Water-sensitive transformation of secondary and tertiary cities

A guidebook for practitioners and decision-makers

POLYURBAN WATERS

Published by
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This publication is an output of the research project “Polycentric Approaches to the Management of Urban Water Resources in Southeast Asia – A Localization of the Sustainability Goals of Agenda 2030 and the New Urban Agenda at the City/Municipality Level”
www.polyurbanwaters.org
(PolyUrbanWaters, 01LE1907A1-C1)

This project is sponsored by the German Federal Ministry of Research, Technology and Space (BMFTR) as part of the FONA program Sustainable Development of Urban Regions (NUR) and managed by the German Aero Space Center (DLR)

Front page image (Source: istock. pipop_Boosarakumwadi)

Back page image (Source: PUW Own Work, 2023)

Citation:

Gutterer, B. (2026). *Water-sensitive transformation of secondary and tertiary cities. Polycentric Approaches to the Management of Urban Waters: A guidebook for practitioners and decision-makers,* BORDA e.V.

With funding from the:

Federal Ministry of Research, Technology and Space

FONA
Climate Research

Sustainable Development of Urban Regions

Water-sensitive transformation of secondary and tertiary cities

Polycentric Approaches for the Management of Urban Waters

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1.1. Foreword

The achievement of sustainable development is largely decided in the cities. Cities represent the future of global living. The world's population reached 8 billion in 2022, over half living in urban areas. The United Nations' 2030 Agenda for Sustainable Development, adopted in 2015, encompasses 17 Sustainable Development Goals (SDGs). Many of these goals are directly linked to urban development challenges. For instance, SDG 11 focuses on transforming cities and communities into more inclusive, safe, resilient, and sustainable places. Other SDGs like Climate Action (SDG 13), Clean Water and Sanitation (SDG 6), Reduced Inequalities (SDG 10), and Responsible Consumption and Production (SDG 12) also have significant implications for urban settings.

As UNESCAP points out, the **Asia and the Pacific including Southeast Asia performs poorly on the environment related Sustainable Development Goals** especially in the field of Climate Action. This shortfall has profound implications for sustainable urban development. (UNESCAP, 2025)

Southeast Asia is witnessing rapid growth in terms of economic development, industrialization, and urbanization, making it one of the world's most dynamically developing regions. In public discourse, urban development challenges are often associated with major cities like Bangkok, Jakarta, and Singapore in terms of new lifestyles, impressive skylines and innovation.

However, **small and medium-sized cities in the region receive far less attention in the public's perception**, even though they are important focal points of economic, social, and cultural transformation across the region. In view of their dynamic growth and megatrends, such as climate change, these cities are facing major water challenges, yet they are hardly being addressed by largely sectoral approaches to urban water management.

Concepts such as **water-sensitive urban development are gaining increasing attention in urban planning and the management of urban water resources in Southeast Asia**. Nevertheless, it remains to be seen how such concepts can be comprehensively and effectively anchored in secondary and tertiary cities, especially in the context of the immense diversity of the economies and cities in the region, each with its own unique characteristics.

Polycentric Approaches to the Management of Urban Waters (PUW) aim to enable cities to strategically embark on a water-sensitive transformation necessary to strengthen their resilience and achieve their development goals.

This book presents experiences from around the world and Southeast Asia, empirically tested tools and examples of how cities may embark on such a transformation. In doing so, particular emphasis is placed on the results and experiences of the PolyUrbanWaters project (www.polyurbanwaters.org), which has been funded by the German Federal Ministry of Education and Research/German Federal Ministry of Research, Technology and Space since 2019.

The reader can learn how such processes are structured and what results may be generated. **Insights are supported with specific experiences of urban water challenges and how to respond to them**. These are intended to add to the discourse on how a successful embarkation on water-sensitive urban transformation may be organized and managed.

May 2025

1.2. Executive Summary

Many secondary and tertiary cities in Southeast Asia are increasingly confronted with **complex and pressing water management challenges**. The provision of water-related public services is often insufficient: safe drinking water is not reliably accessible, wastewater treatment is fragmented or non-existent, and frequent flooding has become a new normal in many urban areas. These challenges are exacerbated by rapid urban densification, which overwhelms existing water infrastructure while new systems are unable to keep pace with rapid urban growth. In addition, significant land use changes in upstream catchment areas are placing increasing pressure on regional water balances.

Urban expansion, frequently driven by a dominant and poorly regulated real estate sector, often occurs in the absence of comprehensive planning frameworks, pushing public institutions into a reactive rather than proactive role. **Climate change** further intensifies the situation through rising temperatures, a stronger urban heat island effect, more frequent and intense extreme weather events, and prolonged droughts, all of which increase vulnerability to floods, landslides, and water scarcity.

In this context, **low-threshold approaches to urban water management** offer promising entry points for cities to adopt a more proactive, adaptive, and inclusive stance. The Polycentric Approaches to the Management of Urban Waters (PUW) concept emphasizes flexible, decentralized, and multi-actor governance and provides an opportunity for secondary and tertiary cities to gradually build institutional capacities and establish integrated water management systems. These approaches are particularly suitable for cities with limited financial and administrative resources.

Several key developments should form the foundation for such a transformation. **Firstly**, there is growing awareness among decision-makers at local and national levels of the limitations of relying solely on grey infrastructure. Increasingly, the value of blue-green infrastructure—such as urban wetlands, river corridors, and floodplains—is being recognized for its multifunctional ecosystem services. **Secondly**, cities are becoming more open to integrated solutions that combine centralized and decentralized systems and blend grey infrastructure with nature-based approaches. However, these solutions must be critically assessed in terms of technical feasibility, cost-efficiency, and long-term maintenance. **Thirdly**, incorporating water-sensitive transformations into the expansion of municipal infrastructures—such as road systems, energy networks, and public spaces—provide multiple co-benefits potentially becoming key drivers of sustainable modernization and, consequently, improving the livability of cities. **Fourthly**, well-targeted elements of a water-sensitive transformation should become an integral part of urban planning and implementation processes—not only in the development of new residential areas, and the transformation and renovation of existing urban districts and peri-urban zones, but also by incentivizing the engagement and investment of businesses and private homeowners.

Strategies must be **context-specific** and reflect **existing governance structures, institutional capacity,** and **financing constraints**. Where a water-sensitive transformation is initiated, it can serve as a platform to develop more targeted strategies, including integrated flood management, climate change adaptation, water safety planning, urban sanitation, and disaster risk reduction.

PUW's experiences and insights show that certain steps are essential for the successful and sustainable implementation of such approaches. **Leadership** must come from the highest possible level of **local or provincial government** in order to enable cross-sectoral coordination and ensure integration into public administration. At the same time, early and continuous engagement with the **private sector** and **local communities** is crucial for building support for change.

Decision-making must be based on reliable and up-to-date information. This includes **baseline assessments**, **scenario modeling** of urban growth and climate impacts, and the identification of **strategic planning options**. Planning processes should, wherever possible and meaningful, be participatory and inclusive—engaging community groups, private sector actors, academia, and civil society organizations. Measures identified must be integrated into short-, medium-, and long-term planning frameworks. To maintain political and stakeholder momentum, early **tangible results**—typically in the form of infrastructure improvements—should be realized within two years. This underscores the need for solid, realistic, and quickly actionable project planning.

At the same time, it is evident that foundational conditions must be created to ensure long-term access to water-related public services and to enable a broader water-sensitive urban transformation. This includes the reform and strengthening of **regulatory frameworks**, such as clear mandates for public agencies in watershed management. It also requires **enhanced capacity** for the enforcement of planning and construction regulations, institutional development for the management of blue-green infrastructure, and the establishment of sustainable financing mechanisms. In this regard, **international development banks and agencies** are called upon to provide targeted support and contribute to building the necessary institutional and governance capacities.

1.3. What this book provides and how it may be used

This book provides:

- **Comprehensive Guidance for Decision-Makers, Practitioners and Scholars:** Aimed at national, city, and community leaders, the book offers cross-sector approaches to addressing urban water challenges, taking into account broader development dynamics and the impacts of climate change.
- **Provision of Comprehensive Information on Urban Development Challenges:** Explores the complex interconnections between urban growth, water management, infrastructure development, and governance schemes, highlighting key issues that cities face in achieving more sustainable urban development and management of urban waters.
- **Tools for initiating Water-Sensitive Transformation:** Presents empirically tested instruments and tools that can help initiate and implement water-sensitive urban transformation, based on informed decision-making processes.
- **A toolbox with Good Practices and Case Studies:** Shares insights into experiences and best practices from Southeast Asia, South Asia, South Africa, and Germany, demonstrating successful approaches to water-sensitive urban transformation.
- **Integration of Concepts, Tools, and Applications:** Combines theoretical approaches with practical tools and real-world examples to support cities in developing more water-sensitive urban areas.
- **Strategies for Planning and Implementation:** Provides planning tools and actionable strategies to guide cities towards sustainable and resilient water management, promoting long-term urban resilience.

This book can be used:

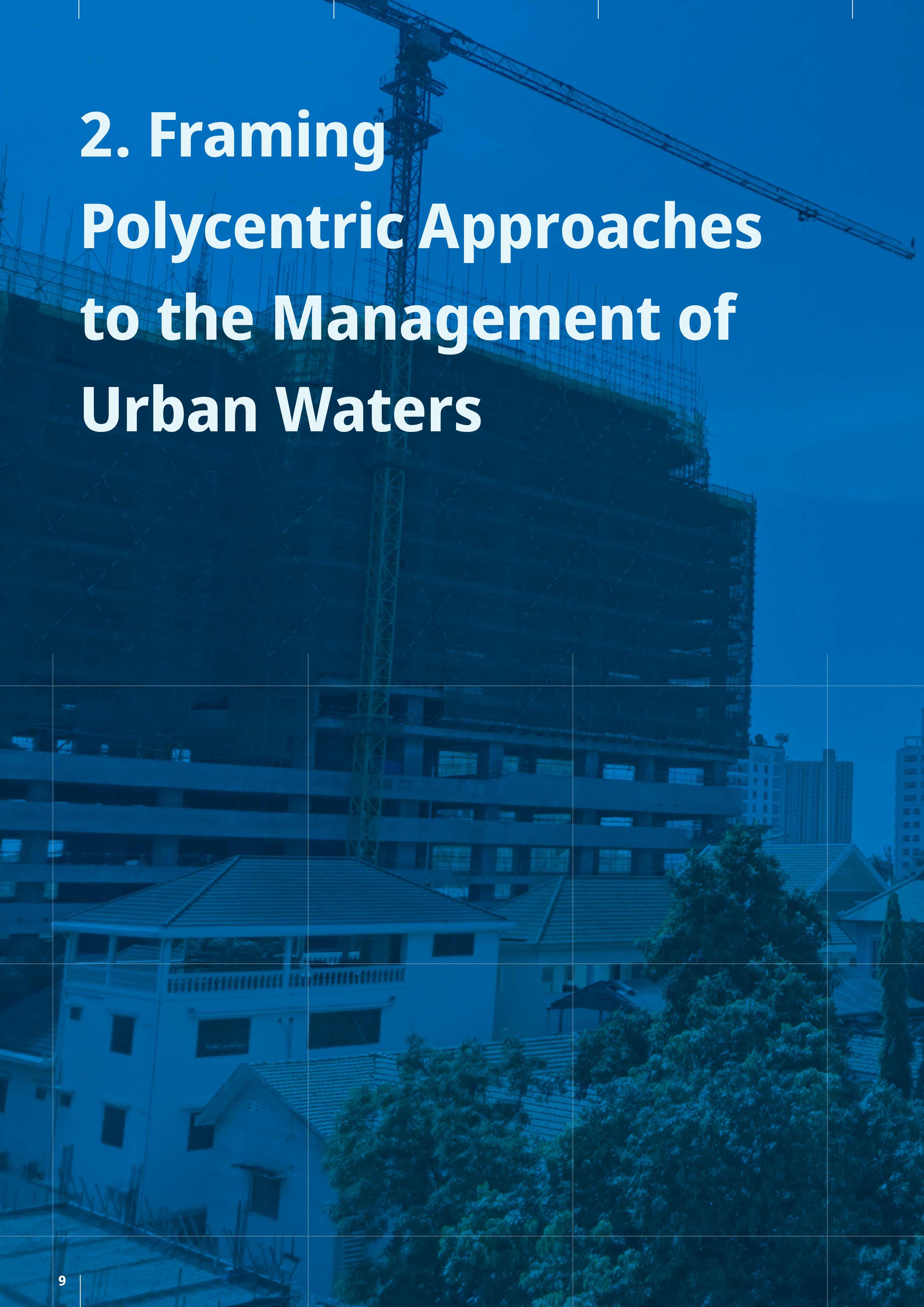
- **As Inspiration and Reference for Policy and Decision-Making:** Government officials, urban planners, and policymakers can utilize the book's insights to design and implement strategies for water-sensitive urban transformation that align with broader sustainable development goals.

- **For Capacity Building and Professional Development:** The book serves as an educational resource for professionals, practitioners, and researchers seeking to enhance their understanding of opportunities for water-sensitive transformation.

- **As a Guide for Urban Planning and Infrastructure Development:** Municipalities, city planners, engineers, and scholars can apply the frameworks and tools provided to improve urban water governance and infrastructure planning.

- **As a Practical Toolkit for Implementing Water-Sensitive Solutions:** Practitioners involved in urban projects can apply the case studies, methodologies, and tools provided to address water-related challenges in their local contexts.

2. Framing Polycentric Approaches to the Management of Urban Waters



Key Messages of Section

The concept of PUW considers "water" as a cross-cutting opportunity for the modernization and sustainable development of urban areas and settlements.

The PUW approach is based on the fact that every city has its own natural, cultural, socio-economic, and governance characteristics.

In its strategic dimension, PUW can assist cities and their stakeholders in several key areas:

1. Developing a comprehensive understanding of local urban development dynamics and water-related challenges through robust baseline assessments.
2. Identifying strategic areas for intervention to guide water-sensitive urban transformation.
3. Translating strategic priorities into concrete development plans at various spatial levels: city, district, neighborhood, or even sub-village.
4. Initiating the implementation of targeted projects and measures that serve as entry points for broader, integrated, and water-sensitive urban development.

This section of the guideline provides:

- A comprehensive overview of the concept of PUW and the key instruments that are elaborated in subsequent chapters of this guideline.
- An outline of how cities can initiate the change toward water-sensitive urban development by taking foundational steps and gradually enhancing institutional and technical capacities to address increasingly complex and strategic water challenges.
- A highlight of the core elements required to effectively shape and implement the PUW approach within diverse urban governance frameworks.
- Based on international good practices, examples of how PUW instruments have been successfully applied in various urban contexts, offering practical insights into their adaptability and effectiveness in different urban development contexts.

2.1. Approaches to the management of urban waters

2.1.1. The overall context

Many secondary and tertiary cities in Southeast Asia are confronting **complex** and **urgent water management challenges**. Essential tasks include securing water-related public services, implementing flood and stormwater protections, establishing effective disaster prevention strategies, and ensuring livable urban environments. Climate change further intensifies these issues: over the past 60 years, **temperatures in the Asia-Pacific region** have **increased faster than the global average**. (UNESCAP 2023b) Extreme precipitation events and related flooding occur frequently. (IPCC, 2022a)

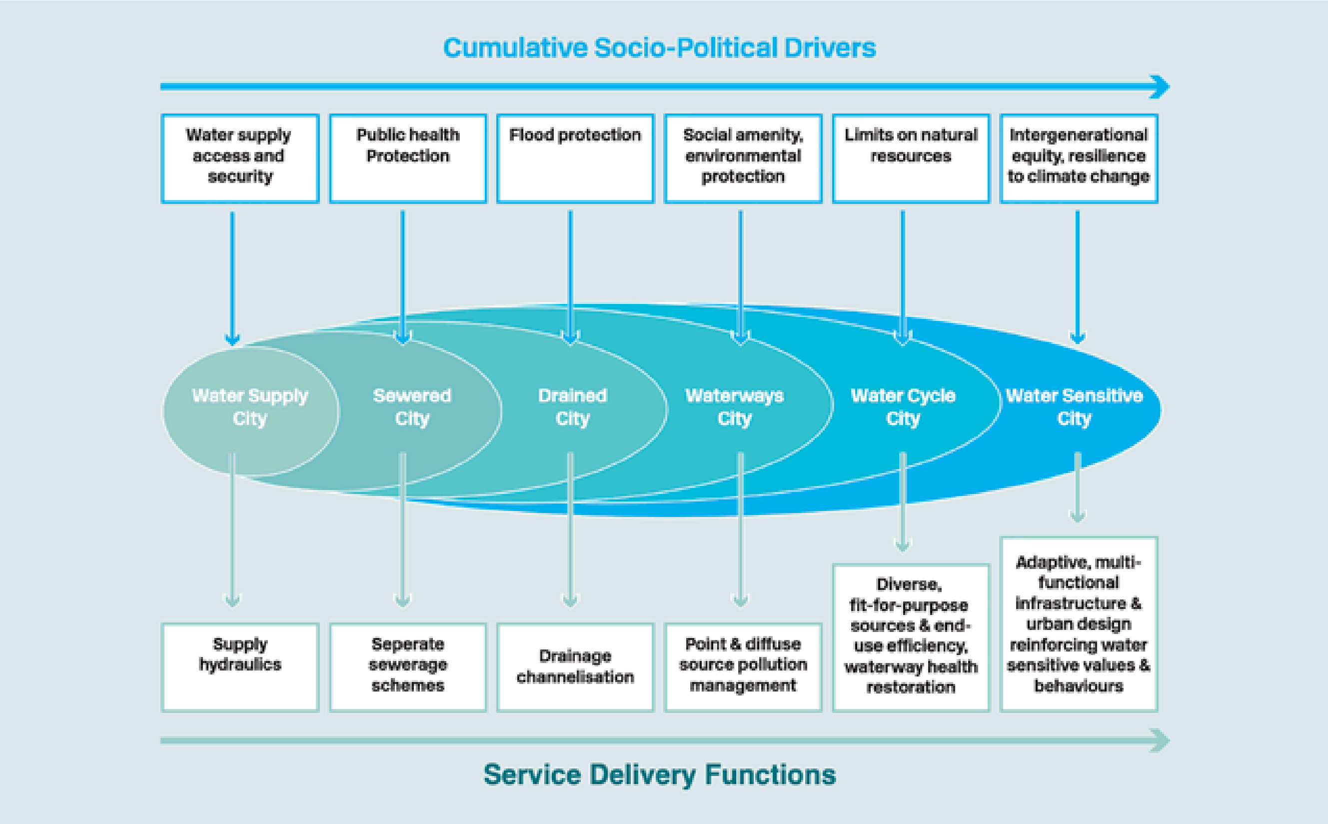
Rapid urban densification overstrains existing water infrastructure, and new infrastructure developments struggle to keep pace with rapid urban growth. Rapid changes in land use within watersheds, ecosystem alterations, and increased urban surface sealing contribute to heightened vulnerability to extreme weather events and exacerbate the urban heat island effect. Urbanization, often driven by a dominant and poorly unregulated real estate sector with minimal urban planning requirements, **forces government agencies to act reactively**. Insufficient institutional capacity, chronic underfunding, and fragmented regulatory frameworks further impede effective urban (water) management.

2.1.2. New approaches for the management of urban waters

Given the existing challenges, water-sensitive urban development concepts are gaining prominence across Asia, particularly in Southeast Asia. These concepts prioritize the integration of **water management into the urban fabric** and **infrastructure** to enhance cities' resilience to climate change. The idea is based on the growing realization that conventional approaches to urban water infrastructure are no longer sufficient to meet the demands of rapidly changing urban environments.

Examples of this approach include China's "**Sponge Cities**", which use green infrastructure to absorb and manage water sustainably, and **Singapore's Green Investments** where the city-state has pioneered integrated water management systems, blending urban design with

Figure 1. Urban Water Transformation Framework (Source: Sharma et al., 2018)



environmental sustainability through programs like the Active, Beautiful, Clean Waters (ABC) Program and Marina Barrage. (Rau, 2022; Center of Livable Cities, 2017)

The city of Bangkok is also adopting water-sensitive strategies. The Chulalongkorn University Centenary Park collects and stores rainwater to reduce flooding, and the city's Flood Management Plan enhances drainage and flood protection. Bangkok is implementing a Climate Change Master Plan (2013–2023), focusing on improved drainage and green infrastructure. (Bangkok Metropolitan Administration, 2020) However, as in other cities, Bangkok needs stronger governance and greater investments to scale up these efforts.

Given these challenges, it is **unrealistic** that secondary and tertiary cities in general could bypass traditional water infrastructure models, such as the ‘water supply city’ and ‘sewered city’ that have dominated urban development for decades in large cities and later in smaller cities around the world, and **leap directly to a model where the natural water cycle** is seamlessly integrated into the fabric of urban environments, an urban development concept known as “**water-sensitive cities**” or “**water wise cities**”. (Wong et all, 2009; IWA, 2016)

Nevertheless, the **possibilities for a water-sensitive transformation** should be seen **in a broader context**. In particular, the already noticeable effects of climate change and the tangible consequences for the society and economy of little-guided urban development are creating a sense among political decision-makers, business and civil society that ‘business as usual’ poses a significant threat to the livability of cities and competitiveness of countries. There is a debate on how city’s transformation scenarios can **progressively integrate new approaches** into their urban and water management schemes.

The PUW approach is inspired by new concepts of urban water management, but seeks to adapt them to the relative capacities of secondary and tertiary cities in Southeast Asia.

For example, rather than relying exclusively on grey infrastructure, the Water-Sensitive City (WSC) framework promotes three core principles.

- **First**, cities should be understood and planned as water catchment areas, ensuring access to diverse water sources through both centralized and decentralized systems.
- **Second**, cities should act as providers of ecosystem services, using sustainable water management to strengthen both natural and built environments.
- **Finally**, effective urban water management depends on creating water-aware communities through participatory governance and long-term civic engagement.

Example 1: A journey towards a water-sensitive city - Singapore

Water fountain, Jewel Changi Airport, Singapore *(Source: PUW Own Work, 2023)*

Singapore is globally recognized for its innovative approach to becoming a water-sensitive city. Over the past decades, it has transformed from a water-scarce nation to a leader in water management through integrated planning and sustainable infrastructure. The city's approach focuses on managing water as a vital resource while enhancing urban livability and climate resilience.

This transformation is guided by the collaborative effort of different public entities: the **Public Utilities Board (PUB)** leads the water-sensitive transformation, overseeing water supply, drainage, and the implementation of sustainable water management programs, like the ABC Waters Program. **National Parks Board (NParks)** plays a key role by managing green spaces and naturalized waterways that support stormwater management and urban cooling. **The Urban Redevelopment Authority (URA)** integrates water-sensitive urban design into long-term planning, while the **Ministry of Sustainability and the Environment (MSE)** provides policy direction on water security and sustainability. **The Building and Construction Authority (BCA)** promotes water-efficient building designs and green infrastructure.

