 / **SHENZHEN'S FUTIAN RIVER—A SOURCE OF ENVIRONMENTAL AND SOCIAL BENEFITS**

Source: Shenzhen Water Planning & Design Institute Co., Ltd.

box 2 / **TARRALLA CREEK NATURALIZATION AND WETLAND CREATION IN VICTORIA, AUSTRALIA**

Urban Context

Tarralla Creek is located in the outer eastern suburb of Croydon in Melbourne, Victoria, Australia. In 2018, GDP of Melbourne was US$102.67 billion, accounting for 7 percent of Australia's total GDP, with a GDP per capita of about US$70,500.

Project Description

The INFFEWS BCA Tool was applied to evaluate the Tarralla Creek Project in Victoria. The project was a proposal to convert a section of Tarralla Creek, which was a combination of concrete-lined channel and grassed channel, into a naturalised waterway while also enhancing adjacent natural habitat and open space. The project also proposed to use constructed wetland areas to treat stormwater and harvest some stormwater for irrigation of adjacent open space.

Outcome of BCA Analysis

Six benefits were identified in the analysis, and all of these were monetized using direct economic benefits or value transfer from reference studies. The net present value of the total benefits was estimated to be AU$20.264 million while the net present value of the total costs, including capital cost and operating cost, was AU$15.607 million, resulting in an overall benefit cost ratio of 1.30, meaning the estimated benefits outweighed the expected costs.

Sensitivity analysis in the INFFEWS BCA Tool was used to examine the impact on the overall result of changing key assumptions. This analysis determined that the project benefit cost ratio ranges from 0.49 to 2.53 with an overall probability of 0.7 that the benefit cost ratio would be greater than 1.

figure B2.1 / **CROYDON WETLANDS**

Wetlands before rennovation

Computer rendering of reimagined Croydon Wetlands *figure B2.2* / **MAP OF TARRALLA CREEK SHOWING THE SECTION TO BE REIMAGINED**

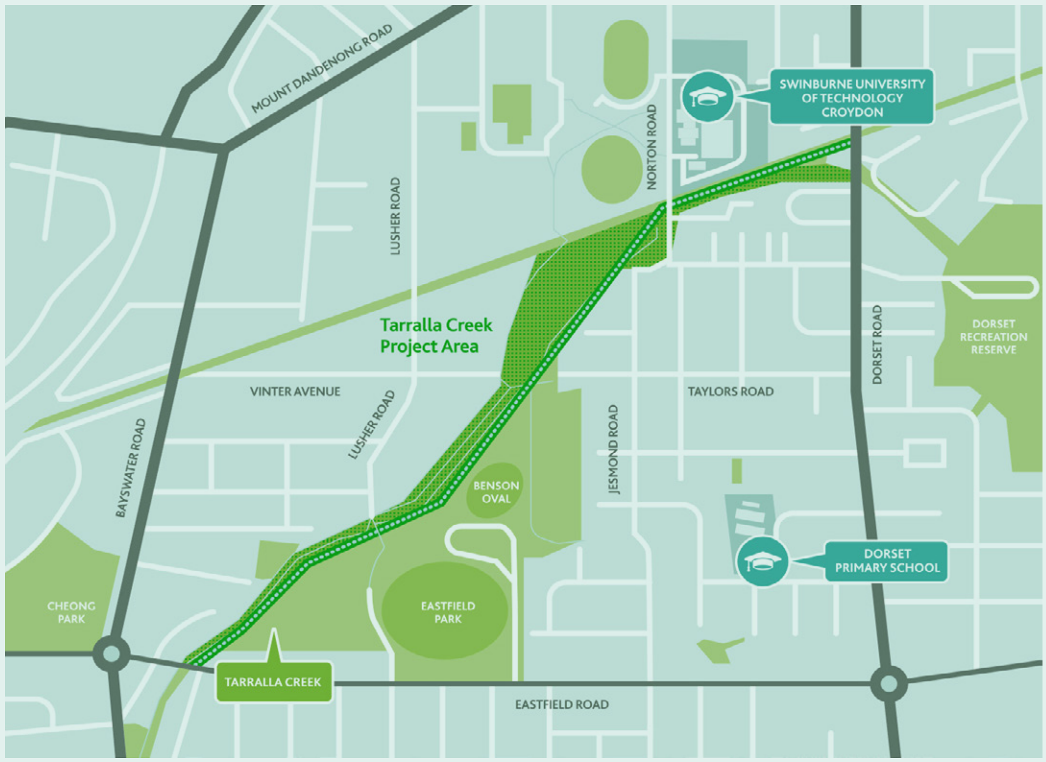
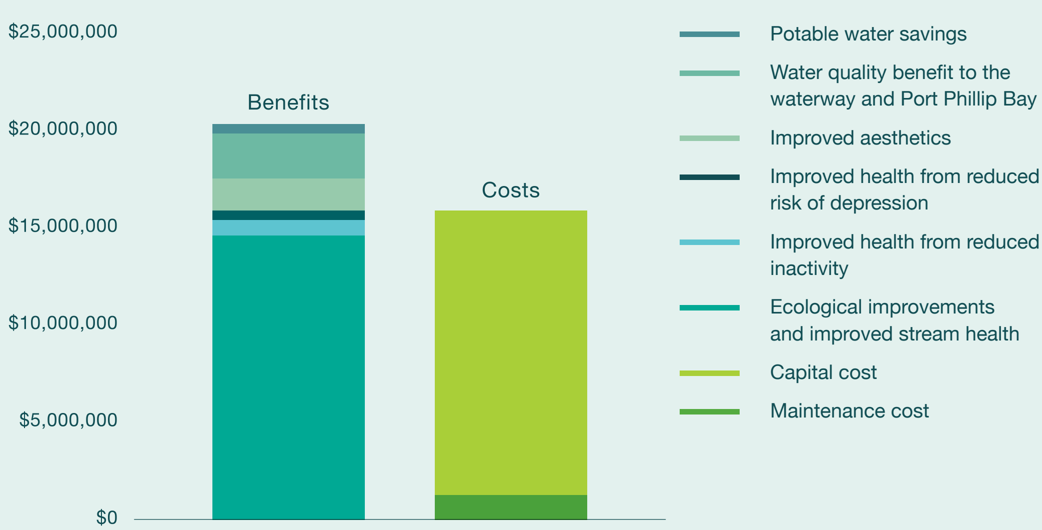


figure B2.3 / **SUMMARY OF BENEFITS AND COSTS OF THE TARRALLA CREEK**



Source: CRCWSC (2020)

box 3 / **SHENZHEN FUTIAN RIVER ECOLOGICAL RESTORATION PROJECT IN CHINA**

Urban Context

Shenzhen in southern China is one of the world's fastest growing cities with a population of 13 million. Gross domestic product (GDP) reached more than US$340 billion (roughly RMB 2.4 trillion) in 2018, with per capita GDP roughly US$28,653 (RMB 189,568) (Shenzhen Statistic Bureau, 2019). In the central area of Shenzhen, the Futian River and its catchment have suffered from ecological degradation caused by rapid urbanization and economic development.