Green Facades, Business Center, Singapore *(Source: PUW Own Work, 2023)*

Key elements of Singapore's water-sensitive strategy include:

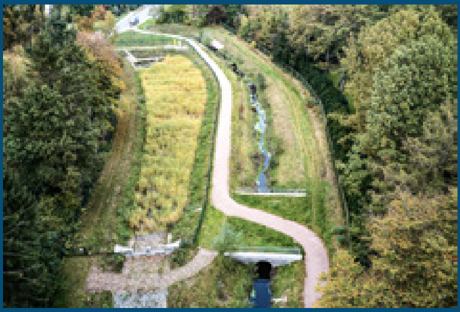
1. **Four National Taps:** Singapore's water supply is diversified across four sources: local catchment, imported water, recycled water (NEWater), and desalinated water. This ensures a resilient system that can meet growing water demands and adapt to climate challenges.
2. **Integration in Urban Planning:** Singapore integrates water management into urban planning by maximizing catchment areas, employing smart water technologies, and engaging the public in conservation efforts.
3. **Climate Adaptation and Resilience:** Measures like the Marina Barrage protect against floods while green spaces and water features mitigate the urban heat island effect, enhancing the city's climate resilience.

4. **ABC Waters Program:** Launched in 2006, this program integrates water management with urban design, turning drains and canals into attractive public spaces. Projects like Bishan-Ang Mo Kio Park naturalize waterways, enhance biodiversity, and improve stormwater management.
5. **Sustainable Urban Drainage Systems (SUDS):** Green infrastructure, such as green roofs, permeable pavements, and rainwater harvesting, help manage stormwater, reduce flooding, and improve urban cooling.
6. **Water Recycling NEWater:** NEWater recycles treated wastewater into potable water, supplying up to 40% of Singapore's needs. This circular water economy reduces reliance on imported water and promotes sustainability.
7. **Desalination:** Desalination plants, such as the Marina East facility, provide a climate-resilient source of freshwater, critical during dry periods.
8. **Public Engagement:** Through pricing strategies, public campaigns, and educational programs, Singapore fosters a culture of water conservation. (Center of Livable Cities, 2017)

Public green space area, Singapore *(Source: PUW Own Work, 2023)*

Example 2: From point to area: Strategically linking polycentric approaches towards a sponge city – Hamburg, Germany

Polycentric water management intervention, Hamburg *(Source: Hamburg Wasser, 2024)*



Retentionsbodenfilter, peri-Urban Area, Hamburg
(Source: Hamburg Wasser, 2024)

Hamburg is considered one of the greenest cities in Europe. However, despite its numerous parks and green spaces, more and more areas are being covered by asphalt and concrete. In 2017, Hamburg's environmental authority calculated that 39 percent of the city's land area is sealed. In 1999, this figure was only 36 percent. As a result, rainwater can no longer easily and naturally seep into the ground or evaporate, while at the same time, the effects of climate change are becoming increasingly noticeable.

With climate change, the likelihood of extreme weather events like heat waves and heavy rainfall increases. Heat, in particular, poses a significant health risk to a city's residents. Facades, roofs, and streets store and retain the sun's heat, creating "heat islands," where temperatures are even higher than in rural areas. Simultaneously, the risk of heavy rain events rises.

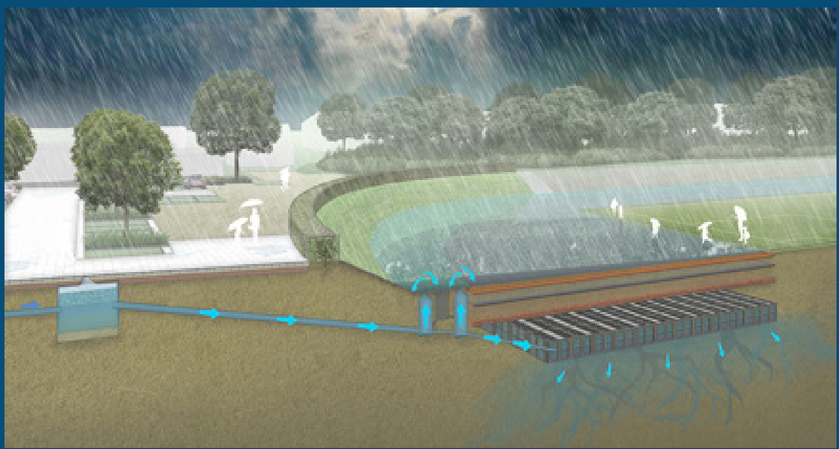
Increasing urban sealing, rising temperatures, and more frequent heavy rainfall are converging, resulting in negative consequences for the city and its residents. Nevertheless, management questions remain: where can all the rainwater go? How can urban drainage systems be prepared for the future? These questions are addressed by the Rain Infrastructure Adaptation initiative—RISA for short. HAMBURG WASSER and the city's environmental authority (BUKEA) are working together on this initiative.

It is clear to all involved that Hamburg must change. A milestone has already been reached through large relief programs: massive underground wastewater highways and storage facilities that hold back rainwater when the sewage treatment plant and sewer network become overwhelmed.

However, even the best sewer system has its limits. That is why the sponge city concept aims for a different goal: ideally, rainwater should seep into the ground and evaporate where it falls. If this is not possible in the short term, rainwater will be temporarily stored. The city of the future is envisioned to absorb and release water like a sponge. This transformation to a sponge city represents a paradigm shift to which HAMBURG WASSER, authorities, society, and the economy must all contribute. The approach involves using green roofs, porous soils, swales, ditches, plants on facades, and grass pavers instead of asphalt. Schoolyards, sports fields, parking lots, or parks can become reservoirs for rainwater.

An example of this is the sports field on Möllner Landstraße, which can absorb over 500,000 liters of water during heavy rains. Another opportunity to implement change is during renovations, such as the one on Wiesenhöfen Street in the urban district of Volksdorf. Previously, the street's profile resembled a roof, directing rainwater to both sides into a sewer. At one low point, water regularly accumulated during heavy rainstorms.

Today, the rainwater flows through a channel into the adjacent Ohlendorff Park, where a natural swale collects the water, allowing it to slowly evaporate and seep into the ground. These are small projects that will become more common in the future, with the goal of turning many scattered initiatives into one large, interconnected sponge. (Hamburg Wasser/RISA, 2025)



Überflutungsschutz durch Einleitung in Sportstadion, Hamburg
(Source: Hamburg Wasser/RISA, 2025)

2.1.3. Polycentric approaches to the management of urban waters as low-threshold approaches for initiating a water-sensitive transformation

Low-threshold approaches to urban water management and urban development are needed that allow cities to take the first steps toward a water-sensitive transformation and progressively build capacity to effectively address more complex water challenges.

With its flexibility and granularity, the PUW concept can support secondary and tertiary cities in Southeast Asia to gradually develop capacities for proactive urban planning and water management schemes.

Ultimately, these processes may support a transformation toward more water-sensitive cities. Such strategies consist of a growing number of coordinated actions that work together to gradually build resilience against climate change and water scarcity. These measures require not only technological innovations and infrastructure investments but also the adaptation of governance structures, active community engagement, and the development of sustainable planning strategies.

Key elements for successfully initiating low-threshold approaches

- **City or provincial governments must take the lead** at the highest possible hierarchical level to enable cross-sectoral measures and ensure immediate integration into public administrative processes.
- **Decision-making and strategy development must be based on robust information**, including reliable baseline studies, modeling key trends, such as urban development dynamics and climate change impacts, and the identification of strategic options.
- Where possible, meaningful, and feasible, planning processes should **incorporate participatory approaches** with communities, the private sector, and other stakeholder groups, such as professional associations, academia, and NGOs.
- **Decision-makers must be convinced** that identified measures are relevant to the city's political agenda and development goals, technically feasible,

financially viable, and implementable within the given capacity constraints. Especially for sustainable management, responsibilities should be clearly defined and anchored within public structures (community organizations, water associations, and private sector bodies where applicable).

- **Initial measures should be realizable within short timeframes** (i.e., one to two years) to demonstrate effectiveness and generate momentum for incremental development of capacities and polycentric measures.
- From the outset, measures must be designed with consideration for their translation into **the short- and medium-term (financial) planning of cities and provinces**. Co-funding options with international organizations should be explored.

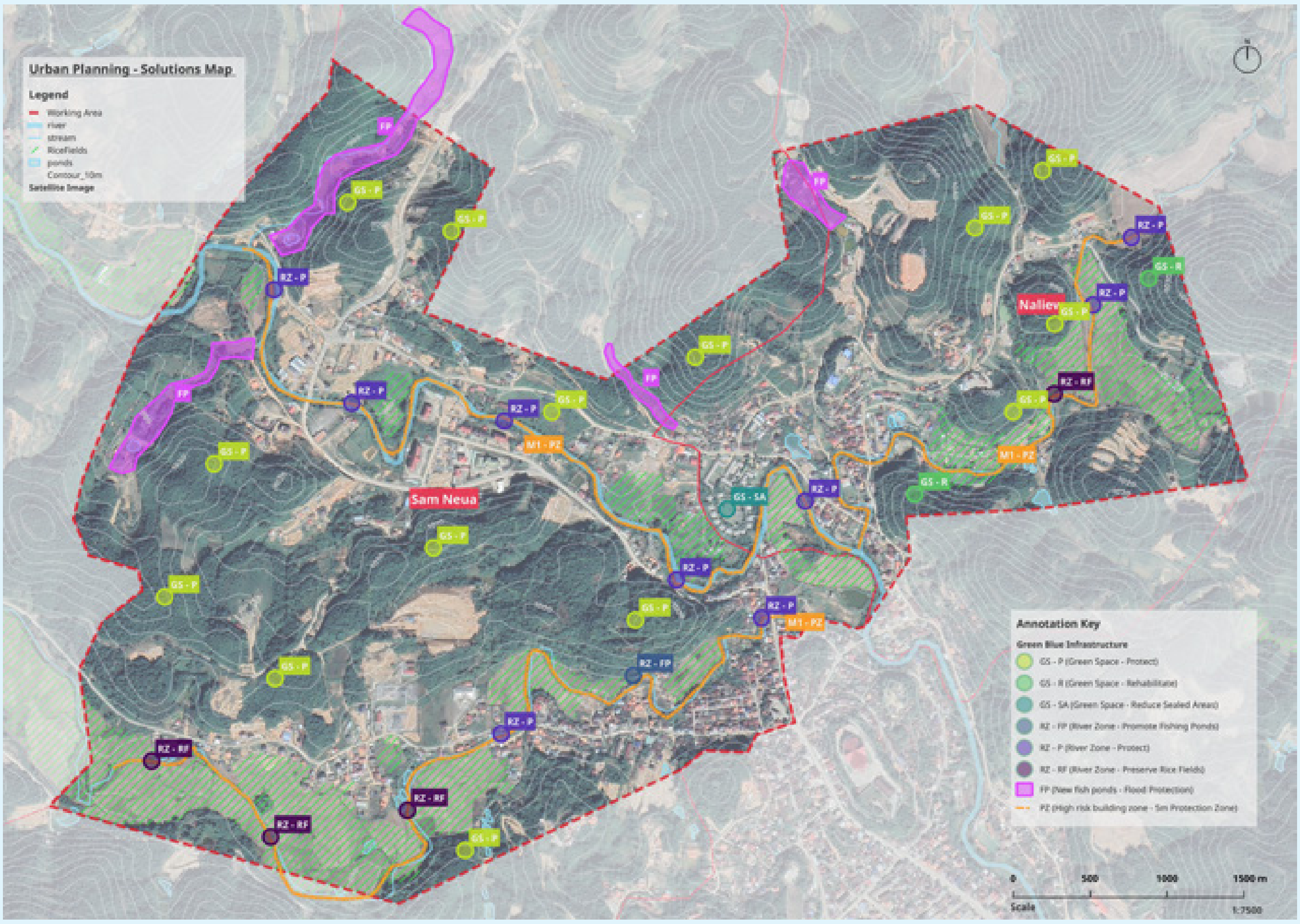
The concept of PUW considers "water" as a **cross-cutting issue** for the modernization and sustainable development of urban areas and settlements. Challenges such as the effective provision of water-related services, including water supply, wastewater and waste management, and flood management, are closely interlinked with the challenges and changes within the overall settlement area and broader water catchment.

Figure 2. Dimensions to capture the urban development dynamics and water use patterns (Source PolyUrbanWaters, 2022)

The PUW approach responds to these challenges by:

- Helping government entities and other relevant stakeholders to generate a comprehensive understanding of the city's existing and emerging water challenges.
- Supporting a strategy development process that reflects the capacities of the cities.
- Integrating strategically urban water management within the overall city management.
- Combining central with decentralized infrastructures and grey with blue-green infrastructure development according to efficiency, technical and financial feasibility, and long-term maintenance.
- Embracing the multi-functionality of space in the context of ecosystem services, societal needs (for example, public spaces), and infrastructure services.
- Promoting granular, tailor-made solutions that help cities to progressively build-up capacities for a water-sensitive urban development.

Figure 3. Plan of water-sensitive polycentric interventions for an urban extension area in Sam Neua, Lao PDR indicating interventions to strengthen blue-green infrastructure (Source: Hodgson et all, 2024)



- Enabling public bodies to fulfill their legally defined mandates in co-production with communities and the private sector.

The PUW approach is based on the fact that every city has its own natural, cultural, socio-economic, and governance characteristics. The management of urban waters or any water-sensitive transformation must be an essential element and may provide an important orientation for driving dynamic development.

Therefore, from its strategic dimension, PUW may support cities and relevant stakeholders to:

a. Generate a comprehensive picture of the specific development dynamics and water challenges of cities **(baseline assessment),**

b. Identify strategic fields of action for water-sensitive urban transformation **(strategic planning)**,

c. Elaborate corresponding development plans for the city/village/sub-village and neighborhood **(operationalization of strategic planning)**, and

d. Identify and implement strategic projects/measures that allow the initiation of more comprehensive water-intensive urban development **(initiation of implementation)**.

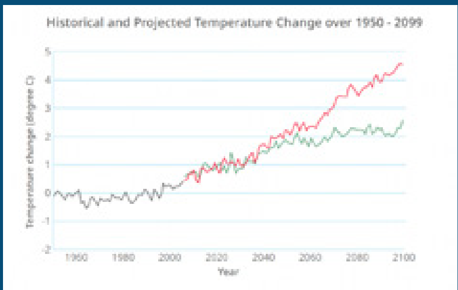
Although it is desirable that the PUW approach generates a comprehensive process for the management of urban waters for a water-sensitive transformation to be initiated, it may help to support the elaboration and implementation of more specific strategies with specific inter-sectoral alignment, such as:

- A strategy on integrated flood management.
- A strategy on climate change adaptation,
- A strategy on water safety,
- A strategy on urban sanitation, and/or
- A strategy for disaster prevention.

Observations from the work of the PUW project:

- In Southeast Asia, as in many other regions, local governments and decision-makers are highly focused on the immediate implementation of **tangible measures** within the realm of water-sensitive urban transition.
- Abstract concepts or long-term strategies often receive less attention, as practical solutions that address **immediate needs take priority**. Furthermore, "water"—beyond basic water supply—is typically not at the top of the agenda for government officials. Other pressing issues like the development of road networks, energy supply, and economic growth are seen as more urgent.
- Given the frequent constraints on public budgets, complex and strategic approaches to urban water management often get pushed into the background. Both elected and appointed officials feel the **need to demonstrate the effectiveness of their actions** in ways that are immediately visible to the public and higher authorities.
- As a result, the success and legitimacy of any strategic initiative or vision for water-sensitive urban transition rely heavily on the implementation of **quick, visible, and clearly beneficial measures** for the urban population and the communities.
- Moreover, developing **projects that are considered "bankable"** by national governments or international donors is crucial. Such projects must not only address immediate needs but also be presented in a way that may give access to funding and support. This **focus on actionable, financeable initiatives** makes it essential to strike a balance between strategic water management goals and immediate, practical benefits for the urban community.

Example 3: Towards a strategy for climate change adaptation – Kratié, Cambodia



Historical and Projected Temperature Change in Cambodia over 1955-2099
(Source: Royal Government of Cambodia, Ministry of Environment, 2022)

Existing green spaces in Kratié
(Source: Baseline Assessment, 2023)

Throughout Southeast Asia and globally, the significant presence of concrete, asphalt, and masonry that absorb and retain heat and prevent urban runoff and infiltration reflects the cities' general adoption of the evolving architectural practices. While the introduction of these materials has brought numerous benefits, including enhanced durability, improved resistance to natural elements, and increased safety, drawbacks include the potential for contributing to the heat island effect.

The urban heat island phenomenon is defined by the temperature disparity between the warmer urban areas and their cooler rural surroundings. As temperatures rise, city residents face a heightened risk of heat-related stress.

This risk is especially pronounced for the elderly, individuals with existing health conditions, and young children, who may struggle to acclimate to increased heat levels. Elevated urban temperatures result in more frequent use of air conditioning and cooling systems, leading to higher energy consumption and increased expenses. Consequently, intensified urban heat island effects can directly reduce a city's livability.

Increasing temperatures due to climate change and the loss of vegetation may significantly contribute to an intensifying urban heat island effect. Observed and projected temperature changes for Cambodia up to 2100 show exemplary patterns of shifts in the mean annual temperature based on two climate change scenarios, RCP4.5 and RCP8.5. (Royal Government of Cambodia, 2022)

Observations from Krong Kratié appear to corroborate an assessment of annual temperatures in Cambodia, which shows a subtle increase from 27°C in 1985 to 27.5°C in 2020—a trend that may accelerate significantly in the future.

View of development of outer-ring road in Kratié, 2024 *(Source: PUW & Partners Own Work, 2024)*

Image view of potential green space development of outer-ring road in Kratié *(Source: PUW, 2024)*

Like many regions in Cambodia, Kratie Province has lost massive amounts of its primary and secondary forest cover over the last hundred years. Today, the outskirts of Kratié city have hardly any vegetation left, and the soil is heavily compacted. The city center itself has seen urban densification for years, leading to an increasing loss of vegetation zones, thus intensifying the heat island effect.

Given this context presented by the results of baseline assessments, a planning question remained about how this city could best address the future impact of a worsening climate given its relatively limited human resources and financial capacity. Of central importance for the city's adaptation to climate change is the management of existing and the development of new green infrastructure. This includes systematic green space planning incorporating suitable forms of drainage, which can encompass both inner-city and suburban areas, such as those close to the city's urban wetlands, integral to regulating the high temperatures experienced by the city.

Of particular importance here is the greening of streets, specifically through tree planting. For example, a new main road is being built in the northern urban areas with financing from the Asian Development Bank (ADB), for which limited greening is currently planned. The expansion of this road will further contribute to the heating of the city and the adjacent residential areas. In response, the city administration has started to discuss more comprehensive greening initiatives, including green networks as part of its progressive development of climate change adaptation and a comprehensive concept for a livable city.

Example 4: Towards a water-sensitive transformation - Sleman Regency, Indonesia

Recently built apartment blocks in peri-urban area of Sariharjo
(Source: PUW & Partners Own Work, 2024)

View of traditional sub-village in a peri-urban area of Sariharjo
(Source: PUW & Partners Own Work, 2024)

The Regency of Sleman is part of the Yogyakarta Special Administrative Region (KPY). Alongside Indonesia's dynamic economy, KPY, like other secondary cities in the country, serves as a crucial focal point for the economic and social development of Southeast Asia's largest economy.

KPY’s urbanization process is accompanied by significant land-use changes and a profound socio-economic transformation. This is resulting in far-reaching ecological, economic, social, and cultural shifts across the region. If not properly managed, these developments could lead to serious impacts on shared and equitable prosperity.

The Sleman Regency faces growing pressure on its water resources. Despite considerable progress in infrastructure development (roads, electricity supply, etc.) over the past few decades, water-related infrastructure in peri-urban areas (especially regarding water, sanitation, and waste management) remains highly fragmented and inadequate.

The challenges of developing effective water infrastructure are substantial. A large portion of residents still rely on shallow wells for their domestic water supply and use soak pits for drainage, jeopardizing access to safe water in much of KPY.

Rapid expansion of a high-quality and as widespread as possible water service through the local water operator, PDAM, is essential for ensuring a safe drinking water supply. At the same time, there is an urgent need to develop an effective decentralized septage management system, as many parts of the peri-urban areas will not be connected to central wastewater treatment systems in the medium term.

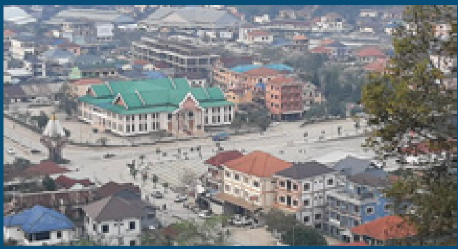
Sleman is also experiencing a dynamic shift in land use, with rice fields and agricultural green spaces increasingly being replaced by residential areas. Between 2000 and 2015, 35.73% of paddy fields in the Ngaglik sub-district were converted into built-up land, a pattern typical for many other sub-districts in Sleman. This trend is likely to accelerate, potentially increasing vulnerability to flooding due to land-use changes. Here, the need for large-scale and localized solutions becomes clear with the development of grey and blue-green infrastructure complementing each other effectively.

This requires targeted measures under the lead of government agencies and with support of specialized expertise for water-sensitive regeneration of old village centers: improving and expanding drainage infrastructure, developing and managing blue-green infrastructure, introducing systems for rainwater infiltration and water retention devices (particularly in light of increasing dry periods), expanding green spaces to meet the recreational needs of residents, relocating highly polluting industries, and implementing effective waste management.

The success and effectiveness of these measures will not be achievable without a high level of community involvement. Participatory and consultation processes and awareness campaigns are as essential as the provision of public funding and effective enforcement of existing regulatory frameworks. This is particularly important in preventing large-scale unplanned urban sprawl, which is heavily influenced by the real estate sector's economic interests in the absence of spatial planning.

Gated communities development in peri-urban area of Sariharjo,
(Source: PUW & Partners Own Work, 2024)

Example 5: Water-sensitive transformation in the context of public budget crises – Sam Neua, Lao PDR



View of recently developed city center of Sam Neua with townhall
(Source: PUW & Partners Own Work, 2022)

View of peri-urban area of Sam Neua
(Source: PUW & Partners Own Work, 2022)

The capital of Houaphan Province, Sam Neua, has experienced significant growth over the past two decades. This growth includes the expansion of several prominent provincial and city government buildings, the construction of new hotels and restaurants, the opening of a 250-bed hospital, and the inauguration of a new airport in 2024. This development has been accompanied by a surge in private construction.

With the region's increasing economic integration and intensifying economic relations with Vietnam and China, further stimuli are expected to further drive the city's growth.

However, the city's location in a mountainous area characterized by deep, narrow valleys imposes natural limitations on its expansion. The side valleys are increasingly being developed into built-up areas, leading to significant land sealing and, consequently, to water-runoff.

As is the case in many Laotian cities, urban development in Sam Neua largely follows the dynamics of an only partially controlled real estate market, and the existing urban planning hardly reflects current or emerging urban development measures. Construction activities often follow the expansion of road networks without sufficient adherence to building standards. Simultaneously, essential water-related public services, such as wastewater and waste management, cannot be adequately provided despite the significant expansion of the drinking water supply network.