Project Description

In 2009, the Shenzhen Water Bureau initiated the ecological renovation of the Futian River to address multiple urban water issues, including urban floods, water quality degradation, and so on, in an integrated manner. Main interventions have included a combination of conventional hard infrastructure, such as stormwater collection pipelines, and nature-based solutions (NbS), such as a constructed wetland and a Futian River central park that serves as a flood retention area (photo 2). The project has generated multiple benefits as shown in table B3.1.

table B3.1 / **COMPREHENSIVE BENEFITS OF THE FUTIAN RIVER ECOLOGICAL RESTORATION PROJECT**

Benefits	Total benefits*	Proportion (%)
Reduced flood risk	264.58	41.10
Increased property prices from proximity to project	163.53	25.40
Carbon fixation	91.23	14.20
Reduced investment in water storage infrastructures by maintaining surface water level and groundwater level	90.88	14.10
Other benefits	33.47	5.20

*RMB, millions

Outcome of BCA Analysis

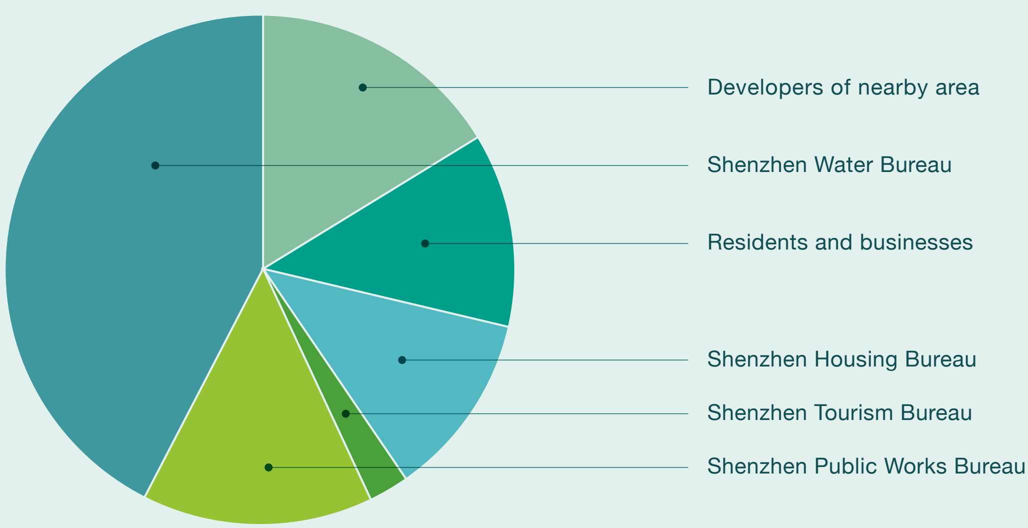
According to the INFFEWS BCA Tool, the project generates an expected NPV of negative 6.34 million RMB for the investment overall with a BCR of 0.99, meaning the benefits generated almost cover all the costs. However, the NPV for the investor, Shenzhen government, is negative 143.39 million RMB with a BCR of 0.76. It is therefore a financially unviable investment for the government, although it already has a higher BCR than most water conservancy projects in the world.

This case demonstrates the importance of valuing comprehensive benefits that NbS can provide and, according to the principle of "who benefits, who pays," identifying beneficiaries enables advocates of NbS to leverage a broader range of financial resources.

figure B3.1 / **LOCATION OF FUTIAN RIVER**

Source: Original for this publication based on Google Maps imagery.

figure B3.2 / **DISTRIBUTION OF BENEFICIARIES FROM THE FUTIAN RIVER PROJECT**



Source: Original for this publication *box 4* / **KUNSHAN FOREST PARK RENOVATION PROJECT IN CHINA**

Urban Context

Located in southeastern Jiangsu Province, the city of Kunshan within the Taihu Lake Basin of the Yangtze River Delta has a dense river network and flat terrain. With a permanent population of about 1.6 million, the cities GDP exceeds RMB 400 billion (Kunshan Municipal Statistic Bureau, 2019), equivalent to RMB 240,616 per person (US$33,975), three times China's national GDP per capita at just over US$10,000.

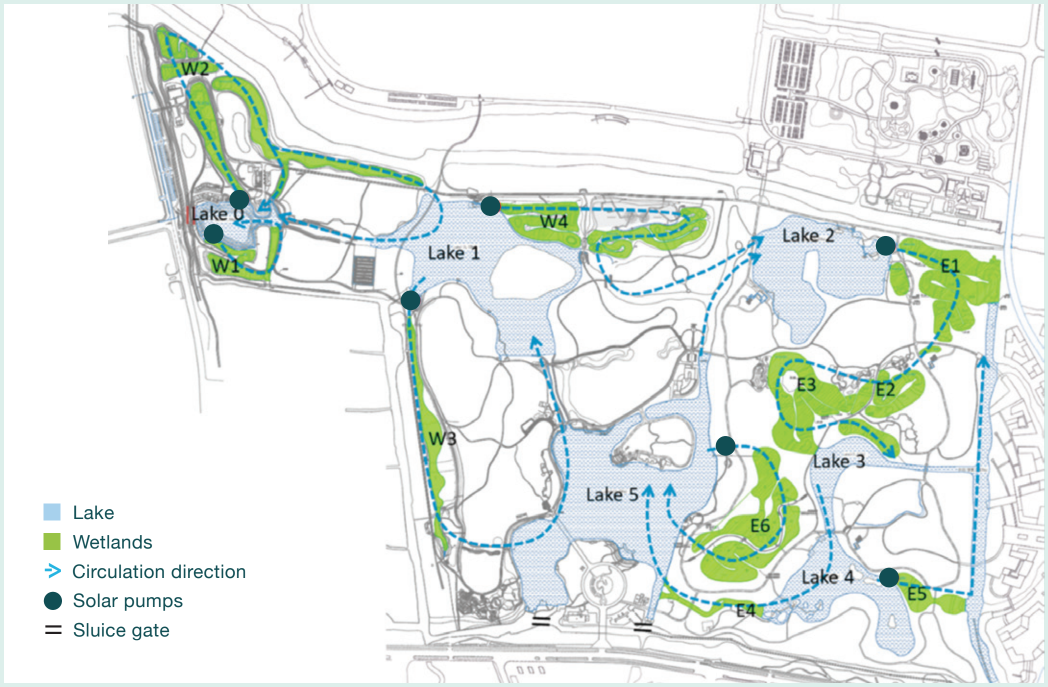
Project Description

The Kunshan Forest Park Company initiated an ecological renovation project in 2016, aiming to improve drainage and storage capacity, to enhance the protection and restoration of urban wetlands and ecosystems, improve water quality, and so on. Project activities included building several artificial lakes and wetlands with water circulation systems continuously pumping water from the lake, through the wetlands, and then back to the lake via small solar pumps to remove water pollutants, such as nitrogen and phosphorus. The lake system also serves as rainwater storage space in the polder area to improve overall capacity and control flooding in the area.

figure B4.1 / **KUNSHAN FOREST PARK IN THE POLDER SYSTEM**

Source: Original for this publication based on Google Maps imagery.

figure B4.2 / **KUNSHAN FOREST PARK RENOVATION PROJECT**



Source: Based on Kunshan Forest Park design documents.
Note: E1 to E6 represent the six wetlands in the eastern part of the Park and W1 to W4 represent the four wetlands in the western part of the Park.

Outcome of BCA Analysis

According to the INFFEWS BCA Tool, the project generated a wide range of cobenefits, including reduced flood losses and improvements in health, air quality, biodiversity, and commercial values. Overall, the total net present value (NPV) is US$57.91 million with a total BCR of 49.63. For the Kunshan Forest Park Company, the total NPV is only US$3.07 million and the BCR is 2.71. In conclusion, accounting for a broader range of benefits makes a stronger case for investment and facilitates leveraging broader financing mechanisms.

table B4.1 / **MAJOR COBENEFITS OF THE KUNSHAN FOREST PARK PROJECT**

Type of Benefit	Benefits (US$, millions)
Health benefits	23.244
Air quality improvement	18.734
Greenhouse gas reduction	07.137
Reduced flood losses	06.843
Increased real estate values	01.963
Reduced water consumption	01.084
Increased commercial values	00.517
Water quality improvements	00.182
Biodiversity improvements	00.049

Funding and Financing NbS for IUFM

Every context for IUFM faces different issues, involves different solutions, has different sources of funding, and has access to different financing options. Further, it is possible that the range of financing and funding options will increase over time as technologies advance; governments undertake policy, institutional, and sectoral reforms; and local capability increases. Such considerations will influence the revenue streams that can fund NbS and enable new forms of financing and new partnerships among governments, the private sector, and communities. As a result, there is a need to explore a menu of options rather than a prescriptive approach.