Due to the exacerbation of the public finance crisis following the COVID-19 pandemic and resulting economic consequences, priority projects, like a planned sanitary landfill, cannot be implemented in the foreseeable future. This has increased the reliance on international donors to fund public infrastructure investments.

In 2021, the Ministry of Public Works and Transport and the Public Works Training Institute, responsible for urban planning and investments in Laotian cities, initiated a water-sensitive urban planning process with support from the PUW project.

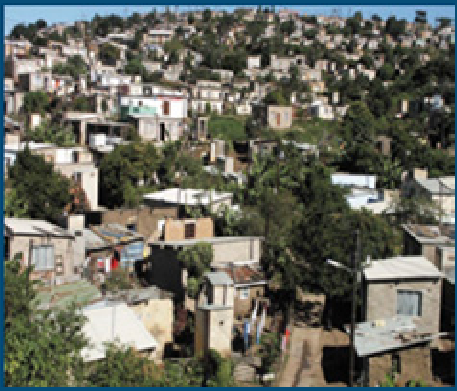
This process addresses these challenging conditions. In addition to the effective expansion of water-related infrastructure, the vision of a green, clean and beautiful Sam Neua with relevant indicators is being further developed.

Strategic measures for a water-sensitive transformation will be identified, and these can then be proposed to international donors as "bankable projects" for funding. Water-sensitive urban planning is also aimed at the systematic development of green spaces and the prevention of construction in areas prone to flooding and landslides.

The flood disasters in September 2024 demonstrated how valid and necessary are the scientifically grounded analyses of flood vulnerability. During a baseline assessment, a high vulnerability had already been diagnosed due to the topography of Sam Neua and changes in the city and the surrounding water catchment areas. (The Government of Lao People's Democratic Republic, 2018) This vulnerability is likely to be further exacerbated by factors such as the effects of climate change and further land use changes outside and inside the city.

Landfill of Sam Neua *(Source: PUW & Part-ners Own Work, 2022)*

Example 6: Entering water-sensitive transformation – An experience from eThekwini, South Africa



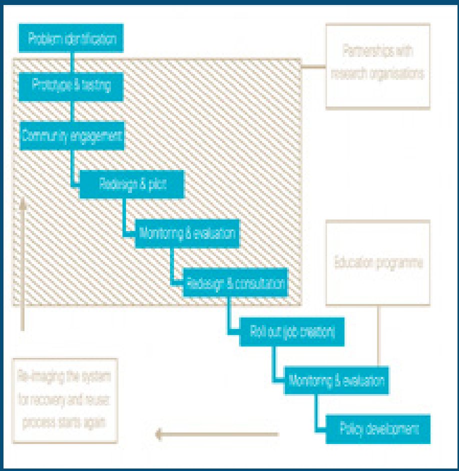
Settlement area, Durban, South Africa
(Source: eThekwini-Sanitation/South Africa)

The eThekwini Water and Sanitation Unit (EWS) is responsible for providing water and sanitation services to over 3.4 million residents in the eThekwini Municipality, which includes the city of Durban and surrounding areas in South Africa. As part of its effort to manage sanitation services in diverse urban, peri-urban and rural settings, EWS adopted a participatory approach that involved the community in the progressive implementation of sanitation services.

The key challenges in providing sanitation services across eThekwini were:

1. **Diverse Sanitation Needs:** Different areas required different solutions. For example, informal settlements, rural areas, and new housing estates all had distinct needs. Informal settlements faced acute problems like open defecation and home-built pit latrines, while rural areas had pit latrines (both improved and unimproved), many of which were already full.
2. **Water Supply Constraints:** South Africa's semi-arid climate, with below-average annual rainfall, made water scarcity a critical issue. This limited the ability to provide water-borne sewage systems and highlighted the need for water-efficient sanitation solutions.
3. **Awareness and Acceptance:** There was a lack of understanding among some communities about how to properly use sanitation systems, as well as a cultural attachment to flush toilets. The perception that the flush toilet is the "gold standard" of sanitation was a barrier to the adoption of more water-efficient and suitable alternatives.

Given these challenges, EWS did not wait for a perfect solution. Instead, they adopted a "learning by doing" strategy, where sanitation technologies were implemented, monitored, and improved based on community feedback. This approach allowed for continuous improvement in service delivery.



Sanitation Management System for Peri-Urban Areas
(Source: eThekwini-Sanitation/South Africa)

Key components of this participatory approach included:

1. **Community Involvement:** EWS involved community leaders and organized various participatory forums to get feedback and ensure that local needs were considered.
2. **Political Support:** The initiative had strong support from political authorities at the national, provincial, and municipal levels, which facilitated innovative thinking and the deployment of new sanitation systems.
3. **Technical Capacity:** EWS had good technical expertise, which enabled them to design and implement appropriate sanitation systems.
4. **Educational Campaigns:** A major component was educating the public about the proper use of sanitation systems and changing perceptions about the necessity of water-borne sewage systems.
5. **Collaboration with Academic Institutions:** Research partnerships with universities were established through memorandums of agreement to support the development and refinement of sanitation solutions.
6. **Monitoring and Evaluation:** Independent entities were tasked with continuously monitoring and evaluating the effectiveness of the implemented systems, allowing for adjustments and policy improvements. (Gounden, 2016)

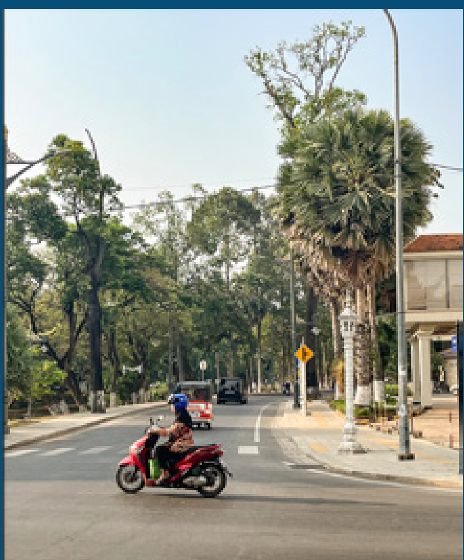
Example 7: Opportunities for water-sensitive urban transformation - the Siem Reap Tourism Master Plan, Cambodia

Sustainable City Strategic Plan 2020-2030 *(Source: Royal Government of Cam-bodia, 2020)*

The Sustainable City Strategic Plan 2020–2030 is a long-term initiative aimed at promoting green growth in strategically important secondary cities in Cambodia, identified by the national government as priority cities for green development.

One of these cities is Siem Reap, home to the Angkor Archaeological Park, a UNESCO World Heritage Site and one of Cambodia's most visited tourist destinations. The Siem Reap Tourism Development Master Plan 2021–2035, approved by the Royal Government of Cambodia on March 30, 2021, is a key part of this strategy. It aims to sustainably develop and enhance tourism in Siem Reap, ensuring the city continues to attract both international and domestic visitors while preserving its cultural heritage, protecting the environment, and promoting economic growth. (Royal Government of Cambodia, 2021)

Some of the main objectives of the Siem Reap Tourism Master Plan include:



Renewed road with shaded pavement and drainage *(Source: PUW Own Work, 2023)*

1. **Sustainable Tourism Development:** This aspect of the plan focuses on achieving a balance between tourism growth and environmental conservation, particularly around the Angkor Wat temples. The goal is to protect both natural and cultural resources while ensuring that the local economy and communities benefit from tourism.
2. **Urban Development:** Siem Reap itself is being developed into a more attractive, tourist-friendly city. The focus is on beautifying public spaces, improving traffic management, and promoting cultural and entertainment activities, aiming to make the city a world-class destination that complements the Angkor site.
3. **Environmental Protection:** A major focus of the plan is protecting the natural environment. This includes managing waste, conserving water resources, and encouraging eco-friendly tourism practices.

Integrated green space and water ways
(Source: PUW Own Work, 2023)

As part of the plan's implementation, several important projects have been completed by 2024. These include the renovation of waterways in Siem Reap's city center, the redesign of public parks, and the upgrading of streets, sidewalks, and the introduction of bicycle lanes.

In addition, key infrastructure improvements have been made, including an improved drainage and sewerage network aimed at preventing stormwater flooding by removing blockages. This will reduce environmental and biodiversity impacts by directing stormwater away from the ground, thus enhancing the city's attractiveness and public health. The plan also includes measures to reduce the disposal of fecal sludge and contaminated water into waterways, improving the environment, biodiversity, and public well-being, while enhancing the city's beauty. This is achieved by upgrading fecal sludge containment units, its collection, transportation, and treatment/ reuse. Moreover, efforts to reduce waste in public spaces and limit its disposal into natural ponds, canals, lakes, and waterways further enhance the environment, biodiversity, and public health, contributing to the city's overall beautification.

The fact that by 2024 no effective solution has yet been found for the management of the central wastewater facility built as part of this urban renewal plan highlights the need for and challenges in developing efficient water management structures. These challenges cannot be addressed solely through massive investments and a predominantly top-down planning and implementation approach. Respective organizational structures have to be developed to ensure the appropriate long-term management of solutions.

2.2. How polyurbanwaters instruments may be applied

The tools may be applied for different urban levels:

- A whole city area,
- Urban districts,
- Neighborhoods, or
- Sub-villages.

Additional tools may be applied to address specific challenges within the urban area's broader **water catchment area.**

Experiences of the PolyUrbanWaters project show that:

- The elaboration of a **baseline assessment on a city-wide level** is important to understand the specific characteristics of the city and its water management challenges. Based on this analysis, strategic lines and larger projects for more water-sensitive urban development can be developed.
- For the specification and operationalization of water-sensitive approaches, a **"zoom-in" at urban district/neighbourhood/sub-village level** has proven successful.
- At all these levels, **consultative processes** involving local government, communities, the private sector and other stakeholders, are crucial to generate effective and sustainable results.

How the PUW instruments and tools have been developed

The tools and instruments were elaborated as part of the research and development project "Polycentric Approaches to the Management of Urban Waters in South-East Asia" between 2021 and 2025 from the specific development contexts of three cities in the region:

- **Sariharjo/Sleman,** with currently 22.000 residents, is undergoing a rapid transformation from rural communities to a middle-class urban area located in the greater metropolitan region of Yogyakarta/Indonesia with its 1.2 million inhabitants,
- **Sam Neua,** provincial capital, located in the mountainous regions of Lao PDR with more than 45,000 inhabitants, whose population is predicted to more than triple by 2040, and
- **Kratié**, provincial capital, located on the banks of the Mekong and in extensive wetlands, with a current population of 30,000 inhabitants.

With their specific **urban characteristics** and their **water management challenges**, these three urban areas can be perceived as exemplary for many secondary and tertiary cities in the region. The elaborated approaches can also be applied to cities with different settlement characteristics, such as those that are more industrial, by tailoring the tools to those locations.

This document makes strong reference to the products developed by the PolyUrbanWaters network that are accessible at www.polyurbanwaters.org/resources.

Example 8: Shaping a process of water-sensitive transformation: Strategy development and implementation - City-State of Bremen, Germany

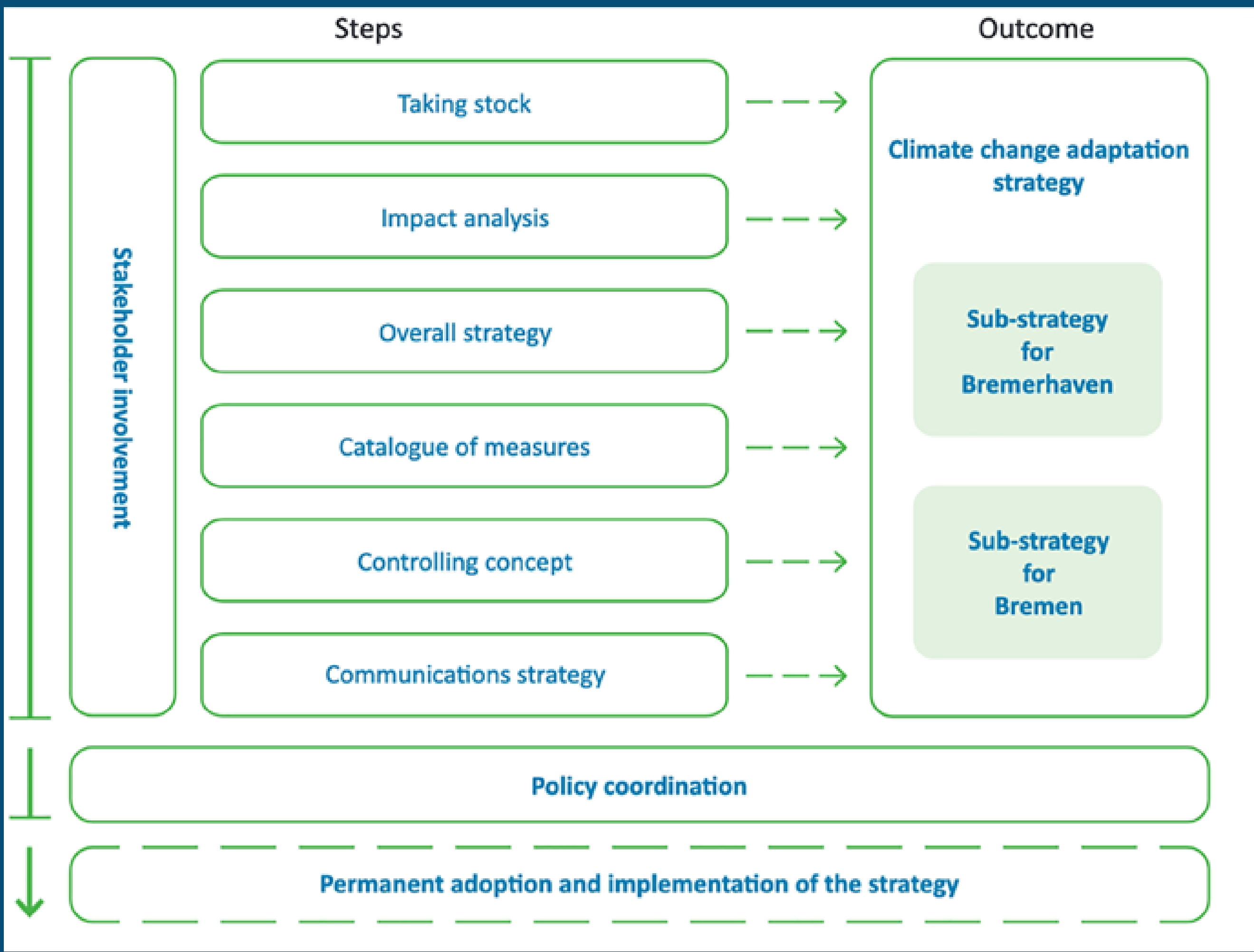
The city-state of Bremen has developed an approach for defining and implementing a climate adaptation strategy that serves as a reference for strategies aimed at water-sensitive urban transformation. Based on comprehensive analyses and projections of urban, natural, and climatic changes and their impacts, a holistic strategy has been formulated in collaboration with various societal stakeholders. This strategy is underpinned by a wide array of individual measures implemented within the framework of a monitoring concept, allowing for continuous development and the identification of new measures as needed. (City Government of Bremen, 2021)

A key component of this strategy is a communication plan that fosters acceptance and active participation in these measures by institutional entities, the private sector, and local communities. Over the long term, the strategy envisions maintaining favorable living and working conditions while ensuring the region's competitiveness, even in the face of potential climate-related changes. To address regional concerns, the climate adaptation strategy outlines key preventive measures aimed at mitigating the primary consequences of climate change in Bremen and Bremerhaven.

Bremen state authorities acknowledge that adapting to the impacts of climate change is a long-term societal challenge. The strategy primarily targets public authorities and focuses on what political and administrative stakeholders can do to improve the resilience of the state and municipalities while enhancing their adaptive capacity. It also includes measures to bolster personal protection for the population.

The strategy development process leveraged results, experiences, and approaches from various projects conducted at local, regional, and municipal levels. These insights were integrated into a comprehensive strategic approach, covering all relevant action areas for both municipalities, tailored to their unique needs and capacities.

Building on the experiences of other municipalities and research initiatives, extensive stakeholder involvement has been a cornerstone of the strategy development process. Early in the process, a network of stakeholders was identified and assembled to include all relevant parties interested in climate adaptation. This network covered key sectors highlighted in the impact analysis, such as health, water management, nature conservation, and urban planning. For this broad stakeholder group, diverse participation formats were developed. Additionally, a concept for ongoing communication and public engagement was embedded within the strategy, ensuring sustained collaboration and community involvement.



Strategic Framework for Climate Change Adaptation Strategy of Bremen
(Source: City Government of Bremen, 2021)

3. Urban Development Challenges

Key Messages of Section

- Heavy weather event-induced disasters are a strong indicator that many cities in Southeast Asia are still not sufficiently prepared to respond to the challenges of effective urban management—particularly in terms of managing urban water systems.
- The policy of decentralizing public governance structures has not yet gained sufficient traction to ensure the comprehensive provision of water-related public services.
- Effective water management schemes must go beyond a sector-focused approach and become an integral part of urban modernization strategies.
- Governance frameworks must be multilayered, incorporating strong feedback loops from stakeholders across urban society.

This section of the guideline provides:

- The foundation for understanding why a shift towards water-sensitive transformation approaches is both necessary and feasible.
- A structured introduction to the key issues and opportunities surrounding urban water management in Southeast Asia by including:
  - **An overview of urban development dynamics and water-related challenges** commonly faced by secondary and tertiary cities in the region, such as rapid urbanization, inadequate infrastructure, and increasing climate-related risks.
  - **A discussion of the challenges in achieving better water security and urban resilience**, with a focus on the requirements for transitioning towards more integrated and water-sensitive urban development and governance models.
  - **Examples of good practices** from both the Southeast Asian region and around the world, showcasing how cities are successfully initiating or advancing water-sensitive transformations.

3.1. Typical development characteristics of urban regions in Southeast Asia

Key Takeaways:

- **Rapid Urban Growth:** Southeast Asia's secondary and tertiary cities are undergoing fast-paced urbanization, highlighting stark disparities in wealth and services.
- **Water Management Challenges:** Climate change and urban expansion are overwhelming water management systems, causing issues in water security, flood control, and wastewater management due to rising temperatures, altered rainfall, and dense construction.
- **Infrastructure and Governance Gaps:** The swift transformation from rural to urban areas is outpacing infrastructure and governance, resulting in fragmented efforts to manage water services and urban resilience effectively.
- **Emergence of Water-Sensitive Urban Development:** Cities across Southeast Asia are increasingly adopting water-sensitive approaches to integrate water management into the urban fabric, making cities more resilient to climate change.

The cities of Southeast Asia are undergoing **rapid and complex transformations.** Countries such as Indonesia, Singapore, Malaysia, Thailand, Lao PDR, Cambodia, and others exhibit forms of urban growth, marked by the expansion of residential, commercial, and industrial areas. These cities, which serve as provincial government hubs and **production centers** for regional and global markets, are also becoming key destinations for migration from across these countries and from rural areas. This migration is fueling significant changes in both rural and peri-urban zones.

As a result of these changes, these cities are experiencing **shifts in social structures** and **cultural patterns** influenced by the increasing use of information and communication technologies. These technologies are linking local consumption and production habits to those of larger urban centers. Furthermore, the varied growth dynamics across cities and within their urban areas underscore the **diversity** of their **governance structures**. In peri-urban zones, traditional **settlement patterns** now exist alongside rapidly developing mixed-use areas that include modern apartment complexes, gated communities, business hubs, and industrial zones. However, this development often occurs next to emerging slums, revealing the uneven distribution of wealth and services.

Historically, many Southeast Asian cities, located in monsoon climates near large rivers, were perceived to have abundant water resources, symbolized by expansive paddy fields. However, **climate change** has intensified the challenges of **urban livability**, as altered precipitation patterns, more frequent heavy rainfall, and rising temperatures strain existing water management systems. (UNESCAP 2022, IPCC 2022a) High levels of surface sealing and dense construction further exacerbate these problems, leading to negative impacts on public health, property, and the local environment.

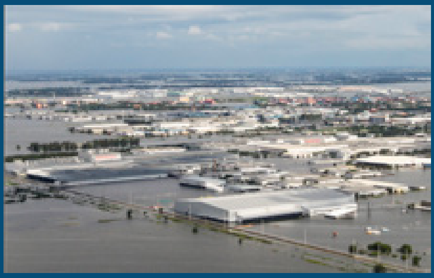
Water security has emerged as a **critical issue** in many rapidly growing cities. (ADB, 2020) The establishment of reliable water supply and wastewater management systems is lagging, as many cities struggle to maintain efficient water service structures. Even where investments in sewage systems are made, operational inefficiencies, inadequate maintenance, and weak financial models highlight the scale of the challenges faced. Flood control and prevention measures also remain fragmented, and the increasing frequency of floods reflect the broader problem: the rapid transformation of rural areas into urban zones **without adequate infrastructure** or **governance frameworks to support this growth**.

There are evident consequences of reactive action. For example, once green spaces in urban areas have disappeared, creating new ones becomes complicated: open spaces must be identified, funded, and negotiated with property owners. When a new settlement area is developed without an effective drainage system, later corrections are costly and often ineffective, causing harm to public and private properties. Once an urban area is almost completely sealed, retrofitting it with infiltration areas within the city can become an overly complex issue, involving disputes with property owners and extensive modifications to existing infrastructure.

Example 9: The 2011 flood disaster highlighting the relevance of PUW approaches on a large-scale - Thailand

Flooded area outside Bangkok 2011
(Source: U.S. Navy, 2011)

Flooding in Ayutthaya and Pathum Thani Provinces in October (right), compared to before the flooding in July (left)
(Source: NASA Earth Observatory, 2011)



Industrial estates affected by flooding
(Source: US Marine Corps, 2011)

The 2011 Thailand flood disaster is a prime example of the water-related vulnerabilities facing many urban areas in Southeast Asia. Primarily driven by excessive monsoon rains and intensified by tropical storms, the country's river systems and drainage infrastructure were overwhelmed. Thailand's natural geography, characterized by extensive floodplains, worsened the situation, while rapid, unregulated urbanization heightened the risks.

In Bangkok, the conversion of wetlands and floodplains into urban areas significantly reduced the region's ability to absorb excess water. Additionally, inadequate management of critical infrastructure, including dams, further exacerbated the flooding.

The disaster affected over 13 million people, resulting in more than 800 deaths and displacing thousands from their homes. Stagnant floodwaters became breeding grounds for waterborne diseases, raising serious public health concerns. Economically, the devastation was immense, with damages estimated at over $45 billion. This figure includes direct damage to infrastructure and factories, along with indirect losses caused by disrupted production, services, and the extended time required for recovery. (SWISS Re-Institute, 2021)

One of the most significant global impacts of the floods was the disruption to supply chains. Thailand is a key player in global manufacturing, particularly in the electronics and automotive sectors. The flooding of industrial estates led to halted production for major global companies, with consequences for international markets. Delays and shortages in products, such as cars and digital hard drives, highlighted the vulnerability of global supply chains reliant on Thailand's industrial sector, placing its strategic position in global trade in jeopardy.

This disaster, along with its underlying causes, underscores the urgent need for better spatial and urban planning in Southeast Asian cities. Preserving natural floodplains and wetlands as buffers against future floods is critical. Furthermore, improved infrastructure, such as more effective dams, drainage systems, and flood management technologies/practices, will be essential in mitigating the growing intensity of storms and rainfall linked to climate change.

Strengthening local capacities to implement flood prevention measures and promoting collaboration between governments, businesses, and communities are key steps in reducing existing vulnerabilities and preventing future disasters.

Example 10: The 2024 flood disaster highlighting the relevance of PUW approaches for smaller cities in SEA - Sam Neua, Lao PDR

Flooded city center of Sam Neua, September 2024
(Source: Pathedlao Newspaper, 2024)

In September 2024, a tropical depression brought heavy rainfall across northern, central, and southern Lao PDR, leading to severe downpours in the northeastern Houaphan Province. These rains caused major flooding in the provincial capital with streams in the surrounding valleys turned into raging torrents, resulting in widespread destruction of homes and infrastructure.

The city is gradually expanding into narrow mountain valleys, after initially developing primarily on former rice fields and their floodplains. The sealing of these areas has been accompanied by rapid deforestation and the conversion of land for agricultural use in the water catchment area, significantly reducing the soil's absorption capacity. This, in turn, has led to a significantly increased surface water runoff, particularly during heavy rainfall events.

These heavy rain events are likely to increase in both intensity and frequency in the future due to climate change. Overall, the urban area is increasingly vulnerable to flooding events.

The insufficient flood protection in Sam Neua is emblematic of many cities in Southeast Asia. So far, the city has grown largely without planning. Manifest and potential flood-prone areas are partially designated. The reinforcement of the riverbanks along the Sam Neua River, expanded in the city center in recent years, has proven inadequate to safely and effectively divert the large volumes of water during extreme rainfall events.

Flooded peri-urban area of Sam Neua, September 2024
(Source: Pathedlao Newspaper, 2024)

Given the available institutional and financial capacities, flood control measures, particularly upstream in the form of water retention basins and their effective management, are currently difficult to finance, to implement and to manage effectively. Given the rapid loss of forest areas and vegetation zones that slow water runoff, an increase in vulnerability is to be expected.

A certain reluctance is obvious among government officials to build dams after severe floodings occurred following a dam collapse in the Attapeu Province, the result of heavy rain events in 2018. This caused the confirmed death of 40 people, hundreds of people reported missing and thousands displaced. As causes of the collapse, heavy monsoon rains, deficient structural integrity of the dam and poor management have been identified. (The Diplomat, 2018)

Government agencies are increasingly recognizing the need to develop a strategic flood protection plan that includes measures to mitigate land use changes within the overall catchment area, as well as an effective integration of infrastructure development—so-called "grey solutions"—with the management of blue-green infrastructure. This plan emphasizes the involvement of local stakeholders, with a particular focus on ensuring that communities play a key role in the sustainable management of green spaces and riparian areas.

However, the fragmented regulatory framework currently in place and limited financial capacities present a significant challenge to coordinated and effective action.

3.2. Obstacles to achieving better water security and more resilient cities

Key Takeaways:

- **Decentralization Gaps:** Many secondary and tertiary cities in Southeast Asia struggle with implementing water security and climate resilience strategies, despite efforts to decentralize governance and strengthen local mandates.
- **Policy vs. Practice Disconnect:** There is a gap between policy-making and practical implementation, with local governments often lacking the resources to turn guidelines into effective action.
- **Centralization and Fragmentation:** Centralized decision-making limits local autonomy, while fragmented regulations in urban-rural transition zones hinder effective governance and planning.
- **Financial Constraints and Real Estate Influence:** Cities heavily rely on national funding, limiting local decision-making. Urban growth is driven by market forces rather than sustainable policies, highlighting the need for stronger regulation.
- **Growing Awareness of Climate Impacts:** The noticeable effects of climate change and the tangible consequences of poorly managed urban development are raising awareness among political leaders, businesses, and civil society that the "business as usual" approach threatens city livability and competitiveness.

While there is growing consensus among decision-makers at local, provincial, and national levels that issues, such as water security and resilience to climate change can only be addressed through **cross-sectoral collaboration**, the formulation and implementation of complex strategies often exceed the mandates, the capacities and operational logic of many secondary and tertiary cities in Southeast Asia. Additionally, concepts like "resilience" are often abstract and difficult to grasp for local stakeholders, requiring **clear and actionable solutions**.

Over recent decades, most Southeast Asian countries have undergone significant reforms to **decentralize public state functions**. This process has involved nominally strengthening the mandates and decision-making capabilities of local public bodies. Nevertheless, key challenges persist.

For instance, most cities face **significant barriers** to providing comprehensive **water-related public services**. Thus, effective water-related public services—such as adequate sanitation—are more often the exception than an assumed standard of municipal service provision. The formulation and implementation of consistent plans for water security for protection of water resources or the formulation and implementation of climate adaptation pose significant challenges for municipalities.

The following features of water governance and urban planning are observed throughout the region:

- One key issue is the persistent **gap between policy formulation and practical implementation**. Although policy guidelines are often established, there is frequently a considerable disconnect between their design and execution at the local level. As a result, intended reforms remain largely unrealized due to insufficient translation of policy into actionable steps.
- Another challenge concerns the **inadequate capacities** of local governments and agencies. Many of these institutions lack the institutional, human, and financial resources necessary to effectively manage tasks such as urban planning and water management. Consequently, even when local authorities are granted the mandate to oversee certain functions, they often do not possess the expertise or resources required for effective execution.
- The issue of centralized decision-making further complicates local governance. Despite ongoing efforts to decentralize authority, **major investment decisions**, particularly those related to urban development, continue to be **made predominantly at the national level**. This centralization limits local participation and often results in decisions that fail to adequately reflect the specific needs and contexts of individual localities.

- There is also a significant need for the development of more coherent regulatory frameworks. In many Southeast Asian countries, existing **regulations are fragmented and frequently overlapping**, particularly in urban-rural transformation zones where the mandates of cities and provinces may conflict. Harmonizing these frameworks is essential to ensure more effective governance and planning.
- The **dominance of the real estate sector** on urban development presents another significant challenge. Urban growth is often driven by market forces alone rather than guided by comprehensive urban development policies. This underscores the insufficient enforcement of existing regulations and highlights the need for stronger regulatory oversight to promote sustainable development practices.
- Furthermore, there is a clear **mismatch between local realities and the regulatory tools** intended to guide urban planning and infrastructure development. These tools and frameworks are often misaligned with the specific needs and conditions of local areas, underscoring the necessity for more flexible and context-sensitive approaches to urban planning.
- Lastly, **financial constraints** represent a major limitation for many cities. Most cities lack sufficient capacity for self-financing and remain heavily dependent on national budget allocations to support urban development. This financial reliance curtails local decision-making autonomy and restricts the ability of cities to pursue independent development agendas.

3.3. Requirements for moving towards urban development and water governance schemes for a water-sensitive transformation

Key Takeaways:

- **Effective Governance:** Southeast and East Asia show examples where collaborative governance structures support sustainable transformation, especially in sanitation and disaster preparedness.
- **Central Role of Governments:** Provincial, district, and local governments are key in planning and implementing water-sensitive measures, requiring integrated top-down and bottom-up approaches and appropriate budget alignment.
- **Need for Strong Water Management Entities:** Efficient water associations and operators are crucial for water security, highlighting a need for capacity building as in Indonesia and Cambodia.
- **Community Involvement is Crucial:** Active citizen participation in water conservation, waste management, and green space maintenance is essential for creating livable cities.
- **Private Sector's Impact on Sustainability:** Businesses play a significant role in promoting sustainable practices, with investments in flood-proof infrastructure and green standards strengthening resilience and competitiveness.

There are already examples in Southeast and East Asia where institutional environments have been created to ensure effective governance structures for sustainable transformation, for example in the field of sanitation or disaster preparedness. (CWIS TA-Hub, 2020)

These mechanisms involve key government bodies, community representatives, civil society organizations, and academia.

- Though there is significant variation in governance structures and the distribution of roles between national, provincial, and local governments across the region, it is evident that **government entities** at all levels—provincial, district, and local—play **a central role in initiating, planning, and implementing measures for a water-sensitive transformation**. In addition to providing financial resources, it is their responsibility to create the management, legal, planning, and administrative frameworks necessary for effective and sustainable implementation. It is essential to combine top-down (national, provincial) and bottom-up (city, district, neighborhood) approaches, along with **local stakeholder consultation processes**. Planning processes and identified measures must ultimately be reflected in the development plans and budgets of both local and provincial governments. In planning and budgeting, not only the respective responsibilities within local government structures should be reflected, but also robust operational models must be considered.

Water-sensitive modernization of secondary and tertiary cities in Southeast Asia: Learning from Tiger States

Numerous countries in Southeast Asia have made spectacular progress in the development and modernization of their cities over the past decades. In particular, the so-called Tiger States, such as South Korea, Malaysia, and Singapore, stand out. Although the governance structures in Southeast Asia are extremely diverse, a 2015 study by WaterAid shows that key success factors of these development achievements can certainly contribute to the discourse on sustainable water-sensitive urban development in the region:

- **Vision of Total Coverage:** The ambition for total sanitation coverage was established early on, irrespective of the nation's wealth levels. This vision provided a clear and overarching goal.
- **Health-Driven Objectives:** The primary goals were hygiene, cleanliness, and public health. These objectives drove the sanitation improvements, ensuring a clear focus on outcomes.
- **Proactive Leadership:** The initiative was driven by proactive leadership. Leaders at the top took the initiative to prioritize sanitation improvements.
- **Ongoing Engagement:** Leaders did not merely issue high-level directives but remained actively engaged in the implementation process. Their continuous involvement ensured that plans were effectively executed.
- **Multi-Sector Coordination:** A well-coordinated approach involving multiple sectors was essential. This collaboration facilitated rapid progress and comprehensive coverage.
- **Subsidy and Demand Creation:** Subsidies were incorporated to support the initiative. These were often indirect, such as housing subsidies, which helped create demand for sanitation improvements.

- **Course Correction Mechanisms:** Systems were in place at all levels to identify and address obstacles quickly. This adaptive approach allowed for timely policy reforms to ensure the initiative progressed effectively.
- **Continuous Monitoring and Improvement:** Continuous monitoring was a key component, with standards being raised progressively as initial goals were met. This ensured sustained progress and improvements in sanitation standards. (Northover, 2015)

- **Water management associations and capacitated water operators** are becoming increasingly important in Southeast Asia, as seen in other regions globally. Their capacity in managing, developing, and regulating water resources are vital for ensuring water supply, managing wastewater, maintaining water bodies including rivers and lakes, and addressing challenges such as flood control and irrigation. In contrast to Malaysia, for example, water operators play a rather limited role in urban water management in countries such as Indonesia, Cambodia and Lao PDR. Even in the area of drinking water supply, services in these countries can often be intermittent. While this will be a major task, comprehensive water security will be difficult to achieve without such efficient professional entities.

Why should cities seek collaboration with academic institutions?

For example: a climate change adaptation strategy

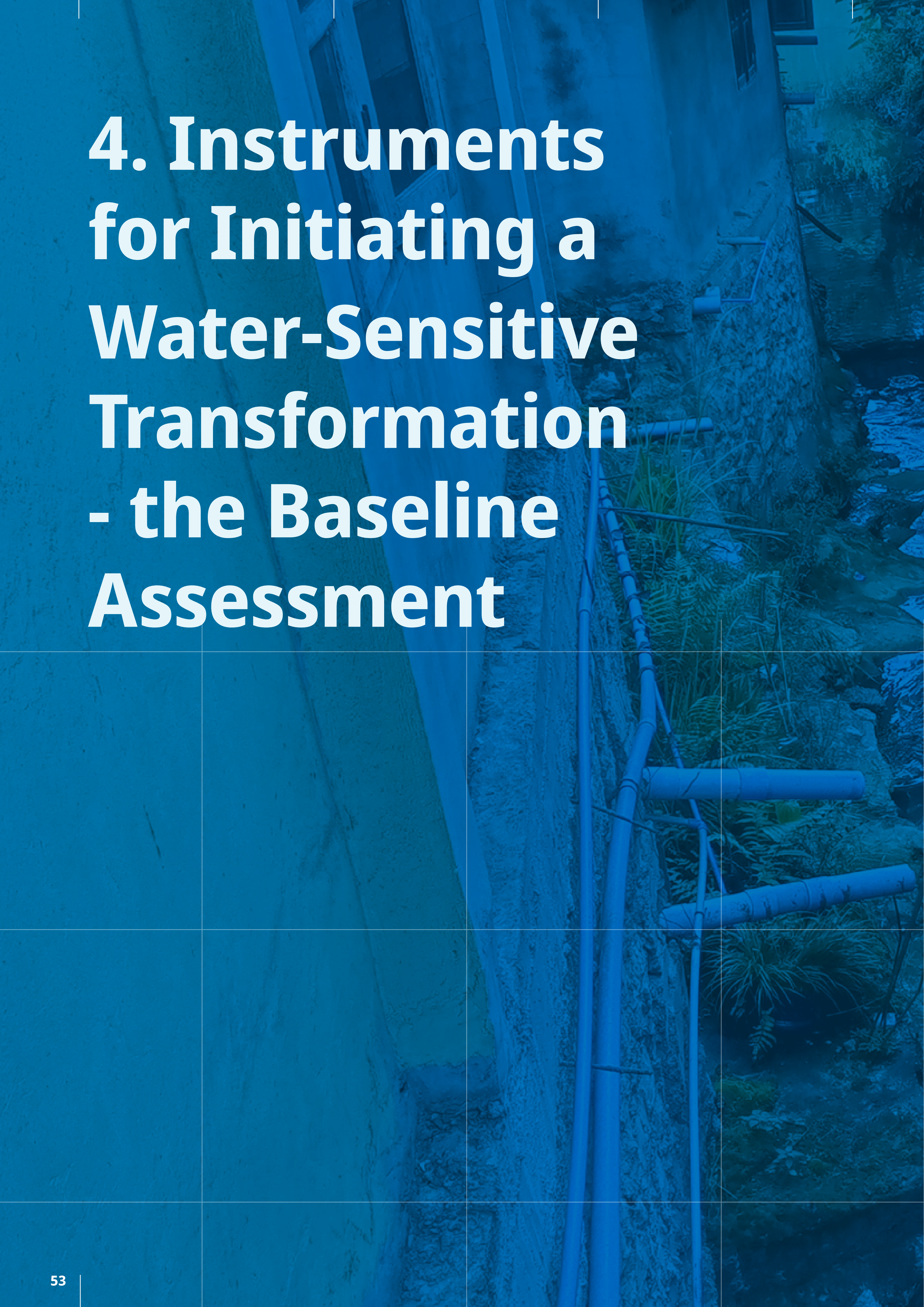
- Academic institutions can support cities with climate modeling that simulates future impacts on urban and water systems, such as sea-level rise, extreme rainfall, and prolonged droughts.
- By evaluating a range of scenarios, cities can develop adaptive, climate-resilient strategies, including phased flood-resilient zone development and risk-based infrastructure planning.
- Tailored climate adaptation plans with neighborhood-specific strategies, based on local demographic needs, ecosystem impacts, and water management infrastructure, ensure that each community receives customized protection rather than a one-size-fits-all approach.
- Such a scenario-based approach allows for cost-effective, scalable investments that strengthen urban resilience over time.

- **Civil society institutions and civil society** engagement can play an important role in initiating and implementing water-sensitive transformation measures. These measures can range from raising awareness at both government and community levels, to providing advisory services for cities and governments, to undertaking technical and planning-intensive tasks—provided they possess the necessary expertise. However, such specialized expertise is limited, which means that even successful individual measures are only partially scalable through non-governmental structures alone.

- In general, the political level recognizes that livable cities can only be achieved through the support of citizens and communities. Without **community involvement** in waste management, flood protection, water conservation, rainwater harvesting, and the maintenance of green spaces, this is hardly conceivable. Communities also play a crucial role in managing local watersheds and green infrastructure, especially in subsistence or part-time agriculture, which is closely tied to their livelihoods. Particularly at the local level, their knowledge and participation should significantly contribute to citizen engagement processes, and they should be consulted in important restoration and infrastructure development projects. Citizen consultation should not be a mere technical or methodological obligation. It is essential to ensure the genuine interest of communities and citizens. It is not only about improving water management but also about creating livable, safe, and attractive public spaces. These include playgrounds for children, recreational green areas, well-lit and safe walkways, and traffic-safe streets.

- The **private sector**, including commercial enterprises, restaurants, hotels, and industries, has a significant role in water conservation and waste management as major water users and waste generators. Their management practices and investment strategies are critical for sustainability, especially in promoting green spaces on private properties. Their interest in mitigating climate change impacts, such as flooding and heatwaves, is closely linked to their interest to ensuring effective business operations. Flood-proofed industrial areas will increasingly become an important factor in securing locations. Construction standards geared towards sustainability and the associated public incentives can be an important driver for green building. In Singapore, the Green Mark Scheme was introduced by the Building and Construction Authority (BCA) in 2005. (Building and Construction Authority, 2025) The LEED (Leadership in Energy and Environmental Design) standard of the Green Building Council (USGBC) is increasingly being adopted in the region and in other Asian countries. For example, as of August 2024, 226 textile factories in Bangladesh were LEED certified. In light of global political and economic upheavals, “Green Factories” are proving to be a crucial factor in maintaining the competitiveness of the country's textile industry by ensuring continued access to overseas markets. (Textile Insights, 2023)

4. Instruments for Initiating a Water-Sensitive Transformation - the Baseline Assessment



Key Messages of Section

A baseline assessment is an important tool for informed decision-making. It provides a detailed picture of the urban development dynamics of a city. And it helps to identify existing and to model upcoming water management challenges.

Such a picture allows public sector decision-makers, urban planners, investors, communities and other relevant stakeholders to generate specific information that are crucial for developing a strategy for the water security, inclusiveness and livability of the city.

This picture should capture the specific characteristics of a city. Every city has its own distinctive characteristic for what is relevant to understand the specific water challenges. The "fabric" of each city is characterized by very different natural spatial, economic, socio-structural, socio-cultural and governance characteristics and development dynamics.

A major challenge to conduct baseline assessments is to structure efficiently the specific information needs for understanding the interconnectedness of the urban development dynamics and their respective water challenges.

Conducting an effective baseline assessment requires making informed and strategic decisions about the types of information that is necessary and relevant to the objectives of the assessment. It involves identifying key data that will establish a clear understanding of current conditions, serve as a reference point for evidence-based planning and decision-making.

Based on this analysis, specific fields of intervention for the well-focused management of urban waters and water-sensitive urban development can be derived.

This section of the guideline:

- Familiarizes readers with the purpose, conceptual foundations, instruments, and international good practices related to baseline assessments.
- Demonstrates how targeted data collection can be used to understand the development dynamics of a city and its water resources, thereby generating relevant information to support informed decision-making.
- Identifies key characteristics of urban development and water resource systems that can be selectively addressed based on local priorities and needs.
- Presents a guide to the development of a baseline assessment, covering all stages from initial preparation and data collection to analysis and the communication of results.
- Indicates the significance of a structured process, and the application of appropriate data collection tools are illustrated through practical case examples.

Comprehensive Baseline Assessments and further resources are available at www.polyurbanwaters.org/resources.

4.1. Why a baseline assessment is necessary for a water-sensitive urban transformation

Every city features distinct urban development and water usage patterns that are influenced by its unique natural environment, settlement characteristics, economic conditions, social fabric, historical and cultural context, and governance models.

These patterns and related water challenges evolve significantly with urbanization trends, land-use changes in the overall water catchment and climate change.

- A baseline assessment is a crucial instrument to move towards a water-sensitive urban development, ensuring that efforts are well-informed, strategic, and aligned with the city's specific context and needs.

- A baseline assessment provides a comprehensive perspective of urban transformation and water-related challenges, enabling stakeholders from both public and private sectors, as well as community members, to make well-informed decisions about the city, its districts, and neighborhoods.
- A baseline assessment sets benchmarks against which the progress of water-sensitive initiatives can be measured. It helps in setting realistic and achievable goals for sustainable urban water management.
- A baseline assessment can project a business-as-usual scenario (BAU-scenario) that indicates an urban development pathway under current urban development and water management practices and their implications. In the same, a baseline assessment can identify options that may spur the pathway for a more water-sensitive urban development.

Recommendations I

- The conceptual configuration of a baseline assessment and the analysis should be done by an **interdisciplinary team** involving professionals from urban water management, urban planning, social science and/or community development.
- Tools such as the **PolyUrbanWaters Octagon** (See section 4.2) and **the Driving-Force-Pressure-State-Impact-Response (DPSIR)-Framework** (See section 4.4) may help to structure and focus the process.
- The project and study management should maintain a focus on the objectives, the key areas of interest of the baseline assessment, and the available capacities to conduct the study. A challenge lies in capturing the complexities without becoming overly entangled in excessive details.
- Implementation of the baseline assessment, its data collection and the evaluation of key findings should **involve key stakeholders** like urban development practitioners, community leaders, and private sector representatives to ensure a more accurate reflection of the ground realities.

4.2. Using the PolyUrbanWaters Octagon for designing a baseline assessment

The "PolyUrbanWaters Octagon" is a conceptual model that helps to capture the characteristics of a city relevant to the water-sensitive development. It considers the dynamic nature of a city's growth and its water resources within the context of both its watershed and municipal boundaries. It aids in comprehending the intricate interconnections between various aspects of urban development and water resources.

Figure 4. Dimensions to capture the urban development dynamics and water use patterns (Source: PolyUrbanWaters, 2022)

By using this model, decision-makers and planners can better assess a city's development trajectory, identifying opportunities for transformations towards improved urban and water management schemes. Working with this conceptual model the following analytical elements can be assessed:

1. **An analysis of the dynamics of urban development and its settlement and land use patterns** should provide an understanding of the interaction between the development of the urban space and its water cycle. This involves projections on water use patterns following population and economic growth. An analysis of development trends of built-up and non-built-up areas, such as residential, commercial, industrial, and green spaces, generate understanding of already existing and upcoming impacts on water resources.
2. **An analysis of natural and water resources characteristics** through an assessment of the status and trends of water resources within the overall water catchment of the city can indicate crucial developments such as water stress. For this purpose, an understanding of surface waters (rivers, lakes) and groundwater (aquifers) and impacts by land use changes is crucial. Information on the quantity and quality of water resources, considering factors like pollution levels, seasonal variations and climate change impacts are important.
3. **An analysis of infrastructure and water services** should provide information on the coverage, quality and gaps of water-related basic services. Apart from information on water supply, waste and wastewater management, an understanding of infrastructure for flood protection is very important. Physical infrastructure should be understood even beyond grey infrastructure (piping, drainage, sewage systems, retention basins, etc.) and include blue-green infrastructures because they provide a multitude of ecosystem services that are paramount for water security and livability of the cities.
4. **A vulnerability analysis** should provide robust information on already existing and upcoming water induced vulnerabilities. Land use changes in the overall water catchment in respect of the urban area and climate change impacts may result in floods, droughts and landslides that may have a significant impact on public health, private and public assets, and the livelihoods of the population.