Identifying a sustainable funding stream is critical for a project's long-term success. This is particularly so for NbS, which require maintenance and protection of natural processes. NbS for IUFM may have significant public good elements, so government funding may be most appropriate for at least part of a project. Going through the process of identifying, quantifying, and valuing the wide range of benefits provided by NbS can help justify the investment and potentially raise the governmental budget allocation. In addition, NbS can offer private benefits and stimulate additional revenue streams that can be privatized and used to offset the project cost. As such, there are still important roles for the private sector and opportunities for collaboration to deliver both public and private benefits.

Three main sources of funding exist for water-related infrastructure, including gray, green, and blue solutions for urban flood management (figure 5). Differentiating among these three sources helps unlock an understanding of funding sources generating cash flows to leverage repayable sources of financing. This differentiation also helps distinguish among sources of direct funding by end users, indirect funding from governments or their agencies, and funding from private sources of finance. The three main sources are:

1.
TAXES

A source that comes from the government through the general budget or a dedicated tax to help pay for a service within its jurisdiction. For example, a municipal or state government may fund a department to provide flood management services.

2.
TRANSFERS

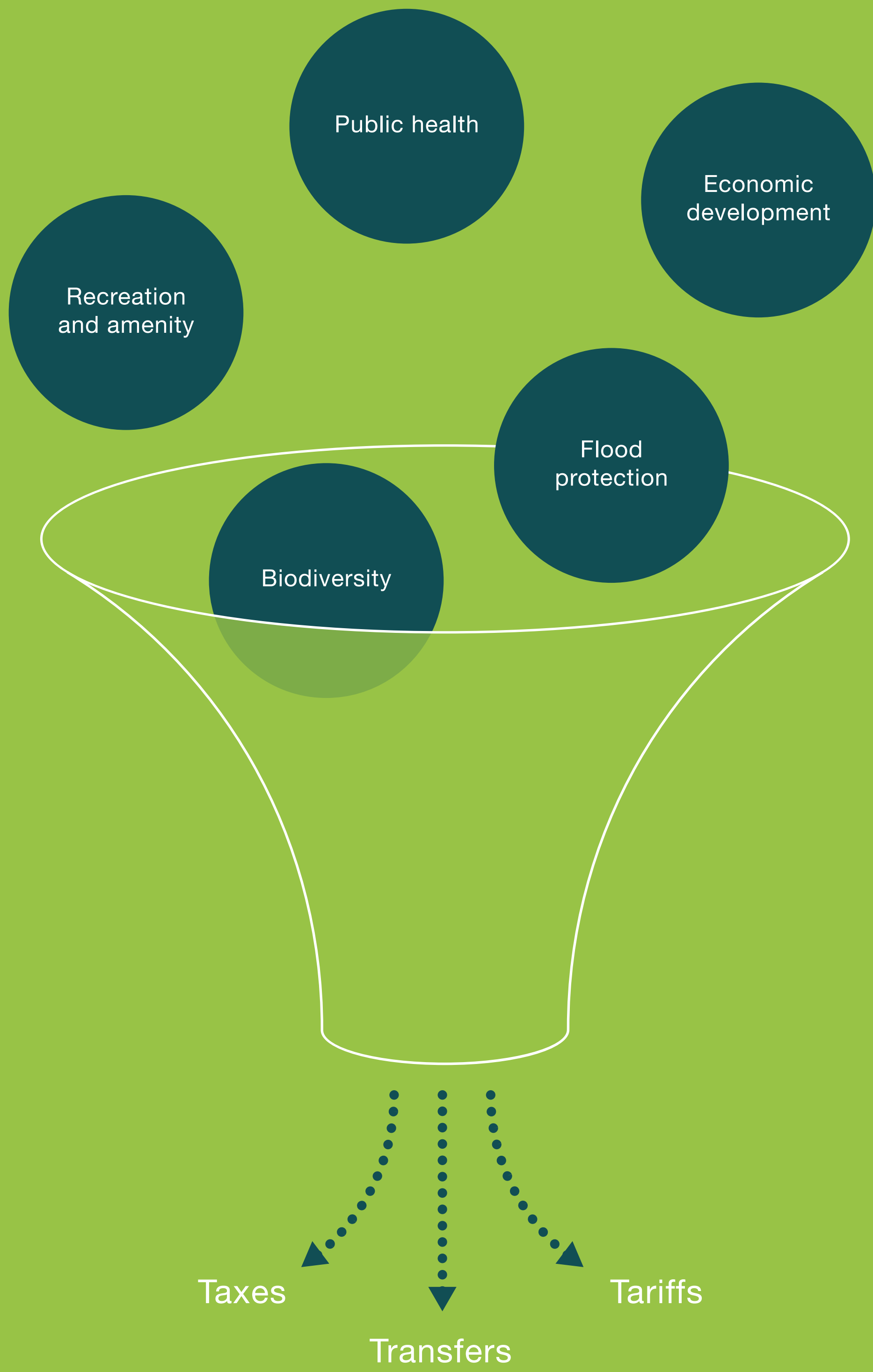
A source that comes from outside the government that is providing the service. For example, a state government may receive a grant from the federal government or an international development agency.

3.
TARIFFS

A source that comes from users paying for a specific service. For example, power companies charge customers for the electricity used, or water companies charge for the quantity of water provided.

figure 5

Considering Project Funding Options



Distribution of costs and benefits

Understand the project's direct and indirect benefits and costs across time, geography, and stakeholders.

Who should pay?

Establish a benefit-cost allocation principle (e.g. polluter pays, beneficiary pays, capacity to pay).

How should they pay?

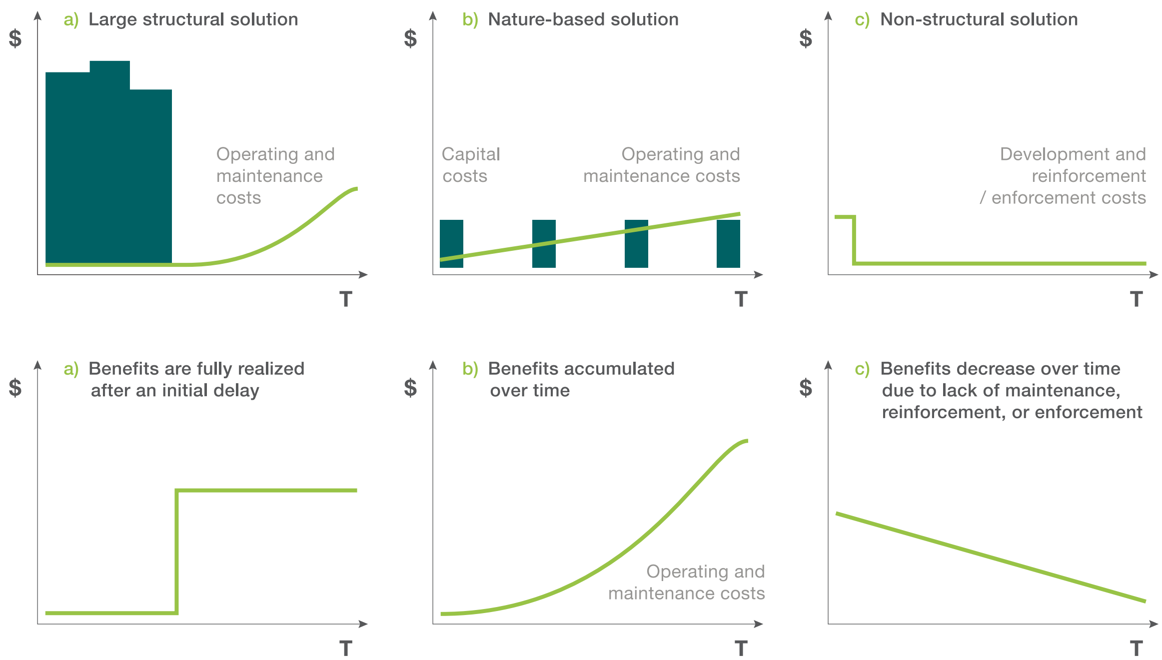
Determine the appropriate funding mix.