5. An **analysis of governance structures** should provide information on to what extent identified water-related urban development challenges can be managed by local government, service structures and local stakeholder involvement. Often there is an overlap or lack of mandates for public bodies, or mandates are fragmented. Mandates between city and provincial governments are poorly defined creating regulatory and operative challenges especially in peri-urban zones. The analysis of governance structures involves assessing the existing gaps in regulatory frameworks, regulations and water rights, and the capacities of stakeholders to be involved in the respective management schemes and financing.

Recommendations II

The overall elaboration of the baseline-assessment may follow the **KISS-principles** (Keep It Specific and Simple).

- **Well-defined Conceptual Framework:** This tool should ensure a structured approach to the assessment, defining objectives, primary and secondary research questions and potential indicators.
- **Focussed Data Collection:** Collecting the most relevant data without overcomplicating the process.
- **Streamlined Analysis:** Analysing the collected data in a manner that is efficient and avoids unnecessary complexity. This might mean using more straightforward analytical methods or focusing on key indicators.
- **Practical Recommendations:** Proposing urban planning strategies that are realistic, cost-effective, and feasible to implement. These recommendations should avoid over-ambitious or overly complex plans.
- **Effective Communication:** Ensuring that the findings and recommendations are communicated in a clear, concise, and accessible way to all stakeholders, including government officials, urban planners, and the public.

Ultimately, the baseline assessment with its various levels of analysis should contribute to the development of more effective management structures. These management structures - and their basic features - correspond to the described octagon of water-sensitive urban development. The different management dimensions should be intricately interconnected or organized across sectors wherever feasible and required. (Gutterer, 2008a)

4.3. Key steps and phases for conducting baseline assessment

Conducting a baseline assessment can follow the recommended steps and phases outlined below.

1. **Preparation Phase:**

    - Assemble a team of professionals who primarily have a background in Urban Water Management, Urban Development, Urban Planning, Community Development, etc., and define roles and responsibilities within the team.
    - Define the scope, objectives and target groups of the assessment.
    - Define and communicate process design including objectives and expected outputs to relevant stakeholders such as government bodies, community members, businesses, and NGOs.

2. **Applying the PolyUrbanWaters Octagon and DPSIR-framework:**

    Apply the Octagon and DPSIR-framework as a conceptual model to understand the interconnections between urban development and water management. The model facilitates a holistic view of the city's development trajectory and helps in planning for sustainable water management solutions. The following dimensions may be addressed:

    - **Natural and Water Resources Characteristics:** Analyse the city's water sources, including rivers and groundwater, to assess their status and trends. Consider impacts of land use changes (even in the overall water catchment area) and climate change.
    - **Urban Development Dynamics:** Evaluate urban growth, land use patterns, and their impacts on water resources and infrastructure.

- **Infrastructure and Services:** Assess the existing water supply, wastewater management, and flood protection infrastructure. Identify gaps in service coverage and quality.
- **Vulnerability Analysis:** Identify vulnerabilities related to water, such as risks of floods, droughts, and landslides, and their potential impacts on public health and assets.
- **Governance Structures:** Evaluate the effectiveness of current water governance structures, regulatory frameworks, and stakeholder engagement

3. Data Collection and Processing:

The conceptual framework should define the data needed for the assessment:

- Check the data already available in respect of the secondary data that are relevant to the subject.
- Identify data to be collected and appropriate collection method.
- Decide on the most relevant data that can be collected with the available resources.
- Transect walks may give valuable insights into ground realities.
- Involve stakeholders, such as government officials, community members, civil society organisations and experts knowledgeable on the local data collection situation.
- Remote sensing data and secondary data should be validated with local stakeholders.

4. Data Interpretation

- Data are never self-speaking. Interpretation from those with professional backgrounds in the topic is needed.
- Bring together different perspectives from involved professionals.
- Use GIS and other analytical tools to visualize data. Verify data with local stakeholders.
- Get feedback and evaluate your findings with relevant stakeholder groups.

5. Reporting and Recommendations:

- Prepare a detailed report that outlines findings, provides an analysis of the current state, and recommends actions for water-sensitive urban transformation.

- Develop strategic recommendations tailored to the city's specific needs and contexts, guided by the baseline assessment findings.
- **Elaborate Scenarios:**
- 1) The scenario that continues the current development path as Business as Usual (BAU-Scenario) over a 5- and 15-year period.
- 2) An alternative scenario that integrates water-sensitive action options

6. **Implementation Support:**
   - Suggest mechanisms for implementing the recommendations, including potential projects, policy adjustments, and community-based initiatives.
   - Define roles and responsibilities for stakeholders, ensuring clarity in execution and accountability.

Why should data interpretation be done by experienced professionals?

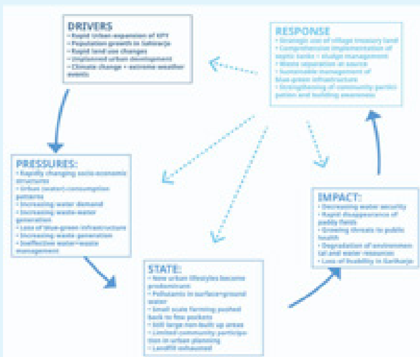
- **Specialized Urban Expertise:** Urban planners, hydrologists, water engineers, environmental scientists, economists and social scientists offer critical expertise to interpret data relevant to water-sensitive design, such as stormwater flow, urban drainage, and land-use impacts on water resources. Their insights are tailored to urban areas where water management intersects with dense infrastructure and complex socio-economic factors.
- **Accurate, City-Relevant Data Interpretation:** Ensuring precise data analysis reduces the risk of missteps in urban policy and planning. In cities, where decisions can have widespread public and environmental impacts, professional accuracy is essential for effective, sustainable solutions, such as flood mitigation or water conservation strategies.
- **Managing Multi-Layered Urban Data:** Cities involve intricate, layered datasets. Professionals can synthesize these diverse elements into coherent strategies, allowing for informed decision-making in dynamic urban settings.
- **Contextual Fit in Urban Development:** Professionals understand how to integrate data

with urban regulations, zoning laws, environmental requirements, public administration processes and community needs. This context-specific interpretation ensures that water-sensitive solutions are not only technically sound but also aligned with the city's broader development goals, regulatory requirements and public finances.

- **Risk Mitigation Tailored to Urban Challenges:** In urban areas prone to flooding, landslides, or water scarcity, professional risk assessments help pinpoint vulnerabilities and elaborate mitigation strategies.
- **Compliance and Public Trust in Cities:** Professionals' familiarity with urban regulatory standards and best practices helps ensure compliance with city, provincial, or national laws. Compliance is key to obtaining the necessary support from public stakeholders, enabling smooth project approvals, community buy-in, and successful funding applications.
- **Interface with Academia and Science:** Engaging academia and scientific communities is crucial for developing innovative, evidence-based strategies for a water-sensitive urban transformation. Academia provides access to cutting-edge research, for instance on climate change, technical expertise, and advanced analytical tools, which are essential for accurately interpreting complex data and applying findings in practical and impactful ways.

4.4. Designing a baseline assessment using the Driving Force-Pressure-State-Impact-Response Framework

The Driving Force-Pressure-State-Impact-Response (DPSIR) framework is a comprehensive analytical tool that supports the generation of in-depth insights into water-related challenges and opportunities for water-sensitive urban development, taking into account current and emerging urban dynamics as well as other influencing factors like climate change. Furthermore, it serves a strategic tool that can guide a water-sensitive urban development.



Exemplary DPSIR Framework
(Source: PUW & Partners Own Work, 2023)

The DPSIR-framework outlines a sequence of causally linked factors, beginning with key urban change drivers such as population growth. These drivers exert pressures, including increased water usage and wastewater production. Evaluating the state of water resources provides a clear picture of water quality levels, which can have significant effects on ecosystems and public health. A rapid decline in water quality underscores the urgency for appropriate measures, such as developing sufficient wastewater treatment infrastructures.

By applying the DPSIR framework at these various scales, it becomes possible to tailor analyses and strategies to the specific needs and characteristics of each area. This localized approach allows for a more nuanced understanding of the issues at play in different urban and rural contexts, facilitating the development of targeted strategies that are more effective and relevant to each unique setting.

The DPSIR framework thus serves as a foundational conceptual framework for identifying necessary information and data collection for baseline assessments. Without such a structured conceptual approach, there's a risk of overlooking crucial information.

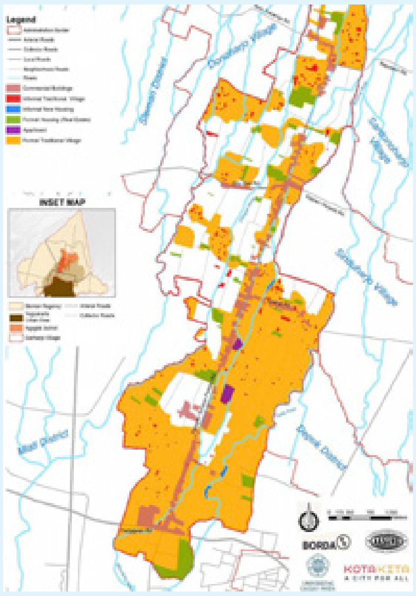
The following section outlines the components of a DPSIR framework, providing examples of indicators that could be considered in conducting a baseline assessment.

These examples represent a selection that can be modified, condensed, or expanded depending on the specific needs for understanding.

Sam Neua: Conversion of paddy fields in central built-up area 2015 – 2020
(Source: PUW & Partners Own Work, 2023)

1. **Driving Forces** are defined as "forceful drivers" for demographic, economic, social, ecological and climate changes that induce urban transformation.
   - **Urban Development Dynamics:** Population growth, economic development, change to the social and income structures of the population, new investment regimes from public and private sector including infrastructure development, and urban sprawl.
   - **Changes in Land Use Patterns:** Changes in the overall water catchment area such as deforestation, and the changes in land-uses (agricultural, settlement, industrial, etc.).
   - **Governance:** Legal regulations for urban and infrastructure development, infrastructure, water governance, and investment regimes.
   - **Climate Change:** Increase in temperatures, change in precipitation patterns, and extended dry seasons.

2. **Pressure** refers to the direct effects that driving forces have on water resources and the urban system.
    - **Water Resources:**
    - Changes in the availability of surface water and groundwater,
    - Changes in water demand and water consumption due to industrialization, agricultural shifts, and increased domestic and business usage,
    - Changes in the generation of wastewater,
    - Changes in water runoff patterns,
    - Changes in water flow regimes,
    - Changes in waste generation both in types and in quality.
    - **Urban Systems:**
    - Rising demand for good quality public infrastructure such as water conservation, water supply, and wastewater treatment,
    - Reduction in surface permeability and loss of infiltration areas,
    - Pressure on blue-green infrastructure, for example, green spaces and wetlands,
    - Decline in traditional water management practices,
    - Changes in the local climate,
    - Necessary effective water and urban development structures.



Settlement Types Map in Sariharjo
(Source: PUW & Partners Own Work, 2023)

3. **State** is critical for assessing the current condition of the urban system and water resources.
    - **Urban Development Patterns:** Settlement structure and typology of settlement, and permeable surface area
    - **Urban Infrastructure:** Extent and quality of existing water supply, sanitation facilities, stormwater management systems, and blue-green infrastructure,
    - **Water Quality:** Specific pollutants in water bodies (for example, nitrates, phosphates, heavy metals), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), turbidity, and incidences of water-related illness,

Flooding in Sam Neua down town
(Source: PUW Partners Own Work, 2018)

- **Quantity:** Groundwater levels, and seasonal water renewability of water sources,
- **Water Services:** Coverage of households, businesses, institutions, etc., quality of services (hours of provision, water quality), technical and financial losses, service coverage, and safe wastewater management,
- **Waste Management Services:** Coverage of households, waste separation, recycling and disposal, toxic waste management,
- **Ecosystem Health:** Biodiversity in aquatic ecosystems,
- **Flooding:** Incidence and severity of flooding events,
- **Governance:** Effectiveness of procedures of governance structures on city and community level, funding schemes, and quality of water services.

Identification of measures to mitigate flood occurrence in Kratié
(Source: PUW Own Work, 2024)

4. **Impacts** give information on pressure induced problems and challenges.
   - **Water Resources and Ecosystems:**
   - Decrease in the availability of surface and ground water,
   - Rising levels of water pollution,
   - Loss of biodiversity,
   - Degree of soil contamination.
   - **Urban Systems:**
   - Increased frequency and intensity of flooding,
   - Economic losses for public, private sector and individuals, and the destruction of infrastructure,
   - **Communities:**
   - Weakened public health such as increased prevalence of waterborne diseases,
   - Inequitable access to water services,
   - Increased vulnerability especially among disadvantaged sections of the population,
   - Generally increased vulnerability to water-related disasters, etc.
   - Increase in urban heat island effects.

5. **Responses** indicate measures that can be taken to mitigate pressure or even to improve the given state.

   - **Water Resources and Ecosystems:**

   - Development of infrastructure for water retention and infiltration effectively combining grey and blue-green solutions,
   - Implementation of water safety schemes for protection of freshwater resources,
   - Implementation of approaches for progressive development of wastewater management schemes,
   - Implementation of solid and toxic waste management schemes including separation at source,
   - Establishment of management schemes for blue-green infrastructure.

   - **Urban Systems:**

   - Elaboration of urban planning schemes and procedures proactively addressing identified development trends at the overall city level and at urban district/neighborhood level,
   - Implementation of schemes for green urban development including public and private properties,
   - Strengthening the capacities of public bodies to create an enabling environment for improved water services,
   - Establishment of mechanisms for participatory planning and implementation of identified measures involving public and private bodies, communities, civil society and academia,
   - Translation of identified measures into public short/medium/long-term planning of urban areas.

Example 11: Capturing key water challenges by applying DPSIR – Kratié, Cambodia

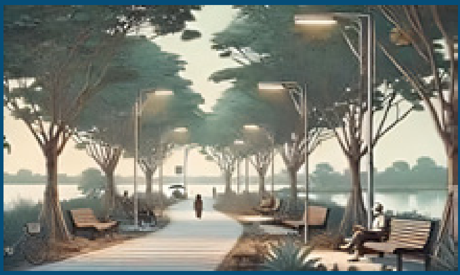
General view over Kratié with wetlands in the background *(Source: BORDA, 2023)*

Release of untreated wastewater to urban wetlands in Kratié *(Source: BORDA, 2023)*

Land use changes and hydro-power development strongly influence the flow regime of the Mekong River and, therefore, the flood regime in Kratié itself. Climate change can have a further impact on the flow regime in future. Presently, the urban landscape of Kratié is being transformed due to ongoing urbanization. This affects its four sangkats (urban districts) in different ways, characterized by increased housing density, the covering of natural surfaces with new constructions, and the expansion of infrastructure as a component of urban expansion. (Driving Forces).

The existing Master Plan 2030 is relatively schematic and insufficiently addresses water-sensitive parameters, such as flood protection, drainage, open space development, and climate change adaptation. Landfilling activities reduce the water absorption capacity of the lake area. Drainage infrastructure is insufficient to cope with large quantities of stormwater. Relatively weak local governance structures and very limited budget for investments are deficient to address already existing and emerging water induced risks for urban development. Krong Kratié still falls short of comprehensive coverage of water relevant infrastructure development and comprehensive basic needs services. Significant improvements, such as water supply, drainage, sewage, waste management, and the development of green infrastructure, are crucial for enhancing the livability and attractiveness of the city. The downtown area primarily relies on infrastructure developed during the colonial-era for drainage, and untreated sewage mostly flows into and around Kratié's lake area (Pressure).

The municipality is home to around 7,240 residential units and more than 900 commercial entities. This includes six markets (with two being main markets and four smaller ones), 16 dining establishments, 15 hotels, and 30 guesthouses. The area boasts three health centers, one referral hospital, 13 public primary education institutions, seven lower secondary schools, and three upper secondary schools (State).



Potential development of wetland area
(Source: PUW, 2024)

The discharge of untreated wastewater into the lake area jeopardizes the health of the public and ecosystems. The rapid increase in urban sealing and densification of building stock is expected to exacerbate 'urban heat islands', particularly in light of the ongoing rise in average temperatures attributed to climate change, and the absence of substantial private and public urban green spaces. Inadequately managed urban expansion in the lake area that obstructs the natural flow of water, combined with insufficient infrastructure development and a marked decrease in catchment capacity, may significantly heighten the city's risk of experiencing dangerous flooding events (Impact).

Through funding from the ADB, a modern rainwater and floodwater drainage and pumping system is to be implemented in 2025, primarily in the inner city area. (However, relevant urban areas—especially in the peri-urban zones—will not be covered for the time being.) Additionally, the development of a separate central wastewater system is planned, which will only cover parts of the city. For peri-urban areas, decentralized systems are to be implemented according to a city sanitation plan, aiming to provide timely wastewater solutions at hotspots that include the slaughterhouse and referral hospital. A plan for the sustainable management of the wetlands in the city and its implementation, with the focus of development on "Wastewater Management," "Stormwater Management," and "Green Space Development", is intended to make a significant contribution to water security and the city's adaptation to climate change (Response).

4.5. Essential dimensions of a baseline assessment for water-sensitive urban transformation

4.5.1. Natural characteristics

Key Takeaways:

A baseline assessment analyzing natural characteristics should offer insights tailored to the specific interest of information.

Below are three examples that illustrate this.

- For a broad analysis of flood vulnerability, it should provide an extensive overview of topography, river and stream hydrology systems, climate patterns, and soil texture.
- For a projection of future availability of groundwater and surface water resources, it should provide information on current water levels, recharge rates, historical data on water availability, patterns of seasonal variation, impact of climate change, and land use changes affecting water bodies.
- When examining the potential impact of land use changes and climate change on the local climate of the city, it should include data on vegetation cover, urban heat islands, and microclimate variations and incorporate projections for changing climate patterns for the region.

Just like every city, urban areas in Southeast Asia have their unique natural characteristics, leading to a range of distinct challenges in urban development and water management. This diversity stems from factors such as geographical location, topography, climate, and the availability of natural water resources.

As a result, the strategies for effective urban and water management adopted by cities in the mountainous regions of these countries need to differ from those employed in cities situated on large plains or within major river deltas. Moreover, within the cities themselves, these challenges can vary significantly from one district to another.

In light of these specific information needs, a good baseline assessment should be able to at least outline the most important natural characteristics of a city, from its watershed to the urban area, and possibly even specify these characteristics for particular city districts.

More specific studies on a local level may be necessary to identify appropriate measures.

Such an assessment is vital in understanding the unique environmental context of each area, enabling more tailored and effective planning and management approaches:

1. Urban water challenges are largely determined by **climate and weather patterns**. Southeast Asia is characterized by substantial rainfall, especially in the monsoon season. The region predominantly has a tropical climate, characterized by consistently high temperatures in many areas throughout the year.

    - However, there are significant differences in temperature across various areas within the region. Intense rainfall and severe weather events put considerable pressure on infrastructure and require urban water management approaches that must be tailored to accommodate these specific climatic conditions.
    - Climate change is altering rainfall patterns, with likely increases in the frequency and intensity of extreme weather events, including heavy rainfall, higher temperatures and prolonged dry periods requiring comprehensive measures for climate change adaptation.

2. A sound understanding of **hydrological patterns** is crucial for the planning of effective water infrastructure, such as water retention, water harvesting, and filtration systems, drainage systems, and flood protection, etc.

    An analysis of hydrological patterns involves the state of water resources, the natural movement and distribution of water within a city itself and its water catchment. Information on hydrological patterns are important to understand the availability and risks of overexploitation of water resources, flood risks, and water scarcity risks, etc.:

    - Regime of stream flow (rivers, creeks, aquifers, etc.) from water catchment through the city including their seasonal variations in water level, flow rate, and its spatial expansion,

- Groundwater levels with the depth, recharge rate, and extraction rate of groundwater,
- Rainfall distribution including its intensity, frequency, and seasonal patterns.

3. The hydrological patterns of a city are deeply intertwined with its **topography**:
   - **Influence of the topography on runoff patterns:** The contours and elevations of the land play a pivotal role in directing the flow of surface water. Water that is not absorbed or evaporated moves towards various water bodies, guided by the land's slope. Factors like the slope's steepness, the directing role of valleys, and the layout of stream networks substantially affect how runoff behaves.
   - **The role of topography in flood risk and water distribution:** The combination of the area's flow patterns, and topographical characteristics is crucial in identifying flood-prone zones and how water disperses across the city. Lower-lying and flat areas, particularly near water bodies, tend to be more vulnerable to flooding due to their position in the landscape as long as no adequate infrastructure is developed.
   - **Topographical constraints on urban expansion:** The physical landscape determines potential avenues for urban development. Areas with steep inclines or within floodplains present challenges, either limiting expansion or necessitating significant investment in infrastructure to make them suitable for development.
   - **Topography determines substantially the layout of infrastructure development:** The slope of the terrain determines the flow of water in canals, drainage, and sewage systems. If the slope is insufficient, the water flow must be ensured via pumping stations. This can involve considerable investment and operating costs
4. **Vegetation** plays a crucial role in the water cycle, local climate, and biodiversity of the overall catchment of a city. It has an important role in the functioning of blue-green infrastructure and its eco-system services. Any comprehensive water management approach should consider the multitude of vegetation in the wider water catchment and in the urban area:

- **The system of vegetation roots and fungi**, often in the form of mycorrhizal associations, plays a crucial role in soil stabilization, maintaining water quality and infiltration of water into the soil. Land use changes to forests, wetlands, grasslands, and agricultural areas is directly linked to changes in vegetation cover and may result in increased soil erosion, and impacts natural water treatment and water runoff. Loss of vegetation in the broader water catchment and in the urban areas may result in increased water runoff, respectively an increased vulnerability to flooding.

- **Rich riparian vegetation** is crucial for maintaining the health of rivers and streams. Vegetation slows down stream flow, stabilizes the banks and is an important habitat for aquatic life that contributes to the health of the water system. In order to maintain these eco-system services, a rethink has been taking place in the professional world for years. Instead of exclusively channeling flows and streams, hybrid solutions that combine grey with blue-green infrastructures are increasingly being sought today.

Paddy fields in the outskirts of Sam Neua
(Source: BORDA, 2022)

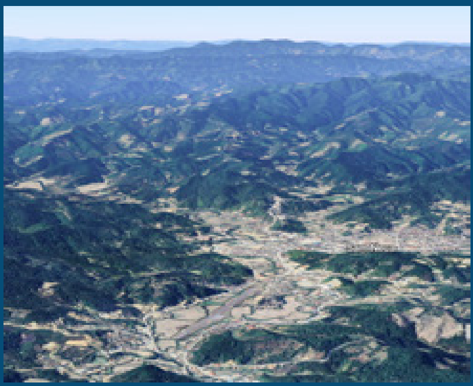
- **Evapotranspiration** plays a pivotal role for the climate in the overall catchment area and in the city itself. Changes in vegetation cover may result in more humidity and higher temperatures and may exacerbate the impacts of climate change. Green infrastructure management and development is paramount for maintaining a pleasant local climate and the livability of the cities and should be an integral part of effective climate change adaptation.