Several aspects of NbS and nonstructural solutions can affect the relative appeal of some forms and sources of funding and financing. Often, projects that would deliver a net benefit to the community do not proceed because they cannot secure the necessary resources. This may happen for several reasons, such:

- **Size of investment required.** The level of funding required for many solutions (particularly structural ones) is often significant, and it may well be beyond the local or even national government's capacity to support the project. This is particularly the case in low- and middle-income countries.
- **Scope of investment required.** Effective implementation often requires action by many stakeholders across time. The more coordination needed, the higher the transaction costs and the greater the risk of one partner walking away, unravelling the financing and funding arrangements.
- **Competing priorities.** Flood management often involves up-front investment for long-term projects with uncertain benefits. However, the urgency of short-term issues often crowd out long-term projects and acute events override chronic risks, especially in resource constrained environments.
- **Inability to sustain benefits and funding.** Financial support is often easy to obtain after a flood event. But realizing the full benefits of IUFM projects over time requires sustained funding. Infrastructure must be maintained and renewed over time so that it delivers the promised functionality day to day (for example, maintaining the amenity provided by parks used as retention basins) and during peak events (for example, reducing litter and cleaning drains so that they convey large volumes of water during a flood). Governments and development agencies may provide up-front capital support for construction without ensuring that beneficiaries have the financial or technical capacity to maintain an asset over its useful life.
- **Ensuring a fair distribution of costs and benefits.** The costs and benefits of IUFM projects are distributed across stakeholders, geography, and time. They also often have a significant public good component; that is, the benefits of flood management are often nonexcludable. The challenge is to ensure that those who benefit also bear an equitable share of the costs. BCA can provide insights into the most efficient means of achieving an outcome. It can also make the distribution of costs and benefits transparent, but it cannot judge if that distribution is fair. Ultimately, the distribution of costs and benefits is a decision for the community concerned (or the community's representatives). It is often more complex to identify who benefits, and hence, who should pay for NbS. Projects in which NbS are used are often multipurpose projects involving a wider range of sectors and stakeholders. This creates several additional challenges in bringing together funding from different sectors and requires a higher degree of facilitation than relatively simple single-sector, one-dimensional projects.

Nature-based and nonstructural solutions have different cost, risk, and benefit profiles than conventional structural flood protection responses, such as levees and dams (figure 6). These differences can also affect the cost and appropriateness of different financing options. For example, nature-based projects are often smaller in scale, they can involve lower initial capital investment, and they are more "scalable." Thus, they may have a lower financing requirement, and investments can be staged as nature-based projects that are prioritized and rolled out over time.

figure 6 / **COST AND BENEFIT PROFILES OF DIFFERENT TYPES OF FLOOD INTERVENTIONS**



A wide range of financing instruments exist for NbS in cities and include the following:

- Public budgets
- Grants and donations, including development funding, philanthropic contribution, crowdfunding, and so on
- Revenue from land sales or leases, user fees, or voluntary contributions from beneficiaries
- Green finance, including loans from public or private financing institutions, and green bonds, among others.

Other innovative financing instruments with potential include the following:

- Business development districts or tax increment financing districts (box 5)
- Market-based mechanisms, such as credit-trading systems and payments for ecosystem services (box 6)
- Revolving funds
- Public-private partnerships (PPPs) or state-owned enterprise-public partnerships
- Community asset transfers.

box 5 / **BUSINESS IMPROVEMENT DISTRICTS AND TAX INCREMENT FINANCING DISTRICTS**

Type: Public financing
Public financier(s): Localized tax
Private financier(s): N.A.

Originally developed in Canada, a business improvement district (BID) defines a geographical location where local stakeholders oversee and fund the maintenance, improvement, and promotion of a designated area. Stakeholders within a specific area enter an agreement with the local government to contribute an additional levy to finance improvements in this area. Such a model also has facilitated financing of nature-based solutions (NbS) for integrated flood management.

One of the first such BIDs is the Lower Don Valley Flood Defence Project in Sheffield, United Kingdom. The project aims to improve flood defenses at more than 50 locations along an 8-kilometer stretch of the River Don, helping to protect more than 500 businesses and thousands of jobs and ensuring that the valley remains an attractive place for new investments. The funds go toward building flood defenses and maintaining green infrastructure, such as constructed wetlands. The BID applies an annual levy based on businesses' expected benefits from those projects. A higher levy rate of 2.25 percent per year applies to businesses expected to receive the greatest flood protection from the scheme, and a lower annual rate of 0.75 percent applies to businesses that would benefit significantly but to a lower extent.

Similarly, a tax increment financing (TIF) district is set up when tax revenues going to general city services are frozen at a certain rate in the base year. All additional tax revenues (normally because of property value appreciation) directly fund new development or service debts related to new development until the end of the TIF period, which usually lasts 20 to 30 years. For example, a TIF has been used as a special funding tool by the city of Chicago, United States, to promote public and private investments across the city.

Source: Sheffield Chamber of Commerce and Industry 2013.

box 6 / **STORMWATER RETENTION CREDIT TRADING**

Type: Government regulations
Public financier(s): N.A.
Private financier(s): Stormwater retention credit purchasers

In 2013, the Washington, DC, Department of Energy and Environment (DOEE) introduced standards requiring new developments larger than 5,000 square feet to install green infrastructure, such as green rooftops, to reduce stormwater runoff. Developers in the US capital are required to meet 50 percent of their water retention requirements onsite. For the remaining 50 percent, developers may purchase stormwater retention credits from others in the city who have either voluntarily installed green infrastructure on unregulated sites or have exceeded their retention requirements on regulated projects. The DOEE certifies the stormwater retention credits for up to three years, and sellers are responsible for maintaining the green infrastructure projects, which are subject to DOEE inspections.

To reduce the investment uncertainty for credit generators, DOEE has also introduced a price lock mechanism for the stormwater retention credits. As a buyer of last resort, DOEE agrees to purchase credits from the sellers at a price lower than the market price. This encourages the sellers to sell their credits on the market but also provides them with some certainty that their investment will bring them reasonable returns.

More than 650 transactions occurred from 2014–19 at an average market price of US$1.82 per credit, which is attractive compared with the equivalent installation fee of US$3.61 as of 2017, estimated by DOEE.

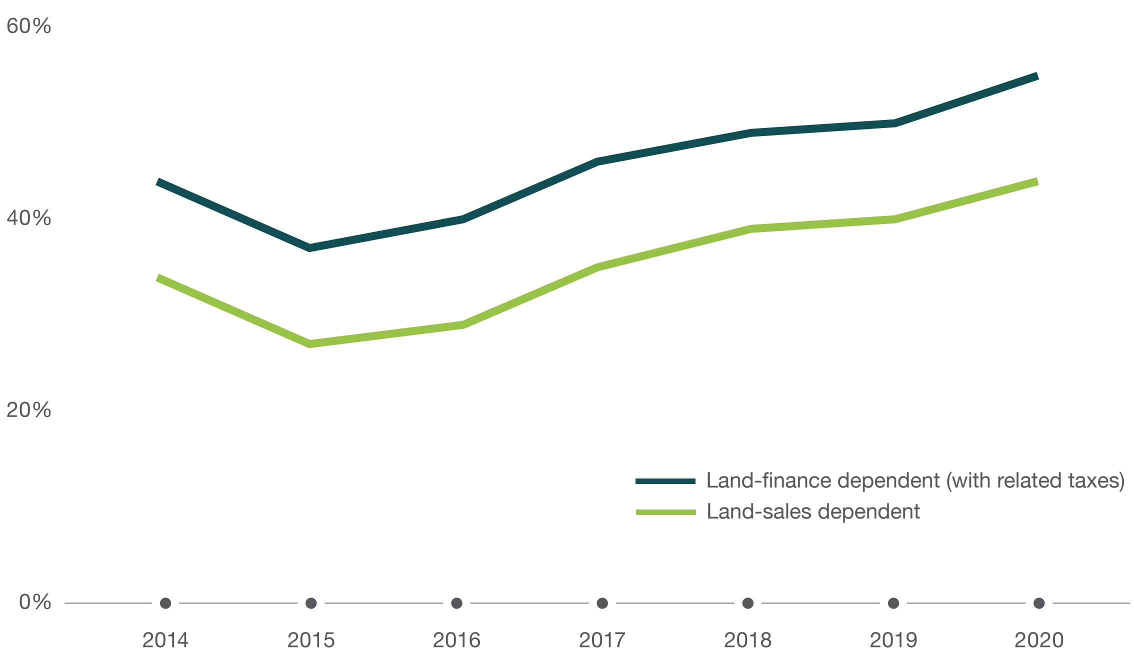
Source: Odefey et al. 2019.

A series of documents have been developed to provide general guidance on the financing of sponge cities. The China Development Bank and the Ministry of Housing and Urban-Rural Development issued the notice “Promoting the Development Finance to Support the Construction of Sponge Cities” (no. 208 [2015]), which outlines the role of development financing in supporting the construction of sponge cities. It provides details of the project pipeline, credit support, and coordination mechanisms. Similarly, the Agricultural Development Bank of China and the Ministry of Housing and Urban-Rural Development jointly issued “Notice on Promoting Financial Support for Sponge City Construction” (no. 240 [2015]) on the project reserve system, credit support, innovations using public-private partnership (PPP) financing models, and measures to strengthen policies for financial support of sponge urban construction. The “Guidance on Promoting the Construction of Sponge Cities” issued by the State Council of China (no. 75 [2015]) specifically requires sponge city pilots to promote PPPs to attract private sector and the participation of social capital.

Several considerations and conditions determine if a project attracts private sector financing. They include:
- Generation of sustainable revenue streams
- Ability to ensure sufficient collateral
- Probability of success and associated risks
- Acceptable risk-adjusted rate of return
- A clear exit strategy
- A clear concept and proven track record.

Given the challenges, financing and funding of infrastructure and services to support China's urban growth have relied heavily on government contributions. Subnational governments (that is, provincial governments, municipal governments, and counties and townships) have depended on a wide range of "off-budget" fees, charges, fines, and penalties on local business and households; monetization of state assets, in particular land; and the establishment of local investment corporations.[2] Although initially created as a vehicle for loans from international development organizations, these now play an important role as a means of financing investment in local urban infrastructure, including flood protection. Among these, land revenues have been a major source of local revenue. This is because income from land conveyances is not a part of the budgetary revenues and does not need to be shared with the central government (Ding 2003). To overcome restrictions on direct financing, many local governments established local government financial vehicles (LGFVs),[3] including Urban Development Investment Corporations (UDICs or Chengtou), and state-owned enterprises (figure 7). However, the heavy reliance on land-based financing can be problematic, and has led to overdevelopment of land in many municipalities. Further, it exposes local governments' fiscal health to volatility in land prices and inventory of land assets (Campanaro and Masic 2017).

figure 7 / **LOCAL GOVERNMENT REVENUE DEPENDENCE RATIO ON LAND FINANCE, 2014***



Source: MoF, cited by China Policy September 4, 2020, policycn.com.
Note: *2020 estimation.

2 The 1994 Budget Law prohibits subnational government from borrowing without explicit permission from the State Council. Local investment corporations were a way for subnational governments to secure investments.

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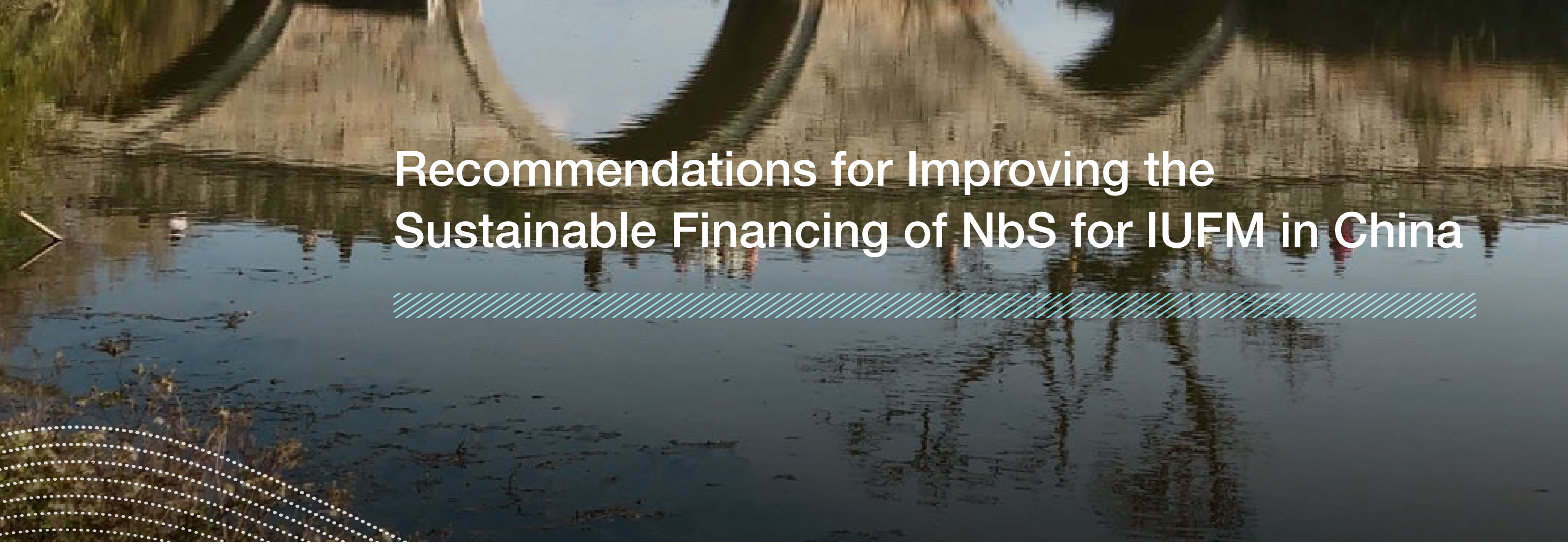


Recommendations for Improving the Sustainable Financing of NbS for IUFM in China

The range of financing options to support NbS for IUFM are informed by the values associated with the direct and indirect benefits. These are typically context specific and informed by the level of social and economic development, as well as exposure to floods. Given the diversity of urban conditions in China, the realization of these values and the appropriate financing instruments will be further informed by both the affordability and collectability of the associated revenue streams. Where these are limited, public instruments and concessional funding will continue to be essential for promoting NbS for IUFM and leveraging private flows. However, the diversity of determining characteristics across the urban landscape in China creates a range of opportunities for various policy instruments and financing options, particularly in higher-income urban areas. Blended financing options can facilitate the transition of middle-income urban areas toward greener development models with increasing contributions from a diversity of financing sources.

Many investments in NbS present unique risks because of their cash profiles that limit access to private financing and social capital. Successful mobilization of private financing and social capital requires certain conditions, including a sizable market for such projects, a good return on investment (compared with alternative investments), and a limited amount of risk (or risk that can be managed without too many complications). Within this context, the major challenges associated with mobilization of private sector financing and social capital for sponge city construction in China are widely recognized as the following:

- Large scale and long cycle of investment and construction costs
- Lack of clear and sustainable return mechanisms or revenue streams that rely heavily on government or user payments without long-term income guarantees
- Inadequate risk-sharing mechanisms in the absence of a comprehensive set of laws and regulations on PPPs (Zhang and Zheng 2019).