5. **The characteristics of the textures of soils** are vital in determining their ability to infiltrate and retain water, which is essential for the development of blue-green infrastructure, such as those utilized in flood management.

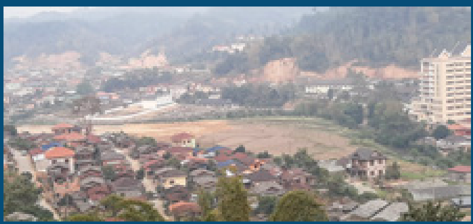
   Soils with a loose, granular structure allow more water to infiltrate and are better for storing water. Clay, silt, and sandy soils each have different infiltration rates and water-holding capacities.

   Strongly compacted soils, often resulting from deforestation or the loss of vegetation cover, can significantly reduce infiltration capacity thus limiting the effectiveness of Nature-based Solutions. This may be considered for the configuration of infrastructure that is aimed to be effective and sustainable.

Example 12: Understanding the topography of a city and its relevance for flood vulnerability - Sam Neua, Lao PDR



Topography of Sam Neua
(Source: Google Earth, 2025)



Suburban area of Sam Neua
(Source: PUW & Partners Own Work, 2022)

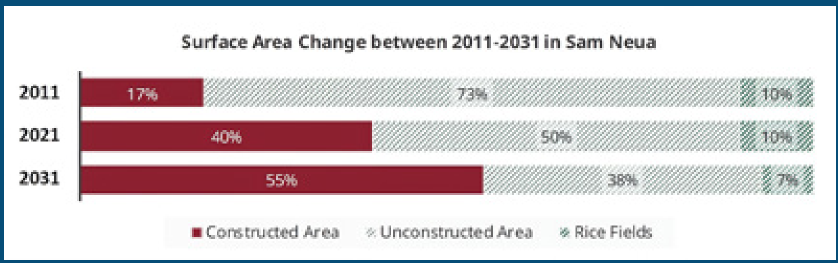
Sam Neu is located in the Annamite Range, which stretches along the border between Lao PDR and Vietnam. An analysis of the topographical conditions shows that Sam Neua is defined by its deep, narrow valleys surrounded by steep hills and mountains. The urban area of Sam Neua is primarily located in a valley along the Nam Sam River, which flows through the city. This river and its tributaries are critical to the region's drainage system.

The city can only grow primarily along narrow mountain slopes and riverbanks, and agricultural land, i.e. mainly rice fields, is rapidly being displaced by new settlement structures. Most of the urban development can expand only along the valleys and riverbanks.

When modelling urban growth, it can be predicted that by 2031 55% of the overall city area will be settlement area, compared to 17% in 2011 and 40% in 2021. This results in a kind of 'bathtub effect' in the overall city area, which significantly intensifies water runoff especially during heavy rainfall events.

There is intense land use change in the water catchment area. Forests are converted into agricultural land resulting in the loss of soils' drainage capacities and consequently intensified water runoff.

Apart from the down-town area, inundations occur increasingly in the zones of the peri-urban and rural areas. Already in 2022, community members reported



Surface change Sam Neua 2011-2021 *(Source: PUW & Partners Own Work, 2022)*

Flooding of suburban area 2024
(Source: Pathedlao Newspaper, 2024)

that flooding regularly washes away protective structures having a strong impact on settlements and agricultural harvests.

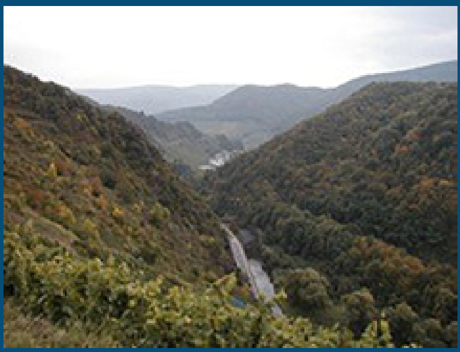
Although there was in 2022 a growing awareness among public entities, communities, and private investors about flood risks, there was still a lack of systematized knowledge regarding danger zones and, more importantly, the potential future dynamics of these risks.

The diagnosis from the Baseline Assessment revealed a significant flood risk for the overall settlement area, although the short-, medium-, and long-term risk potential was difficult to estimate until severe flooding occurred in the city in September 2024, along with flash floods in peri-urban areas. After analyzing video and photographic material, as well as oral reports from local observers, large parts of the urban area will likely need to be classified as high flood risk zones. This is particularly concerning given the ongoing dynamic changes in land use patterns and the likely intensifying effects of climate change.

For a final assessment of the risk potential, however, more in-depth investigations are now required. In order to reduce or mitigate vulnerability to floods and landslides, the following measures should, among others, be implemented:

1. Modeling of various flood scenarios and detailed mapping of existing and potential risk zones throughout the urban area and in peri-urban areas.
2. The development of a flood risk prevention, mitigation, and response plan covering urban, peri-urban, and rural areas.
3. This plan should include a short-, medium-, and long-term infrastructure development strategy that identifies measures and interventions that can be realistically financed and effectively managed with the available capacities.

Example 13: Understanding the topography of a city and its relevance for flood vulnerability - Ahr-Valley, Germany



Topography Ahrtal
(Source: Ralfk, Wikipedia, 2021)

Flooding Altenahr-Kreuzberg 15. July 2021
(Source: Martin Sei-fert/Wikipedia, 2021)

When evaluating the data from baseline assessments for assessing flood vulnerabilities of a city, incorporating lessons learned from similar situations is beneficial.

At the time of the preparation of the baseline assessment for Sam Neua in July 2021, large parts of Western Europe were affected by extensive floods and massive damage events, during which at least 220 people died and the total damage amounted to approximately 46 billion Euros.

The evaluation of the data on the topographic location of Sam Neua, the dynamics of changes in land use patterns, and rainfall regimes was enlightening for assessing the increasing vulnerability to flooding events in the city.

Due to a particular weather situation, massive rainfall occurred in large parts of Western Europe in early July 2021. In the Eifel Mountains, there were intense rains of 150 to 200 litres per square meter within 48 hours. Although it is not unequivocally clear that this heavy rainfall event can be attributed to climate change, climate simulations show a significantly increased probability of this.

As a result of the rainfall, the water levels of numerous rivers rose. A denser construction in the floodplain reduced the flow area and, therefore, the local water levels rose disproportionately. Factors that contributed to the high runoff regime include deforestation, soil sealing, dried-out soils, and/or incorrectly dimensioned and missing flood protection measures.

As in Sam Neua, the topography of the water catchment of the Ahr-Valley, which was particularly affected by the flood disaster, is characterized by narrow valleys. Small water streams flow into the Ahr river, which then flows into the Rhine River. Increasingly dense construction in the floodplain since the 19th century has reduced the flow area and therefore contributed to disproportionate rises in local water levels. The increasing vulnerability to flooding events has been known since at least the 1920s. At that time, extensive measures for the construction of water retention basins had already been planned but were never built due to other political priorities.

In the Ahrweiler district, 124 people lost their lives, 760 were injured, significant infrastructure, such as roads were destroyed, and numerous houses collapsed. (Neue Zürcher Zeitung, 2012)

Today, there is a public and professional debate on how to prevent such disasters in the future. The following measures are being discussed:

1. Enhancing efforts to renaturalize land as floodplains,
2. Development of a system of 19 large water retention structures including management of the schemes throughout the water catchment. Retention structures are only effective if they are emptied of water before a heavy rain event hits the region,
3. Spatial and urban planning and its enforcement preventing settlements in particularly high-risk areas.

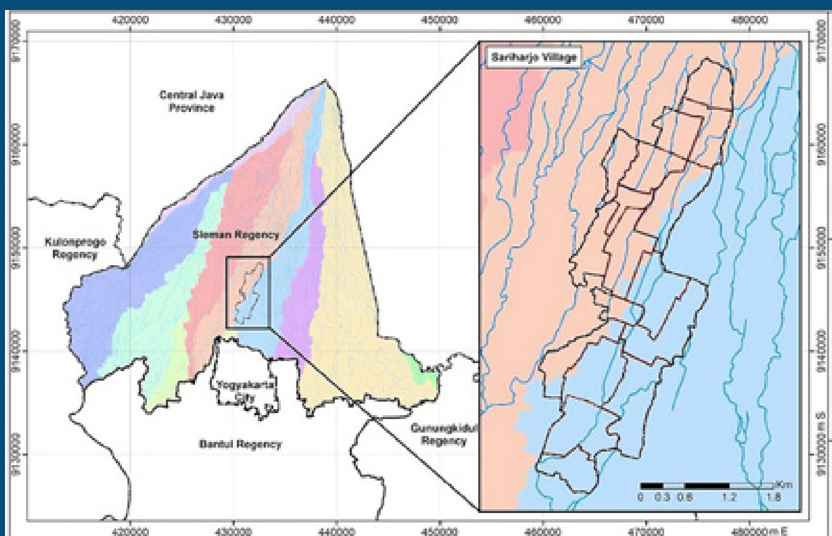
Damage in the city of Pepinster *(Source: European Union, 2025, Wikipedia)*

Example 14: Topography and hydrology and flood occurrence in the context of dynamic urbanization – Sleman Regency, Indonesia

View of Mount Merapi and topographical profile of Sleman
(Source: PUW & Partners Own Work, 2023)

The topography of Sleman Regency is dominated by Mount Merapi, an active stratovolcano with a peak elevation of 2880 meters above sea level, and one of the most active volcanoes globally. The settlement areas within Sleman Regency are characterized by moderate to steep slopes, which influence both water flow and soil stability, creating challenges for land use and urban development. The region experiences a tropical monsoon climate, characterized by a pronounced wet season with high annual precipitation levels, averaging 2283.6 mm. The wettest month is typically January, with an average rainfall of 349.8 mm.

Flooding is a recurrent issue in Sleman Regency, particularly in areas adjacent to the major rivers, the Code River, Boyong River, and Opak River. These rivers are prone to overflowing during heavy rainfalls, contributing to flood disasters of low to moderate severity. In particular, the Opak River in the Prambanan Subdistrict and areas in central Sleman, such as Sariharjo Village in the Ngaglik Subdistrict and Depok Subdistrict, are identified as high-risk flood zones. The region's hydrological regime is further impacted by rapid urbanization, particularly in the expanding metropolitan area of Yogyakarta. This urban growth, which has been concentrated in uphill areas,



Water catchment of Sleman *(Source: PUW & Partners Own Work, 2023)*

Flooding in Sariharjo in 2022
(*Source: PUW & Partners Own Work, 2022)*

exacerbates stormwater runoff due to the reduction of agricultural and vegetative cover, which historically facilitated natural infiltration processes.

The loss of permeable surfaces due to the expansion of settlement areas has resulted in increased surface runoff during heavy rainfall events. The existing drainage infrastructure is insufficient to handle this increased volume of water, leading to frequent flood occurrences. As urbanization continues, it is anticipated that the increased runoff will accumulate in downstream areas, further elevating flood risks in these regions.

In response to these challenges, local authorities have implemented a series of flood mitigation policies aimed at improving water management in Sleman Regency. These include the promotion of biopore infiltration holes and infiltration wells, the protection and conservation of groundwater recharge areas, stream restoration projects, and the revitalization of water infrastructure. However, these localized measures are likely insufficient to address the broader scale of the flood risk. Given the topographical and hydrological complexity of the region, larger-scale infrastructure projects, such as the construction of water retention basins, are necessary to mitigate the impact of increasing surface runoff effectively.

The development of robust hydrological models is essential for informing future infrastructure planning and flood risk mitigation strategies. These models must account for key parameters, including the region's topography, the spatial expansion of urban settlements, and variations in precipitation patterns.

Additionally, scenario-based modeling should be conducted to explore the impacts of different urban development pathways and drainage infrastructure improvements. A realistic assessment of the capacity of current and planned drainage systems – consisting of grey infrastructure and blue-green infrastructure – is critical to identifying gaps in flood preparedness and informing the design of future flood mitigation efforts.

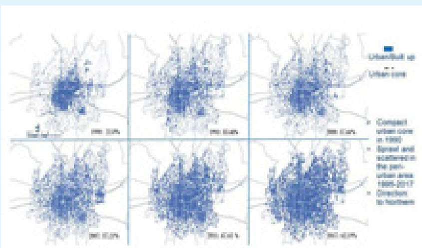
4.5.2. Urban characteristics

Key Takeaways:

A baseline assessment analyzing urban characteristics should focus on providing insights relevant to the specific interest of information.

For example:

- For an analysis of **current water challenges**, it should give a comprehensive overview of how urban economic structures, settlement patterns, and infrastructure are influencing water demand, supply, and distribution. This includes assessing how urban growth, informal settlements, and industrial zones are impacting the city's water systems.
- For a **projection of future water challenges in the context of urban development**, it should offer forecasts that take into account anticipated population growth, urban sprawl, and industrial expansion. This projection would provide insights into how ongoing trends could intensify water demand, affect water quality, and exacerbate issues with infrastructure, especially in the absence of improvements in water management.
- For an analysis of **diverse urban development trends and their impacts** on water management, the assessment should include a detailed analysis of various urban areas, such as densely populated centers, suburban expansion areas, and peri-urban settlements. It should analyze how these different patterns of development create unique water management challenges, such as higher water consumption in planned residential areas versus inadequate services in informal settlements.



Urban growth of Yogjakarta Metropolian Area between 1996 and 2022
(Source: PUW & Part-ners Own Work, 2023)

A baseline assessment on the specific urban characteristics should:

1. **Analyze current water challenges linked to urban economic and settlement patterns** by assessing how the present urban economic structures and settlement distributions are influencing specific water-related challenges. This includes understanding the impact of urban growth on demand in terms of provision of water services and for infrastructure development.

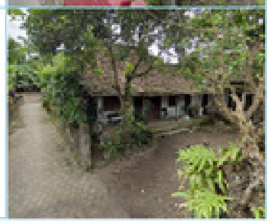
2. **Forecast future water challenges based on urban dynamics** by predicting how ongoing urban development and economic growth trends are likely to intensify or alter water challenges, assuming no improvements in management structures. This projection should account for factors like expected population growth, industrial expansion, and urban sprawl.

3. **Identify diverse urban development trends and their impacts** by recognizing that urban development trends may vary significantly within different parts of the city. This aspect of the assessment should detail how these various trends – such as high-density urbanization in one area versus suburban sprawl in another – impact water management needs and challenges in different ways.

It may be helpful to analyse urban development trends and their respective settlement patterns considering the following features:

- **The development of a local economy** propels population growth, new production, services and consumption patterns with related patterns of water uses and waste generation. An industrial sector may range from small-scale manufacturing to more advanced industries; an agricultural sector may include traditional farming and modern agribusiness; the service sector may include tourism, retail, local markets and (higher) education. Often, they are the seat of provincial governments.

- Secondary and tertiary cities are marked by a **diverse array of building types and settlement patterns**. This may include industrial zones characterized by factories, commercial buildings and warehouses. Buildings are the visual economic characteristics of an urban area, such as shops, restaurants, hotels, and other service-oriented establishments that cater to the daily needs of the residents, tourists, and other visitors to the city. Government buildings, marketplaces, and hospitals are critical for the city's administrative, commercial, and healthcare needs, respectively.

Settlement Type	Illustration
Commercial buildings (shops, restaurants, hotels, etc.)	
Apartment blocks	
Formal housing (Real Estate)	
Formal individ-ual/sprawled housing	
Informal tradi-tional village	
Informal new housing	

Settlement typology of Sariharjo
(Source: PUW & Partners Own Work, 2022)

- **Residential areas may exhibit a mix of settlement patterns.** Formal housing developments, such as apartment blocks and gated communities, often managed by real estate companies, provide planned and well-equipped living spaces and are the most visible signs of modern urbanisation. Individual or sprawled housing represent a more dispersed form of urban growth very often along arterial roads.

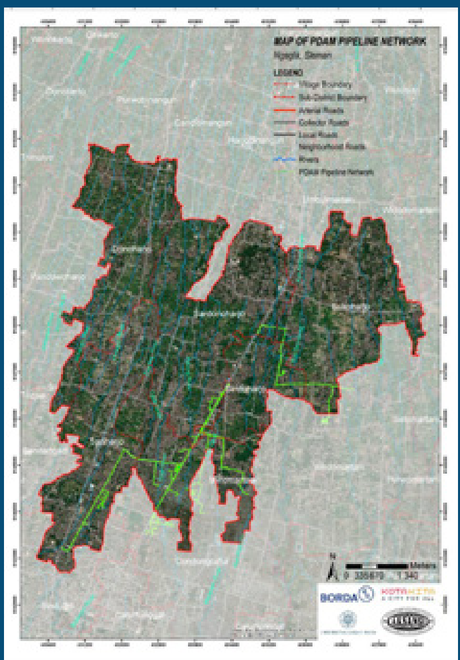
- **Generally, urban centres are experiencing a trend in densification,** which often leads to the reduction of green spaces in both private properties and public areas. This process involves transforming existing open or green areas into more densely developed spaces, accommodating the growing needs for housing and infrastructure in city centres.

- **Urban development is predominantly propelled by the real estate market.** New urban development areas, in particular, often emerge rapidly, often only following urban development guidelines to a limited extent and highlighting the dynamic and largely unplanned evolution of the city's fabric. Many cities still have in their peri-urban areas, "traditional“ areas where the original rural and agricultural character often is still tangible. However, these areas are often gradually upgraded with improved infrastructure and building structures.

- **Informal settlements** are developed and inhabited primarily by poorer inhabitants in unsecured areas such as riverbanks or along industrial sites.

Example 15: Urbanisation trends and their impacts on water use patterns - Sariharjo/ Sleman Regency, Indonesia

New apartment blocks in Sariharjo
(Source: PUW & Partners Own Work, 2023)



Water supply network in Sariharjo
(Source: PUW & Partners Own Work, 2023)

The water needs and water use patterns of rural communities differ substantially from those of urban communities. With the growth of cities and the associated cultural shift towards urban societies and their general consumption patterns, urban water consumption patterns are becoming increasingly prevalent.

In 2020, Sariharjo had a population of 21,438 registered residents compared with 16,664 in 2010. Models project a total population in 2030 (including non-registered residents) of approximately 34,000 residents. Recent studies found that domestic water consumption in Indonesian urban areas is ranging from 89 to 244 liters/capita/day and in rural areas from 34 to 194 l/c/d. Legal regulations in Indonesia assume a per capita fresh water consumption for rural areas of 80 l/c/d and for urban areas 120 l/c/d.

Today's population growth combined with higher per capita water consumption already translates into significant pressure on water resources. In future, this will be exacerbated unless effective management schemes in water supply and wastewater treatment are implemented.

So far, the water-related infrastructural development lags behind urban development requirements. Piped water supply by the operator PDAM is ensured only along a few arterial roads. In 2021, only 948 households out of the 5908 (17%) in Sariharjo were connected to the water supply system of the public water utility.

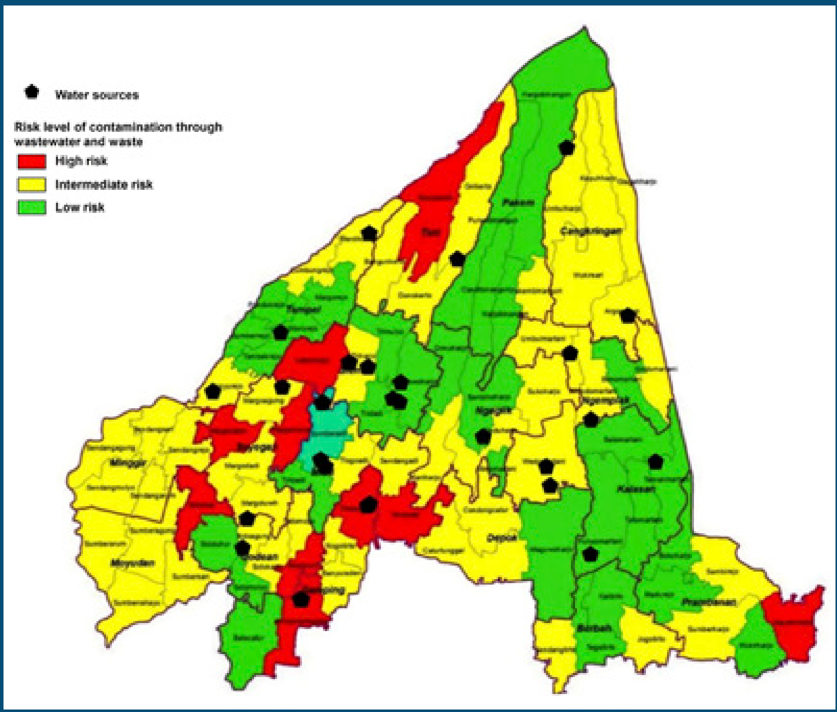
The aquifers show significant changes in the water tables. Between 2011 and 2017 annual decreases in the groundwater levels in the Sleman Regency in the range of 0.1– 0.26 m/year were observed.

For managing wastewater, 92% of the households in Sariharjo still use soak pits. Improved septic tanks are not used. Therefore, fecal sludge is not safely managed. 499 HH (8%) are connected to five communal water treatment plants.

As of now, inadequate water management patterns have a negative impact on public health, the environment, and water resources in Sleman Regency. The water quality of most of the water reservoirs in the Sleman Regency has severely deteriorated.

The Baseline Assessment for Sariharjo suggested to the public administration of Sleman Regency among others the following strategic interventions until 2027:

1. 100% of new residential areas, commercial facilities and private homes are connected to the PDAM services.
2. 100% of all new residential areas, public buildings and private sector facilities are connected to improved septic tanks at least or more advanced technologies.
3. 50% of the existing building stock or residential areas will be progressively connected to improved septic tanks and sewerage systems.
4. Area-wide septage management will be ensured by effective law enforcement in accordance with existing regulations.



Water pollution in Sleman Region, 2022 *(Source: PUW & Partners Own Work, 2023)*

4.5.3. Land use patterns and settlement patterns and their water-related impacts

Key Takeaways:

A baseline assessment analyzing land use and settlement patterns for water security should provide focused insights.

For example:

- **Current land use patterns:** Assess how residential, industrial, and agricultural zones impact water resources. High-density residential areas increase water demand, industrial zones can cause pollution, and converting agricultural land reduces groundwater recharge.
- **Future impacts of urban growth:** Forecast how urban sprawl, unplanned settlements, and population growth will strain water resources. Urban sprawl increases surface runoff, unplanned areas may face water access issues, and population growth puts stress upon infrastructure.
- **Urban densification:** Analyze how densification reduces green spaces, increasing surface runoff and water demand. Densified areas create urban heat islands, and informal settlements lack adequate drainage, causing water contamination risks.