In order to leverage a wider range of potential sources of private financing and social capital, there is a need to provide a more systematic and comprehensive framework for policy makers, investors, and practitioners to identify and evaluate the wide range of tangible and intangible environmental, social, and economic benefits derived from NbS associated with IUFM. Investments in hybrid infrastructure that bridge the continuum from gray to green and incorporate blue considerations require country-specific policies and instruments led by the public sector and tailored to local conditions. The following recommendations outline a framework for facilitating sustainable funding mechanisms and appropriate financing options to realize those values in support of building an ecological civilization in China.

1

Improve the Recognition and Valuation of Benefits Provided by NbS for IUFM

Improving access to appropriate financing requires a robust approach to project preparation and appraisal over the entire life cycle. This should include appraising fiscal affordability, assessing social and environmental aspects, identifying risks, determining financial viability by comparing public and private options, and sounding out the market. This should include identifying the full range of benefits derived from NbS and the values associated with each of the benefits, in addition to adopting innovative technology and striving toward environmental and social sustainability, resilience against natural disasters, and governance to assure transparency in procurement and robust institutions. It is particularly important to identify all beneficiaries and to show the distribution of benefits among stakeholders and beneficiaries. Investments aligned with these principles will support the value-for-money proposition, help extend the life of the infrastructure asset, and increase returns on investment. To do so, a comprehensive database of values associated with the each of the benefits to be derived from NbS for integrated urban flood management should be developed.

2

Enhance the Policy, Institutional, and Regulatory Framework

The national government should implement fiscal policies to improve incentives for NbS for IUFM. These policies should improve targeting of public resources through performance-based subsidies and conditional transfers as well as through interest rate support and tax incentives to stimulate demand. China has issued a large number of departmental regulations and documents, but the legal basis is not sufficiently robust. Departments and governments at all levels have different interests, demands, and administrative processes, resulting in contradictions and operational difficulties in realizing policy intentions. The national government should accelerate the formulation and issuance of specific financing laws and regulations related to sponge cities. For example, there is a need to clarify risk-sharing mechanisms for PPPs to increase confidence among private sector investors. Provincial and municipal governments should establish water management entities with dedicated offices for guiding the planning and implementation of sponge cities as core components of IUFM. This would help unite management and supervision of urban water-related administrative affairs, avoid fragmentation of departments and authorities, and promote coordination among departments and levels of government. Given variations in climate, geography, and hydrological conditions, each city in China should be encouraged to develop context-specific guidance that best fits its socioeconomic and natural environmental conditions (Sun 2019).

3

Improve Targeting of Public Funds for NbS for IUFM

Public financing will continue to play an important role in developing hybrid solutions and funding blue and green infrastructure. In addition to setting policies that enable investments in NbS for IUFM, government will continue to have an important financing role. There are a range of sources of public funding, including general revenue along with such dedicated revenues as levies on water-related services, that can be directed toward financing NbS. The performance of government funding can be improved through targeted performance-based subsidies and conditional transfers for national priority programs. Strengthening arrangements for managing performance expectations, providing support for improvements, and monitoring progress can go a long way toward rewarding performance, creating positive incentives for facilitating fiscal transfers, and improving accountability for results. Such incentives can also shift expenditures from postdisaster responses to more cost-effective preventive measures, such as incorporating NbS into integrated urban planning and integrated spatial planning at the catchment scale. The advent of machine learning provides opportunities for mapping city-scale landscapes to a typology of urban characteristics that can provide the foundation for a performance-based investment framework applicable to NbS for IUFM.

4

Use Market Mechanisms to Promote NbS for IUFM

A range of regulatory measures can promote market-based approaches and create positive incentives for investing in NbS for IUFM. Systems for trading stormwater rights have emerged as one such area; the government allocates rights to users and allows free trade between owners of these stormwater rights. Such regulations typically include onsite retention or detention requirements for new development and redevelopment projects above a certain size. For example, Kunshan municipality issued a regulation in 2013 requiring all new development to apply NbS, thus laying the foundation for establishing stormwater rights that could be traded if a proper market is established. Urban planners in Shenzhen are also gradually introducing a system for stormwater management charges and trading of rainwater discharge rights. The “Planning Guidelines of Rainwater Utilization System in Shenzhen” requires 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 (see box 7). Where land developers are identified as major beneficiaries, specific requirements can be used to encourage commitments in investing in NbS, such as linking higher floor-area ratios to commitments by developers to invest in NbS. Such regulations provide opportunities for promoting NbS by enabling property owners or developers to meet a portion of their obligations by buying volume-based “credits” generated through blue and green investments in offsite NbS. To succeed, such initiatives require a strong regulatory foundation and 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.

5

Establish a Revolving Fund for NbS Investments for IUFM

A dedicated revolving fund could guide investments and make affordable credit available to support blended financing solutions. The fund could be established as a window under the National Green Development Fund established in 2020 (see box 8) with a specific focus on NbS. This would allow the close coordination of NbS investments with other green projects and leverage the full range of cobenefits and environmental outcomes. Advantages of a guiding fund include:

- Risk-sharing between the government and partners and investors to help build confidence
- Leveraging comparative advantages of the private sector, government, and financial institutions and more effectively integrating technical, administrative, and financial resources (An 2016)
- Transparency in definition and distribution of benefits to meet expectations of different shareholders
- Flexible and diverse exit methods, including project liquidation exit, equity repurchase/transfer, securing of assets, and so on, which would eliminate investors' concerns about the long investment cycle.

National regulations provide for such mechanisms. The approved trust scheme establishes the trust company as the trustee, which can issue infrastructure investment certificates to the public to raise trust funds. The trustee can then use the proceeds to invest in nature-based investments associated with the sponge city initiative in accordance with the approved trust scheme and national regulations (figure 8).

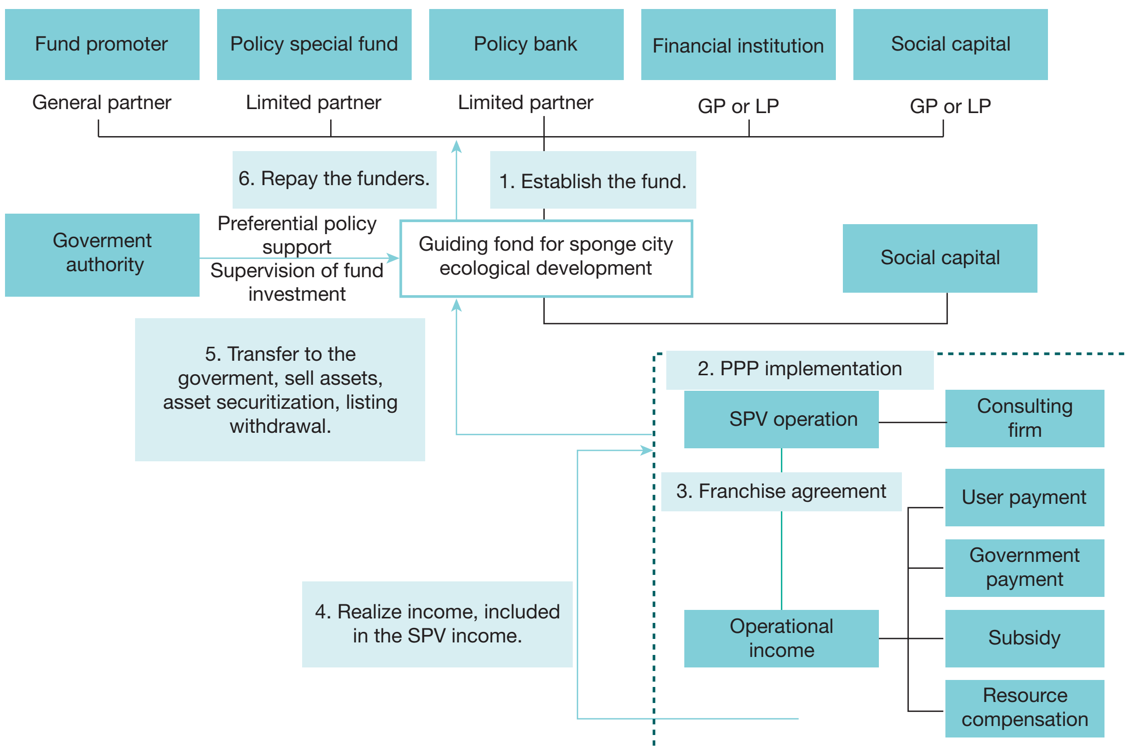
box 7 / THE FIRST STORMWATER PURCHASE AGREEMENT IN CHINA

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 since utilized 0.5 million cubic meters of rainwater, which amounts to 2 percent of the total rainwater during the past 6 years, which means there is still large potential for rainwater utilization.

Source: Changsha Evening News 2020.

figure 8 / **SCHEMATIC OF A GUIDING FUND FOR FACILITATING PPPS TO BUILD SPONGE CITIES**



6

Issue Green Bonds Targeting NbS for IUFM

The emerging green bond market has the potential to help mobilize financing for NbS within the urban context, particularly in areas with strong revenue streams. The green bond market has grown more than tenfold since 2013, with US$389 billion in labeled green bonds issued in 2017, with China recognized as a global leader since introduction of its Green Credit Policy in 2007. This provides a comprehensive policy, including specific provisions for monitoring and evaluation (IFC 2018), that can further contribute to mainstreaming NbS for IUFM. The Green Credit Guidelines issued by the Banking Regulatory Commission in 2012 and the Green Credit Statistics System introduced in 2014 attempt to define green credit (including a tool for monitoring environmental benefits). The People's Bank of China subsequently required bond issuers to refer to the China Green Bond Endorsed Project Catalogue, which lists six categories (31 subcategories) of projects eligible for financing via green bonds. Although the use of bonds has been limited in the financing of sponge cities, the green bond market has developed rapidly, reaching about US$7.1 billion (RMB 260 billion) in 2016. The number of issuances doubled in 2017, with a similar scale, providing promise for investments in NbS associated with sponge cities. In May and October of 2018, the Urban Development Company (Chengtou) of Anji county in Zhejiang province issued two Sponge City Green Bonds of RMB 0.5 billion each, both with a 7-year tenor period, specifically for investments in the construction of a sponge city demonstration zone in the eastern part of Anji county.

box 8 / CHINA GREEN DEVELOPMENT FUND COMPANY, LTD.

The National Green Development Fund Co., Ltd was established on July 14, 2020 with a registered capital of RMB 88.5 billion. The scope of the Fund includes general equity investments, project investments, investment management, and consulting on green development, including environmental protection, pollution reduction, and energy resource conservation, among others. It aims to generate replicable and scalable experiences for green development, particularly in the Yangtze River Economic Belt (YREB).

The Ministry of Finance is the largest shareholder with a ratio of 11.30 percent. The second largest shareholders are the China Development Bank; Bank of China Co., Ltd.; China Construction Bank Co., Ltd., Industrial and Commercial Bank of China Co., Ltd.; Agricultural Bank of China Co., Ltd.; each holding 9.04 percent; the third largest is Bank of Communications Co., Ltd. with a shareholding ratio of 8.47 percent. The provinces, related departments and agencies in the YREB are among the fund promoters.

Source: Ministry of Finance of the People's Republic of China 2020.

7

Compared with traditional credit mechanisms upon which sponge cities rely, green bonds have several advantages, including low yields, which can effectively reduce the cost of financing. They also lend themselves to promoting green industries because of their long bond cycles that allow for more effective management of the asset maturity mismatch of upstream banks. However, most green bonds are issued by banks, and the average tenor of issuances is still between three to five years, which may be too short for investments required to support NbS for IUFM. Lengthening the tenor of such bonds will require the entry of institutional investors such as pension funds and insurance companies. These kinds of institutional investors are typically not familiar with NbS for IUFM, so efforts are required to sensitize the concept of blue investments and to develop standard guidelines. Further, comprehensive assessments of the environmental and ecological benefits of sponge city investments before and after the issuance of green bonds are required to meet the identification needs of investors. The methodology established in this report can be used to facilitate such approaches.

Develop Special Asset-Backed Programs to Leverage Future Revenues from NbS for IUFM

Asset-backed programs provide an opportunity to finance NbS for IUFM by taking future revenues from underlying investments and financial subsidies from PPPs as the basic assets to secure financing (figure 10). Such approaches allow the pooling of smaller, often illiquid individual assets to make them marketable to potential investors. The advantages of asset-backed financing programs include the following:

- Investors pay more attention to the future income of the project, and the issuer does not need to pay dividends or interest in the short term, which can effectively save cash flow and reduce the cost of financing.
- Effective adjustment of the debt structure reduces the scale of debt and improves the level of asset liability management and capital operation efficiency (He 2019).

Such approaches in China have leveraged the rights to receive service fees in connection with wastewater treatment projects, and they could work for investments in NbS for IUFM. Typically stand-alone investments in NbS for IUFM cannot generate sufficient cash flow from individual benefit streams, but together, they can create an asset-backed security marketable to potential investors for the mobilization of resources (see figure 9).

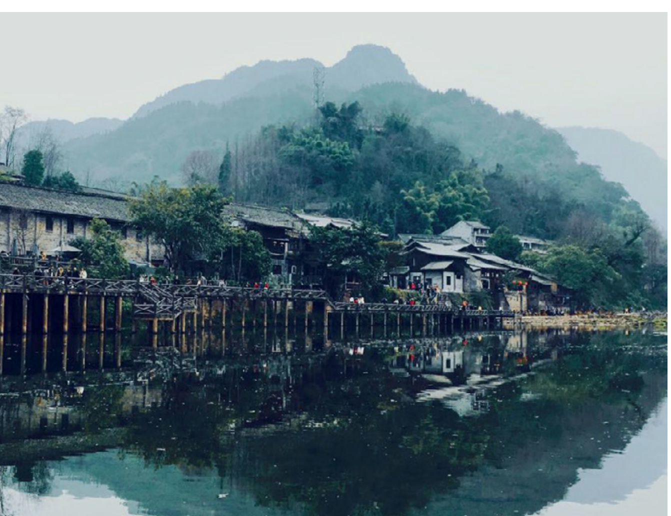
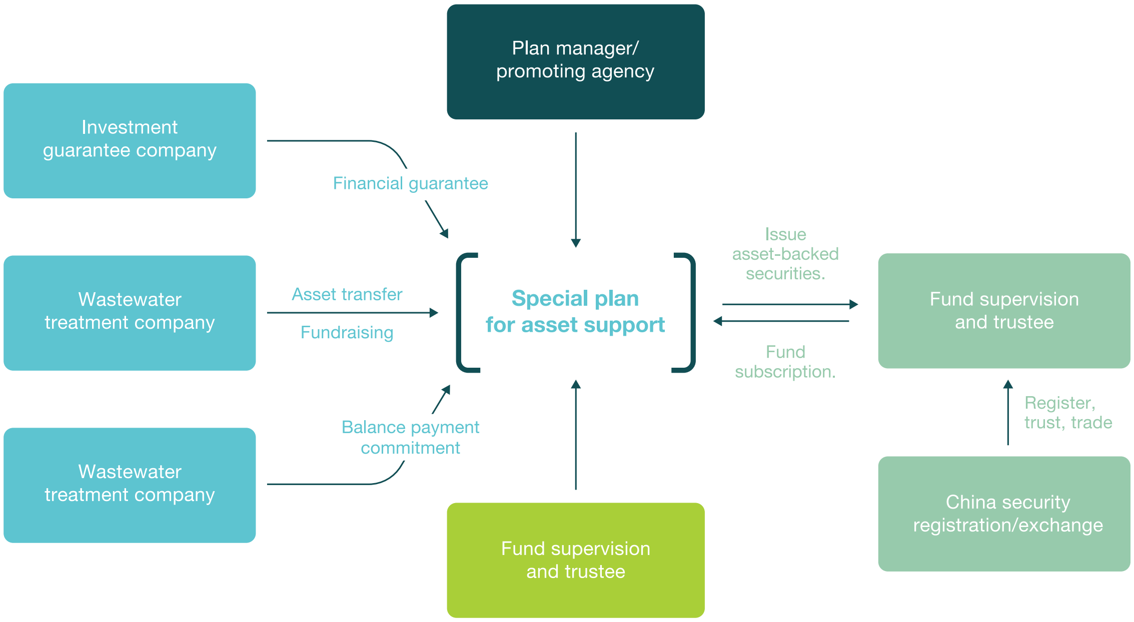