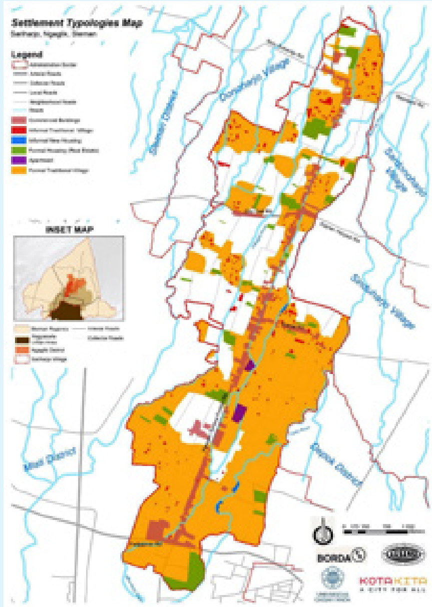
A baseline assessment should offer a comprehensive understanding of the interactions between land use patterns, settlement dynamics, and their present or future impacts on water security. When focusing on water-sensitive urban development in a district or neighborhood, it is crucial to contextualize it within the broader city development framework.

Here is how the assessment can be structured to address the interest of information:

1. Current Land Use Patterns and Impacts:

- **Temporal Analysis:** The assessment should track the evolution of land use over time, identifying key shifts such as urban expansion, deforestation, or conversion of agricultural land. This helps in understanding how historical land and current land use changes are shaping water security challenges, such as altered runoff patterns or reduced groundwater recharge.

- **Detailed Categorization:** Urban areas of interest should be classified into categories: residential, commercial, industrial, and agricultural zones, etc. Additionally, the assessment should map and evaluate blue-green infrastructure (for instance, gardens on private and public premises, parks, wetlands, rivers) and analyze how well these resources are integrated into the urban fabric, affecting water absorption and runoff management.
- **Impact Analysis:** Each land use category should be assessed in terms of its impact on water demand, runoff generation, and pollution. For instance, industrial zones might contribute to higher pollution levels, while residential areas may influence water consumption and wastewater production.



Settlement typology map of Sariharjo
(Source: PUW Partners Own Work, 2023)

2. Modeling Urban Growth Trends:

1. **Analysis of Urban Growth:** This part of the assessment focuses on identifying the patterns and dynamics of urbanization across the city or neighborhood of interest. This analysis would reveal how urban sprawl or densification has progressed and its associated water impacts, including increased demand for infrastructure and changes in water flow dynamics.
2. **Trend Analysis:** By capturing development trends like unplanned growth or identifying typologies, such as apartment blocks, gated communities, commercial hubs, or traditional neighborhoods, the assessment should link these trends to water use patterns and infrastructure demands. For example, gated communities may have higher water consumption due to green space maintenance, while unplanned areas might lack sufficient water services.
3. **Urban Densification:** The assessment should analyze how increasing density in urban areas impacts green spaces, surface runoff, and water management. Densification often leads to new runoff patterns, reduced groundwater recharge, and worsening urban heat island effects, posing challenges for managing both water supply and quality.

Example 16: Dynamics of the real estate sector and its impacts on blue-green infrastructure - Indonesia

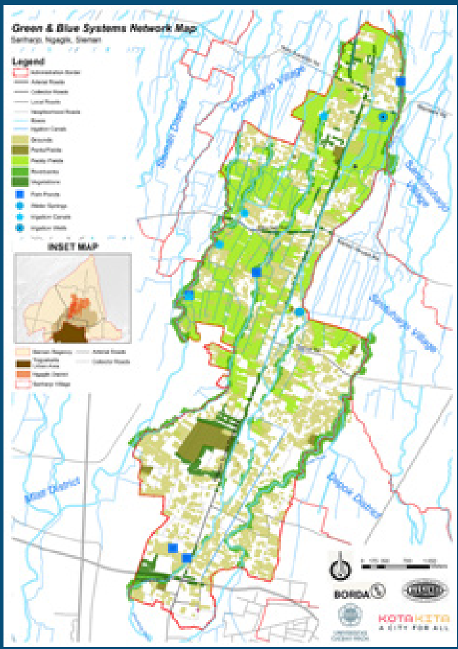
Recently developed gated communities in former paddy field area
(Source: PUW & Partners Own Work, 2023)

Because of its proximity to Yogyakarta city center and to leading educational institutions and its climatically and naturally attractive location, Sariharjo is already and will be in future even more attractive for higher-priced residential and commercial areas.

It can be predicted that by 2035 Sariharjo will be characterized as a settlement and business area primarily comprised of the middle classes, upgraded traditional village centers, and settlement areas in its peripheral zones for lower-income population groups. A considerable number of business places, middle-class settlement areas, hotels and restaurants will significantly shape the village and landscape image. So far, the process of urban transformation and land use change in Sariharjo takes place largely without urban planning guidelines and is driven by a fairly uncontrolled real estate market.

The agricultural land and riparian zones play a major role in the mitigation of water runoff, the protection of water resources, the functioning ecosystems and the high quality livability of Sariharjo and its neighboring areas. These blue-green infrastructures are still mostly maintained by local communities, farmers and day labourers.

Sariharjo is experiencing a dynamic change in land use patterns, in which rice fields and agricultural green spaces are increasingly giving way to settlement areas. Between 2000 and 2015, 35.73 percent of the paddy field areas in the Ngaglik sub-district have been converted to built-up land. It can be assumed that by 2035 the "traditional" economy based on smallholder production will have been reduced to only a few pockets.



Map on blue-green infrastructure in Sariharjo *(Source: PUW & Partners Own Work, 2023)*

The retreat of agriculture in Sariharjo is largely due to its low productivity, rising production costs, and the rapid increase in land-prices. In 1997, land was valued at 100,000 IDR/m^2, in 2022 it was 10-15 million IDR/m^2 (650-950 US-$).

This transformation of land use patterns towards urban areas will have multiple impacts such as:

- Increased runoff of surface waters may contribute to increased flood vulnerability as long as no mitigation measures are implemented, such as effective water retention, drainage and infiltration structures.
- A high degree of sealed areas and loss of green areas will be synonymous with changes in the local climate, potentially an increase of day and night temperatures, especially in the dry season.
- This trend may be exacerbated by climate change. Adequate green space development including public green spaces, greeneries at private and public properties and agricultural land should be addressed in a master plan and other (sub-)village planning.

Aerial view of recently developed gated communities
(Source: PUW & Partners Own Work, 2023)

4.5.4. Infrastructure development

Key Takeaways:

A baseline assessment for infrastructure and public services in urban areas should focus on key challenges and responses.

For example:

- **Current demands for infrastructure:** Assess water demand across residential, commercial, and industrial sectors, and examine how well current infrastructure (drainage, water supply, waste management) meets these needs, including technical and financial performance.
- **Future demands and challenges:** Project future needs based on urban growth, climate change impacts, and economic trends. This includes forecasting increased pressure on water retention, waste management, and wastewater systems.
- **Gap analysis:** Identify infrastructure shortcomings, such as overloaded drainage systems or inadequate sewage management, and assess management weaknesses in maintenance, governance, and stakeholder involvement.
- **Conclusions and recommendations:** Depending on the study's focus, suggest strategies, such as flood protection through wetlands or grey and Nature-based Solutions, or targeting pollution hotspots with improved waste and septic management practices.

The development of effective infrastructure and public services for urban areas encompasses a wide array of challenges. Advances in infrastructure development must be aligned with the establishment of strong management practices, sustainable financing mechanisms, and thoughtful urban planning, all underpinned by efficient governance systems.

In conducting a baseline assessment, it is essential to pinpoint key factors influencing these areas. Specific challenges and corresponding responses are outlined in the accompanying examples in this guide.

Landfill of Sam Neua
(Source: PUW & Partners Own Work, 2022)

Water drainage system in Sariharjo
(Source: PUW & Partners Own Work, 2022)

General Trends

The cities in Southeast Asia have made considerable progress in securing the supply of drinking water in recent decades.

The drainage systems for managing rainwater have also been expanded in line with the expansion of the road systems, but are overloaded in many places, especially during heavy rainfall events.

Cities report the need for infrastructure to expand water retention capacities to manage water runoff and to store water in the face of prolonged dry periods.

Sewage management is generally severely deficient to cope with increasing volumes of used water, posing a significant threat to public health and ecosystems.

The generation of waste and the generation of toxic waste associated with the emergence of new consumption patterns among the urban population is offset by inadequate waste management capacities, which causes considerable problems in the final disposal of waste, particularly in densely populated areas.

Information Needs

- **Diagnosis:**
    - **Analysis of Current Demands for Infrastructure and Services:**

      Assess the current demand for water and related services.

      Evaluate variations in demand across different areas and sectors (residential, commercial, industrial).
    - **Analysis of Existing Infrastructure and Service Structure:**

      Examine the coverage, capacity, and condition of existing infrastructure including drainage systems, water supply networks, wastewater and waste management facilities.

      Assess the technical performance, including efficiency, reliability, and quality of services.

      Evaluate financial performance, including cost-recovery, funding mechanisms, and investment needs.

- **Analysis of Practices Not Covered by Public Services:**

  Investigate the prevalence and impact of alternative water sources, such as private wells.

  Assess the use of informal solutions like soak pits for wastewater, understanding their prevalence, effectiveness, and environmental impact.

  Identify areas with high levels of water pollution, considering both point and non-point sources.

- **Prognosis:**

  Project future demand based on population growth, urbanization trends, and economic development.

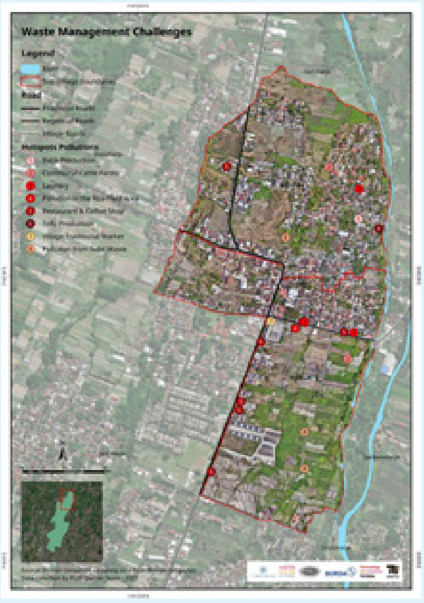
  Consider the impact of climate change on water resources and infrastructure.

- **Gap Analysis:**

  Identify gaps in the existing infrastructure and service delivery, including areas with inadequate coverage or poor service quality.

  Analyze shortcomings in current management practices, including maintenance, governance, and stakeholder engagement.

  Identify potential challenges in scaling up or maintaining existing infrastructure to meet future demands.



Pollution hotspots in Sariharjo
(Source: PUW Partners Own Work, 2023)

Conclusions and Recommendations:

Depending on the level of detail of the baseline assessment - be it for an entire urban area, an urban district or a neighborhood - the analysis can be used to make initial recommendations for strategy development.

- **For example,**
  - If the focus of the analysis is on improved flood protection of the entire urban area, general recommendations can be made on the protection of wetlands, and the systematic development of grey and Nature-based Solutions for water retention and infiltration.
  - If the focus of the analysis is on the identification of the sources of water pollution in an urban district, specific technical recommendations for targeting the pollution hotspots and for improved septic management can be made.

4.5.5. Vulnerability analysis

Key Takeaways:

A baseline assessment on rainfall events and river flooding should provide clear insights into water management risks.

For example:

- **Impact on water management:** Evaluate how changes such as deforestation, increased impermeable surfaces, reduced natural drainage, and slope destabilization increase the risks of flooding and landslides.
- **Rainfall scenarios:** Consider short, intense rainfall, prolonged rainfall, and torrential rain on saturated ground.
- **River flooding scenarios:** Assess risks from continuous rainfall, sudden river surges, structural failures, storm surges, and rising sea levels, especially in low-lying and coastal areas.
- **Modelling:** Elaborate flood scenarios over the next decades taking into account further parameters, such as probable land use changes and changing rainfall regimes.
- **Flood-prone area identification:** Map vulnerable areas using topographic and hydrological data, categorizing flood types (riverine, coastal, urban, etc.).

- **Impact on Water Management:** Evaluating how changes in the water catchment area, increased impermeable surfaces, reduced natural drainage or destabilization and slopes contribute and will contribute to risks such as flooding and landslides.
- **Several Rainfall Event Scenarios:**
  - Short-duration, high-intensity events may cause flash flooding in urban areas where water cannot be absorbed quickly due to impervious surfaces such as concrete and asphalt. These events can overwhelm drainage systems, leading to urban floods even in areas that may not usually be prone to flooding.

- Long-duration, low-intensity events with prolonged rainfall over a longer period can cause rivers to overflow, increasing the risk of riverine flooding, especially in areas near water bodies.
- Torrential downpours on saturated ground may affect areas that have already received significant rainfall, the ground becomes saturated and cannot absorb more water, making both urban and rural areas prone to surface water flooding or landslides in mountainous or hilly terrain.

- **River Flooding Scenarios:**
  - Continuous rainfall may cause rivers to overflow, especially in low-lying floodplains.
  - Intense rainfall may cause a sudden rise in small rivers and streams, often leading to localized but severe flooding.
  - Structural failure of dams or flood protection systems and mismanagement of these systems can trigger sudden, catastrophic flooding in downstream areas.
  - Coastal rivers may flood due to storm surges that prevent river water from draining into the sea, causing backflow and flooding.
  - Rising sea levels and increased extreme weather events (more rain and storms) intensify river flood risks, especially in low-lying areas and coastal regions.
- **Flood-Prone Area Identification:** Mapping flood-prone areas by integrating topographic data, data on land use patterns, and hydrological models, and historical flood information. Categorize different types of flood-prone areas (riverine, coastal, urban, flash, groundwater, estuarine, landslide-induced, and artificial infrastructure).

Example 17: Topography, hydrology and flood vulnerability - Kratié, Cambodia

View of Kratié and Mekong River
(Source: PUW & Partners Own Work, 2023)

The character and urban layout of Kratié, much like other cities along the Mekong River, is deeply shaped by the River's dynamics and the surrounding wetlands. Primarily built on a sandbank, this provincial capital is defined not only by the Mekong's powerful flow but also by the vast floodplains and wetlands encircling it, which play a vital role in the region's ecology and in the livelihoods of its inhabitants.

As the Mekong swells in early June and reaches its peak in October, these wetlands fill, acting as a natural expansion basin for the rising waters. This so-called "lake area" around Kratié temporarily transforms into a large water body, as the river seeks space to accommodate its growing volume. This annual flooding represents both a natural cycle and a major challenge for the city's residents and its infrastructure.

When the Mekong rises to around 22 meters, large parts of Kratié begin to flood. Once the water level exceeds 22.5 meters, the situation becomes critical, as floodwaters inundate much of the urban area, triggering what effectively becomes a disaster. Homes, businesses, and public spaces are exposed to rising waters, and the city’s functionality is severely compromised.

Kratié's hydrological and topographical profile greatly influences its urban growth and infrastructure development options. Urban planning must account for flood risks, with buildings and streets designed accordingly. Adaptive strategies are essential to manage the regular cycles of rising and falling water. In response, Kratié has begun filling wetlands to create new residential areas, improving drainage systems, and planning additional flood barriers, although these measures remain in the early stages.

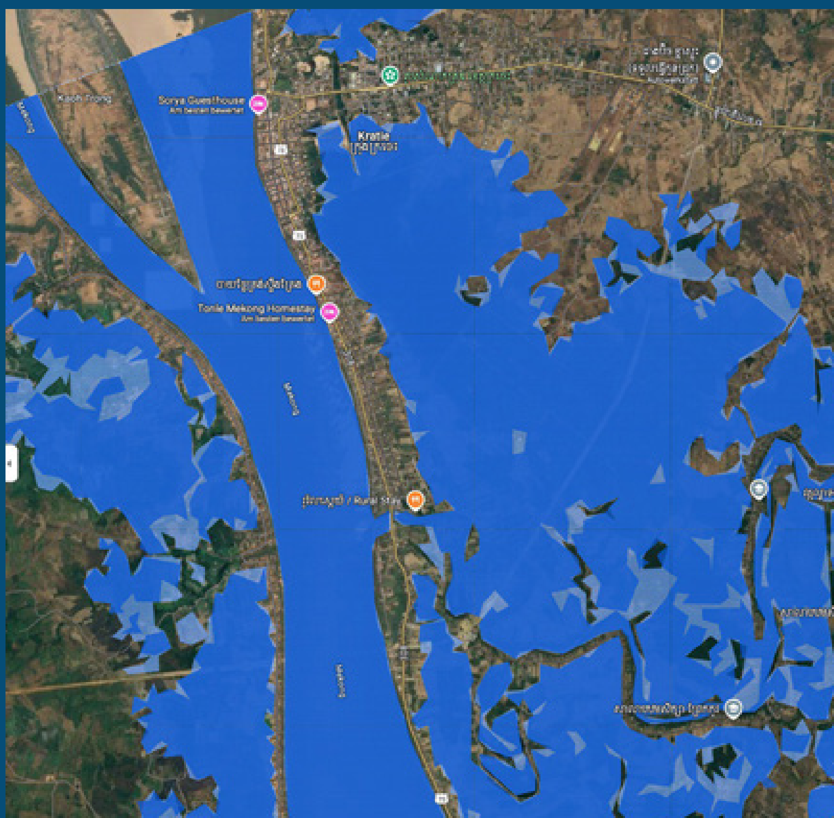
While these annual floods pose significant challenges, they also bring essential benefits that profoundly shape the city’s economy and culture. The floodwaters nourish the surrounding agricultural land, providing critical nutrients that enhance soil fertility. Local farmers

Flooded peri-urban areas of Kratié, November 2024
(Source: PUW & Partners Own Work, 2024)

depend on this cycle to grow rice and other crops, making the Mekong River both a source of sustenance and, at times, hardship.

A flood level between 19.5 and 21 meters is considered optimal for agriculture and ecosystem support. This highlights the sensitivity of this vast blue-green infrastructure to land use changes and upstream developments, which can significantly impact flood levels. Urban interventions, such as filling in the lake area for expansion, may alter the natural flow regime and reduce its function as a water buffer for the city, potentially increasing the risk of flooding. Additionally, these changes could weaken the livelihoods of local communities who rely on the river's natural cycles.

Kratié's hydrology and topography create a tension between the city's development needs and environmental preservation. Given the limited institutional and financial capacity of the local and provincial governments, it is difficult to resolve this tension through adequate infrastructure development. Without proper planning and investment, the city risks exacerbating the very flood hazards it seeks to mitigate, while also undermining the natural systems that sustain both the economy and the communities of Kratié.



Urban areas of Kratié flooded in November 2024 *(Source: Google Earth, 2024)*

4.5.6. Framing water-sensitive urban transformation within governance structures and policies

Key Takeaways:

A baseline assessment on governance structures and decision-making processes for urban development and water management should focus on key insights.

For example:

- **Alignment with policies:** Assess how water-sensitive urban transformation can be integrated into existing national and local policies, such as climate resilience, public health improvements, and urban modernization, to secure support from key decision-makers.
- **Regulatory development:** Identify gaps in existing regulations, such as outdated laws and weak enforcement, and propose reforms for legal harmonization, standardized building codes, and stronger enforcement mechanisms to support sustainable water management practices.
- **Stakeholder engagement:** Analyze the capacities and roles of key stakeholders, including local governments, communities, private sector actors, and civil society, to create more inclusive and effective governance structures for water-sensitive urban development.
- **Sustainable financing:** Explore funding models, such as public-private partnerships and user fees that ensure the long-term operation and maintenance of water-sensitive infrastructure.

A comprehensive baseline assessment must deeply reflect on existing governance structures and decision-making processes, recognizing substantial differences among countries similar to Lao PDR, Cambodia, and Indonesia. Understanding the actual procedures that shape urban development is crucial, particularly since construction activities—especially in **peri-urban areas**—often only partially comply with regulatory guidelines. This non-compliance presents challenges but also highlights **development potentials** and opportunities for **innovation**, such as leveraging **private investments** to support water-sensitive urban transformation.

Importantly, the baseline assessment should not only identify measures for water-sensitive transformation—such as wastewater management systems, green spaces, and flood protection measures—but also propose **actionable options** for governance structures in urban development and water management. Embedding these measures within appropriate governance frameworks ensures their longevity, effectiveness, and sustainable operation and maintenance.

Alignment with National and Local Development Policies

Integrating water-sensitive urban development into existing **national and local policies** is essential for securing support from key decision-makers. By reviewing national development plans, urban growth policies, and water management strategies, areas where water-sensitive initiatives can seamlessly fit are identified. These initiatives should be positioned as integral components of ongoing national goals like **infrastructure development and economic growth**, rather than as separate endeavors.

Water-sensitive urban development aligns with objectives including:

- **Climate Resilience:** Mitigating the impacts of climate change through adaptive infrastructure.
- **Public Health Improvements:** Enhancing water quality and sanitation services.
- **Urban Modernization:** Incorporating innovative technologies and sustainable practices into urban planning.

Demonstrating how water-sensitive projects contribute to broader priorities—like **flood prevention, water conservation,** and **energy efficienc**y—allows local governments to position these initiatives as critical to achieving long-term development goals.

Alignment with Urban Development Priorities

Water-sensitive urban development should be framed as a **value-adding component** that enhances existing priorities such as **housing, transportation, energy**, and **economic growth**. Introducing new water management approaches can complement and enrich these priorities, making them more sustainable and resilient.

Examples include:

- **Housing:** Incorporating water-sensitive features into housing developments improves city livability by reducing urban heat islands and providing green spaces that enhance public health and community well-being.
- **Transportation:** Integrating sustainable water management systems into transportation infrastructure makes roads and adjacent properties more resilient to floods and reduces long-term maintenance costs.
- **Energy:** Implementing energy-efficient water systems contributes to overall reductions in urban energy consumption, supporting sustainable energy goals.

Highlighting the **economic, environmental, and social co-benefits** of water-sensitive approaches can secure broader support. These benefits include:

- **Flood Risk Reduction:** Minimizing infrastructure damage and reducing recovery costs.
- **Improved Water Quality:** Enhancing the health of waterways and lowering treatment expenses.
- **Aesthetic and Recreational Value:** Creating attractive public spaces that improve quality of life.
- **Increased Property Values:** Enhancing neighborhood desirability through green infrastructure.
- **Community Cohesion:** Providing spaces for social interaction and promoting well-being.

Regulatory Development and Harmonization

Effective water-sensitive urban development relies on robust **regulatory frameworks** governing water management, urban planning, and land use. However, existing regulations are often fragmented or outdated, leading to overlaps in mandates—particularly in **urban-rural transformation zones**—which can hinder sustainability and the scaling of water-sensitive measures.

Identifying Gaps in Legislation

- **Inconsistencies and Overlaps:** Conflicting mandates between local and provincial governments create confusion and impede implementation.
- **Outdated Regulations:** Existing laws may not reflect current best practices in water-sensitive urban design or lack provisions for sustainability.

- **Weak Enforcement:** Limited compliance in construction activities, especially in peri-urban areas, due to inadequate enforcement mechanisms.

Proposals to Address These Challenges

1. **Legal Reform and Harmonization:**
    - **Update and Align Regulations:** Revise laws to incorporate water-sensitive principles, ensuring consistency across governance levels.
    - **Standardize Building Codes:** Integrate sustainability requirements into building and zoning codes.
    - **Clarify Mandates:** Define clear roles and responsibilities for local and provincial governments to prevent overlaps.
2. **Strengthen Enforcement Mechanisms:**
    - **Capacity Building for Regulatory Bodies:** Provide training and resources to agencies responsible for enforcing regulations.
    - **Community Engagement:** Involve local communities in monitoring compliance, increasing transparency and accountability.
3. **Incentivize Compliance and Innovation:**
    - **Financial Incentives:** Offer tax benefits, grants, or subsidies for developments that adopt water-sensitive practices.
    - **Streamlined Approval Processes:** Expedite permits for projects incorporating sustainable measures.
    - **Public-Private Partnerships:** Encourage collaboration between governments and private investors to fund and implement water-sensitive projects.