figure 9 / **SCHEMATIC OF A POTENTIAL ASSET-BACKED PLAN FOR NATURE-BASED SOLUTIONS FOR IUFM**



8

Improve Flood Insurance and Risk-Sharing Mechanisms

Flood insurance provides another potential source that could play a more significant role in improving the efficiency and effectiveness of responses to flood events in China (Jiang, Zevenbergen, and Ma 2018). Although there have been several flood insurance pilot projects since the 1980s (Walker, Lin, and Kobayashi 2009), flood insurance remains limited and disaster response continues to rely heavily on government funding. For example, only 2 percent of the damage caused by the July 2016 floods are thought to have been insured, compared with an average of 70 percent of homes covered in the United States (Liu 2016). Where flood insurance is available in China, it is often part of general property insurance, and although several commercial agricultural insurance schemes include flood insurance, these are usually limited to specific locations in high-yield areas where the risks are well understood. Experiences from these pilot programs reflect global experience, demonstrating that flood insurance is most effective when the following occur:

- Insurers can assess the risk (including assessment through access to flood data), and they have confidence in the regulatory framework and the effectiveness of mitigation measures.
- Insurance purchasers can accurately assess their risk and undertake mitigation measures with appropriate insurance products available to cover the residual risk.
- The risk pool is deep enough (for example, through a national scheme or access to reinsurers).

The relatively underdeveloped nature of China's insurance market makes it unlikely that insurance companies will develop such products in the absence of strong demand. Such demand is limited by the high cost, particularly in high-risk areas. As such, China should consider establishing an insurance facility for flood-related risk. This facility could develop a nationwide flood disaster risk pool and serve as a platform for developing and implementing financing solutions for risks associated with disasters.

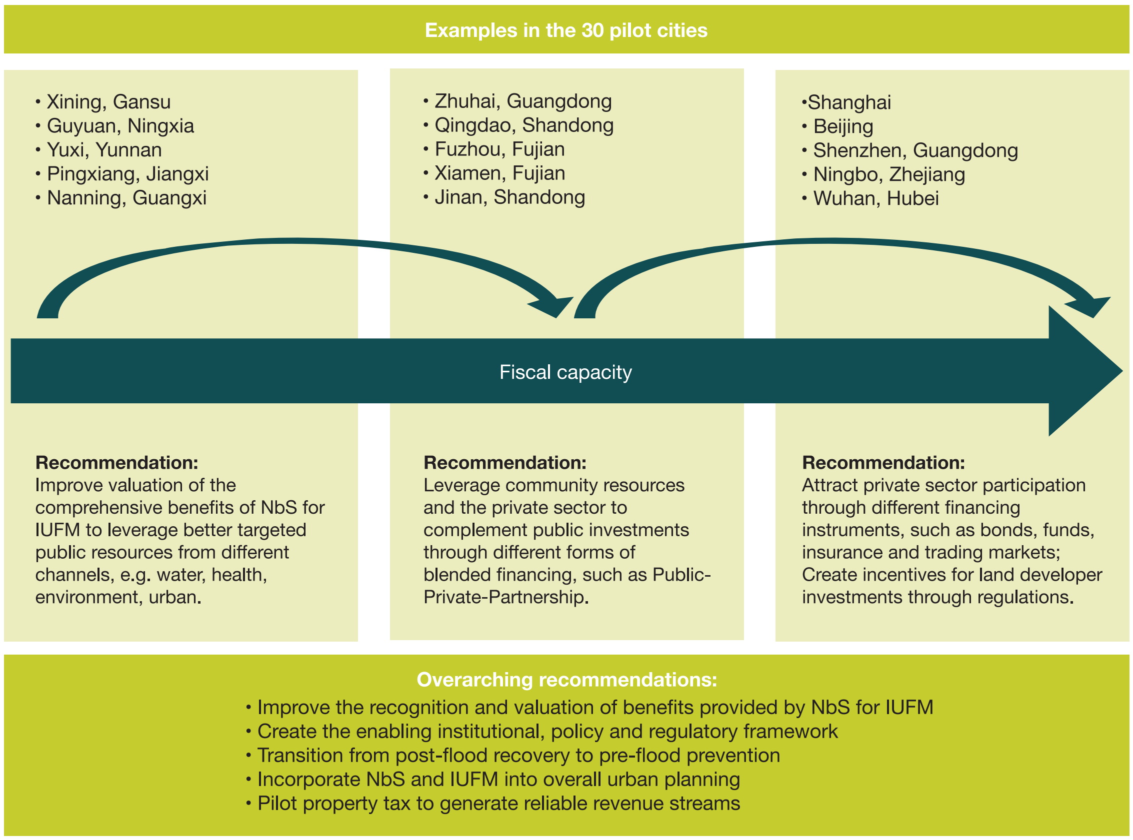
The Way Forward

The future success and scale of China's sponge city program and the promotion of NbS for integrated urban flood management will require an appropriate mix of sustainable funding and appropriate financing sources. Recurrent market value-based property taxes typically provide effective revenue streams for local government investments because they are closely tied to public service delivery through property values, their base is immobile, and they are highly visible, which can improve accountability of local officials. However, the experience with property taxes in China remains limited to a few pilot cities, and there is a need to explore other measures for generating local revenues in support of NbS for IUFM. Given the diversity of urban conditions, a range of funding and financing options could be targeted and tailored to local conditions.

Determining the appropriate mix of funding and financing will rely on the affordability and collectability of associated revenue streams. Where these are limited, public funding will continue to be essential for the investment in public goods associated with many of the benefits derived from NbS for IUFM. However, the deployment of government funding can be improved through an appropriate mix of public funds, structured incentives, and specific policy instruments to promote the inclusion of NbS for IUFM and the participation of private financing and social capital along a continuum. These measures include leveraging government funds as cost-share, targeting performance-based subsidies and conditional transfers, adopting regulatory measures to promote market-based approaches, creating positive investment incentives, establishing special project vehicles that can issue dedicated bonds marketed to institutional investors, pooling investments across project beneficiaries and promoting new asset-backed instruments, developing blue infrastructure guidelines for the green bond market, and engaging insurance companies in developing appropriate products along with the establishment of flood risk insurance facilities to develop a nationwide flood disaster risk pool.

There is increasing recognition of many of the direct and indirect cobenefits that can be derived from NbS for IUFM. However, the value of these derived benefits are not well captured by traditional approaches to project economic analyses. Improving the methods to fully identify and account for the changing values associated with the benefits derived from NbS for IUFM will help increase the sources of funding and options for financing, improve long-term sustainability and increase the liveability of urban environments, facilitating the transition toward greener development models (figure 10).

figure 10 / **RECOMMENDATIONS TAILORED TO LOCAL CONDITIONS TO IMPROVE FINANCING FOR NBS FOR IUFM**



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CRC for Water Sensitive Cities
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