By addressing legislative gaps and enhancing the regulatory framework, it becomes possible to promote sustainable water practices effectively and scale successful initiatives.

Reflection on Governance Structures and Stakeholder Capacities

Developing robust urban development and water governance structures requires an in-depth analysis of the roles and capacities of various stakeholders. A baseline assessment should highlight options for action in governance structures that are central to water-sensitive transformation. For instance, by fostering an inclusive governance structure, water-sensitive urban development can be more effectively planned, implemented, and sustained.

Key Stakeholders to Include:

- **State Actors:** Local and provincial governments are pivotal but may face constraints, such as financial limitations, staff shortages, or conflicting priorities with national policies.
- **Communities and Households:** Their involvement is vital for grassroots adoption of water-sensitive practices. Empowering communities through education and participation fosters ownership and sustainability.
- **Private Sector Entities:** Real estate developers and construction companies play key roles in implementing sustainable urban designs. Leveraging private investments can accelerate development and innovation.
- **Civil Society Organizations:** These groups may have technical expertise and advocate for sustainability, and facilitate community engagement.

Strategies for Building More Effective Governance Structures

- **Establish Collaborative Platforms:**
    - **Facilitate Partnerships:** Leverage resources, expertise, and innovation through collaborations between the government, private sector, communities, and civil society.
- **Enhance Institutional Capacities:**
    - **Targeted Training:** Provide education and training to local authorities and stakeholders to address capacity gaps in water-sensitive planning and implementation.
    - **Resource Allocation:** Allocate funding and technical support for infrastructure development and maintenance.
- **Promote Transparency and Inclusivity:**
    - **Open Decision-Making Processes:** Ensure that planning and policy decisions are transparent, with opportunities for stakeholder input.

- **Recognize Informal Institutions:** Acknowledge and integrate the roles of informal community groups and associations in governance processes.

Ensuring Sustainable Financing and Operation

For water-sensitive transformation measures to be successful, they must not only be well-funded but also sustainably operated and maintained. Embedding these initiatives within appropriate governance structures ensures their longevity. Strategies include:

- **Developing Sustainable Business Models:**
  - **User Fees and Service Charges:** Implement fees that fund the operation and maintenance of water infrastructure.
  - **Revenue-Generating Opportunities:** Explore initiatives like eco-tourism in green spaces to generate income.
- **Leveraging Private Investments:**
  - **Public-Private Partnerships:** Attract investment through collaborations that share risks and benefits between public entities and private investors.
  - **Investment Incentives:** Provide incentives, such as tax breaks or favorable financing, for sustainable infrastructure projects.
- **Capacity Building for Maintenance:**
  - **Training Local Personnel:** Equip local staff with the skills needed to operate and maintain new systems effectively.
  - **Community-Based Management:** Establish committees or groups within the community to oversee local water projects, fostering a sense of ownership.

5. Instruments for Planning a Strategic Water-Sensitive Urban Transformation

Key Messages of Section

- Baseline assessment key insights are instrumental in establishing broad strategic directions for a more water-sensitive urban transformation.
- By assessing urban development trends and pinpointing opportunities, local stakeholders may collaboratively develop a vision respectively a strategic plan for a more livable city.
- This vision ought to be translated into a road map for water-sensitive transformation that indicates specific, tangible outcomes, emphasizing the roles and contributions of the stakeholders involved in making this vision a reality.
- To realize this vision, specific actions should be delineated across different planning horizons, such as short-term (3 years), mid-term (5 years), and long-term (15 years). These actions should then be integrated into official public planning and budgetary frameworks.
- A focused “zoom-in-approach” at the level of urban districts, neighborhoods, or (sub) villages has proven to be effective for the practical implementation of water-sensitive urban planning.

This section illustrates how:

- The results of baseline assessments can be used as a foundation for strategy development, serving as an entry point for initiating a water-sensitive urban transformation,
- Strategic planning can be applied to operationalize urban development goals and support the localization of the Sustainable Development Goals (SDGs),
- Participatory instruments such as vision-building can be used to initiate inclusive processes within urban society, which are essential for anchoring the strategy across stakeholder groups,
- Strategic objectives can be translated into concrete measures, which are subsequently embedded in the cities' planning instruments and processes,
- The overall process—from strategy development to implementation—can be effectively structured from an organizational perspective to ensure coherence and impact.

5.1. Strategy development for water-sensitive urban planning in Southeast Asia

Key Takeaways:

- **Prioritize Public Investments:** Target public investments in infrastructure and sustainable development to drive water-sensitive transformation. Ensure participatory planning to secure broad acceptance and unlock social, economic, and ecological benefits.
- **Make Water-Sensitive Transformation a Cross-Sectoral Task:** Integrate water-sensitive transformation across sectors like road construction, economic development, and energy, embedding it as a core responsibility of public administration.
- **Develop a Vision, Roadmap, and Action Plan:** Start with a clear vision for long-term goals, then create

a strategic plan, roadmap, and action plan. Ensure these are aligned with short-, medium-, and long-term public planning frameworks.

- **Adopt Pragmatic Strategies:** Address real challenges—like weak law enforcement and limited resources—by developing pragmatic, implementable plans that meet the actual needs of communities.
- **Focus on Realistic, Short-Term Measures:** Prioritize "low-hanging fruits" for quick, visible successes to gain stakeholder support and ensure long-term success.

5.1.1. Shaping water-sensitive urban transformation processes

1. **Public Investments as Key for Water-sensitive Transformation**

   Though water-sensitive transformation is meant to contribute to economic and social development and stimulate engagement of respective stakeholders, such as private sector, households and communities, it is highly dependent on targeted public investments, particularly in infrastructure and specific support schemes. These investments are crucial to anchor the transformation processes both in the economy and the urban society. Ensuring the acceptance of these measures is vital to secure their sustainability and effectiveness. Participatory planning processes are essential in this context, as they promote broad involvement from the population and other stakeholders, thus fully harnessing the social, economic, and ecological potential.

2. **Water-sensitive Transformation as a Cross-sectoral Task**

   The water-sensitive transformation should be understood as a cross-sectoral task that spans multiple administrative sectors. Under the leadership of the city administration and based on the results of the baseline assessment, a strategic plan should be developed, focusing on the key action areas identified in the PolyUrbanWaters Octagon (See section 4.2). This plan should integrate important sectors, such as road construction, economic development, energy supply, and social infrastructure. This ensures that water-sensitive transformation is firmly embedded as a cross-cutting responsibility of the public administration and supports sustainable urban development.

3. **Strategic Planning: Vision Formation, Roadmap, and Action Plan**

   The transformation process begins with the development of a vision that outlines the long-term goals of water-sensitive urban development. This vision is then concretized in a strategic plan, which details the implementation steps. A roadmap sets the timeline, indicators and milestones for each action, while the action plan defines the operational tasks and responsibilities. These instruments must be integrated into the short-, medium-, and long-term planning processes of public administration to ensure a seamless implementation of the transformation within the ongoing urban development efforts.

4. **Challenges and Pragmatic Strategies**

   Implementable plans require a realistic assessment of challenges, such as the dominance of the real estate sector, weak law enforcement, fragmented regulations, and limited financial resources. Overly idealistic approaches are not effective in this context. Instead, pragmatic strategies must be developed that address the real needs of citizens and communities and can be realistically implemented.

5. **Focus on Implementable Measures**

   The strategic plan, roadmap, and action plan must be both pragmatic and specific. It is crucial to develop a realistic funding strategy. An overly complex plan that resembles a wish list may lead to poor outcomes. Instead, realistic, short-term implementable measures, often referred to as "low-hanging fruit," should be prioritized. These quick-win measures create visible successes and help secure the support of stakeholders, which is vital for the long-term success of the project.

6. **Local Level: The "Zoom-in-Approach"**

   A proven method at the local level is the "zoom-in-approach", which allows focused attention on neighborhoods, districts, or sub-villages to develop and implement water-sensitive solutions. This approach promotes the consideration of local characteristics and facilitates the creation of tailored solutions that meet the specific needs of each area. This ensures greater acceptance and effectiveness of the measures at the local level.

Indicators as a crucial tool to shape water-sensitive transition

Indicators play a crucial role in creating a robust policy framework essential for supporting a water-sensitive urban transition. For financing such a transition, **integrating these initiatives into the management of public funds** and ensuring compatibility with the planning processes of public institutions is key. With well-defined goals, outputs, and relevant indicators, individual initiatives can become part of a structured framework that supports sustainable, scalable progress.

- Most governments of countries in Southeast Asia have **translated the Sustainable Development Goals of Agenda 2030 and the respective indicators into national planning frameworks**. These are now increasingly being broken down to the level of provinces and cities, which in turn have indicator sets adapted to the national context. Every activity plan should be compatible with these indicator sets in order to qualify for public funding or even to become part of the activity.
- **Mid-term public spending policies often establish goals over a 3 to 5 year period**, allowing cities to track incremental achievements, such as reduced stormwater runoff, increased permeable surface area, or improved water quality. These benchmarks align well with mid-term spending frameworks, facilitating steady progress and building momentum toward long-term water-sensitive urban development.
- **Indicators translate broad water-sensitive urban development goals into specific, measurable targets**, providing cities with clear metrics for assessing their progress. This clarity makes it easier to adjust strategies over time, maintaining consistent momentum toward sustainability goals.
- **Indicators that show tangible progress attract further funding from external sources**, such as national funding, international aid, or private partnerships. By providing clear, data-backed evidence

of impact, indicators make it easier for external agencies and private entities to invest confidently, knowing that resources are being directed toward measurable outcomes.

- **Indicators enable decision-makers to prioritize and allocate resources effectively**. For instance, indicators on flood frequency and severity help identify areas where investments in flood defenses or green infrastructure are most needed. Similarly, water quality indicators inform decisions on wastewater treatment, ensuring funds are directed toward impactful areas.
- **Indicators align goals across departments and sectors**, promoting an inter-sectoral approach to urban water management. Government departments can demonstrate their contributions to broader objectives, enhancing coherence across initiatives. For example, indicators that track urban greenery, water quality, and energy efficiency create a framework where urban planning, environmental management, and public health departments collaborate effectively toward shared water-sensitive goals.
- **Publicly available indicators increase transparency** by clearly showing communities and stakeholders where improvements are happening and where additional efforts may be needed. This openness fosters accountability, building public trust and support for water-sensitive initiatives as stakeholders can clearly see the value and impact of ongoing projects.

5.1.2. Key elements for effective strategic planning

1. **Stakeholder Engagement**
    - **Steering Committees:** Establish a steering committee that involves cross-sectoral government agencies. These committees may also include representatives from the private sector and local communities to ensure a holistic and inclusive approach.
    - **Identify Key Stakeholders:** Include government officials, urban planners, community leaders, business owners, environmental groups, and residents.

- **Provide robust information:** Stakeholders should have a good understanding of water challenges and options for action. Communicate key information from the baseline assessment.
- **Facilitate Participatory Workshops:** Organize workshops and public consultations to gather diverse perspectives and inputs, ensuring the plans reflect the community's needs and aspirations. Make use of tools such as common mapping exercises.

2. **Vision Statement and Strategy Development**

- **Crafting the Vision Statement:** Develop a concise, aspirational statement that outlines the long-term desired outcomes for urban development. Examples include:

- A green, clean, and beautiful Sam Neua
- A green and modern Krong Kratié - an attractive place to live, visit and do business"
- Rejodani: Towards a Livable, Harmonious, and Sustainable Peri-urban Community

- **Ensure Comprehensive Coverage:** While focusing on water-sensitive development, other critical urban planning areas, such as transport, energy, and land use, may be considered in strategy development.

3. **Assessment of Current Capacities**

- **Evaluate Resources:** Assess existing institutional and financial capacities to ensure the vision is realistic and achievable.
- **Identify Gaps:** Determine where capacities are lacking and develop strategies to address these gaps, enhancing the ability to implement the vision effectively.
- **Ensure effective management capacities:** Right from the beginning, it should be considered who will have the capacities to shape and lead an effective implementation process of particular measures.

4. **Balancing Stakeholder Interests during Vision Building and Strategy Development**

- **Manage Conflicts:** Recognize and address conflicting interests among stakeholders to ensure a balanced approach to the vision-building process.
- **Achieve Consensus:** Where possible, work towards a consensus, using negotiation and compromise to harmonize different views.

- **Accept Divergences:** Urban development is often characterized by conflicting interests, such as those between communities and investors. If necessary, a third party—such as the city council—has to make a final decision.

5. **Road Map and Action Planning**

- **Elaborate a Realistic Scenario:** The identified catalogue of measures should not resemble a wish list. Key interventions should be identified that are relevant and feasible within short-term, mid-term, and long-term plans. Close coordination, especially with decision-makers from the relevant government institutions, is essential for this purpose.
- **Prioritize Actions:** Based on urgency, relevance, technical feasibility, financial viability, and impact, prioritize the actions to allocate resources effectively. The profile of each activity should be differentiated and thoroughly developed, ensuring its technical and methodological robustness can withstand review by an expert team. This means that actions should be ranked according to how critical and relevant they are, while considering their practical implementation, costs, and potential impact. Each activity needs to have a clear, detailed outline that demonstrates its robustness, so that an expert team can evaluate and validate its effectiveness before execution.

From Planning to Implementation

6. **Implementation Mechanism**

As a structured process, organize which actions, strategies, or projects are put into practice. This includes an action plan, resources, procedures, responsibilities, institutions, and tools necessary to successfully carry out a particular initiative or policy. An effective implementation mechanism ensures that clear steps are defined, responsibilities are allocated, and progress is monitored.

7. **Tasks of the Steering Committee for Implementation**

The steering committee should comply with the following tasks:

- **Overseeing and guiding** the implementation of the water-sensitive urban transformation plan to ensure alignment with objectives.

- **Defining and ensuring clarity** about who is in the lead for each phase of the project, as well as establishing clear roles and responsibilities to prevent confusion and ensure accountability throughout the process.
- Making sure that the implementation adheres to the **relevant regulations, standards, and guidelines** related to sustainable water management and urban planning.
- **Keeping stakeholders informed** through regular updates and transparent reporting on progress and challenges.
- **Regularly reviewing the progress** of the project to ensure that timelines are met and objectives are achieved. Adjust strategies as needed to stay on track and respond to new challenges.
- **Ensuring clear and consistent communication** among all stakeholders, including government bodies, planners, and community representatives.
- **Identifying any challenges or necessary changes** during the process and making appropriate adjustments to the plan to ensure successful implementation.
- Ensuring that **resources**, both financial and human, are **properly allocated** to support the activities of the project.
- **Involving and engaging relevant stakeholders** to ensure their input and support for the transformation process.
- **Publicize successes and milestones** to maintain engagement and momentum.

Example 18: A strategy for water-sensitive transformation – Sariharjo, Indonesia

Typical residential home and apartment blocks in Sariharjo *(Source: PUW & Partners Own Work, 2023)*

Typical residential home in Sariharjo *(Source: PUW & Partners Own Work, 2023)*

As a result of a baseline assessment conducted in 2022, the local government of Sariharjo with its 31.000 residents, has started a strategic orientation process for water-sensitive transformation.

A mission statement was defined: "In Sariharjo both the village government as well as community have a common understanding, perception, goal, and commitment to develop their village based on water-sensitive principles, based on positive views and behaviors toward water. A water-sensitive village means that all residents live and work in an attractive, inclusive, healthy, and resilient environment." That vision is translated into the following strategic orientation:

- Sariharjo has a medium-term village development plan 2024-2030, which is oriented, among other things, to the dimensions of water-sensitive development. This plan is specified in the annual village development plan - also at sub-village level - and the corresponding budget plan.
- At least 30% of the village area is sustainably dedicated to green open spaces. Here, the development of the village treasury land plays an essential role. The spaces are an integral part of strategic planning that develops the village as a recreational and climate change resilient area. Maintenance is ensured by allocation of respective funds and community engagement.
- Its residents have access to safe water. New residential areas, commercial facilities and progressively more private homes are connected to the services of the local water operator, PDAM. Community awareness, good quality water services and water conservation measures at public and private buildings contribute to water safety.
- Its water resources are well protected. All new residential areas, public buildings and private sector facilities are connected at least to improved septic tanks or more advanced technologies. Awareness campaigns and proactive law enforcement contribute to effective fecal sludge management. Its water protection zones are well-protected

by effective Water Safety Plans. Solid and toxic waste is safely managed. Awareness campaigns at the community level have contributed to waste separation at source. Capacities for composting organic waste and managing toxic waste are developed. Standardization of processes and of tariffs have contributed to a better performance of the waste sector in the village.

- Integrated stormwater management that combines grey with blue-green solutions contributes significantly to the reduction of flooding risks in the village. Urban planning at village and sub-village levels have specified respective infrastructure developments. Protected public green spaces, enforcement of standards for green spaces at private and public premises and increasing the application of porous surfaces ensures high-levels of water infiltration. Water retention structures compensate partly for the loss of buffer zones in the paddy fields.

Public green space developed on community land in Sariharjo
(Source: PUW & Partners Own Work, 2023)

Example 19: Specifying the vision of Sam Neua as a green, clean and beautiful town in the field of water-sensitive urban development – Lao PDR

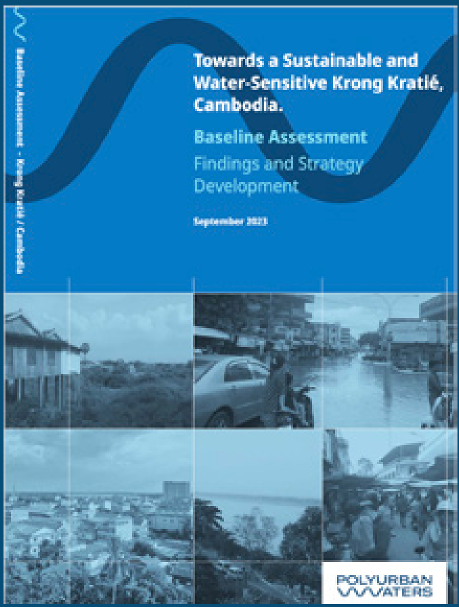
Design of potential water-sensitive interventions in Sam Neua town
(Source: PUW & Partners Own Work, 2023)

In 2023, an official statement to the city's Baseline Assessment "**Towards a water-sensitive Sam Neua Town**" by the Vice Governor of Huaphan Province stated that the results and strategic recommendations should serve as benchmarks for specific action planning and budgeting in the spirit of proactive urban planning.

To illustrate:

- **Effective Stormwater Management:** Avoiding the predicted 'bath tub' effect through a systematic combination of stormwater retention structures (such as water retention basins), drainage systems, restrictions in the sealing of surfaces, solid waste management, and the development and sustainable management of green infrastructures will be implemented. There should be significant consideration of effective measures to mitigate tremendous land use changes in the overall water catchment area.
- **Safe Water Supply:** The systematic introduction of water safety plans and the establishment of a water monitoring system will make a significant contribution to water supply security. In addition to improving the technical performance of the system, i.e. reducing technical losses, measures such as the development of water harvesting structures on private and public premises and the efficient use of tap water (water conservation) will be taken.
- **Effective Wastewater Management:** In accordance with its financial and institutional capacities, Sam Neua will follow an approach of progressive implementation. The compulsory construction of improved septic tanks and mandatory regular desludging, the development of Decentralised Wastewater Treatment System (DEWATS) clusters and their effective operation, and the construction of a Sludge Treatment Plant will be an essential basis for the treatment of domestic and institutional wastewater for the foreseeable future.
- **Green and Water-Sensitive Urban Development and Community Development in Extension Areas:** Public infrastructure in these areas will be planned and implemented proactively before largely uncontrolled construction activity decisively restricts the scope of action for any sustainable development. Settlement structures, such as public spaces, schools, and sports fields, will be integrated into the green infrastructure of the city. Riparian areas and green areas of public interest should be developed and managed in close cooperation with communities.

Example 20: Towards a modern, water-sensitive Krong Kratié - Cambodia



Front page of Kratié's Baseline Assessment
(Source: PUW & Partners Own Work, 2023)

Following the results of the baseline assessment, the following vision statement was elaborated to give guidance to the sustainable development of the Krong: **"A green and modern Krong Kratié - an attractive place to live, visit and do business"**

The vision may be realised by addressing the following fields of actions:

- **Flood Management:** the city should strengthen its resilience to hazardous flooding events. Planning and technical measures include securing the flow regime to the lake area and the implementation of an effective city-wide urban drainage system. Restricting the sealing of surface areas should mitigate stormwater runoff.

- **Lake Area as a Strategic Asset for Urban Development:** The lake area should be brought out of its perception as an underdeveloped area and ought to be thoroughly incorporated into urban planning and development initiatives, not only for its role in flood management, but also as a source of abundant biodiversity, a livelihood base for communities, and an essential natural cooling system for the urban climate. Additionally, its prospective significance as a leisure and tourism destination should be recognized and exploited.

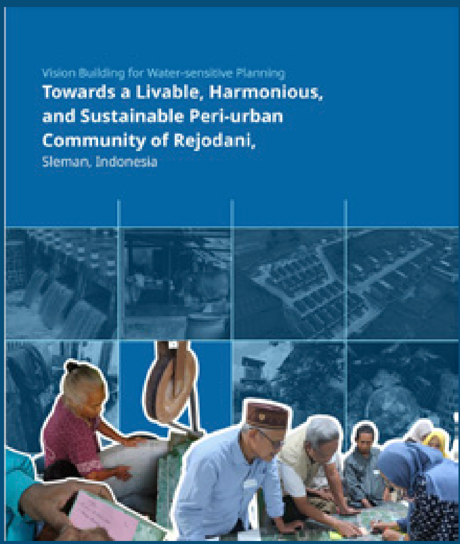
- **Green Urban Development:** To mitigate the degradation of the urban environment or the escalating heat in the urban climate, especially in the face of climate change, there should be a systematic enhancement of urban greenery to avoid the detrimental effects to the most vulnerable residents, such as children, the ill and infirm, and elderly. Well-developed urban green spaces integrated within a wider infrastructure framework, such as pedestrian-friendly street systems, contribute significantly to well-being and livability.

Image of water-sensitive development options for Kratié's riverside *(Source: PUW & Partners Own Work, 2024)*

- **Wastewater Management:** Adopt a mixed approach to wastewater management that combines both centralized and decentralized systems, alongside practices to reduce and manage fertilizer runoff, thereby protecting water quality. Decentralized system solutions should, therefore, be considered for these urban areas, and particularly for pollution hotspots, including the slaughterhouse and the referral hospital.
- **Recreation and Tourism Development:** Integrating the lake area into the city's broader recreational and tourist infrastructure plan, making it a key attraction that contributes to Kratié's economic and social vitality
- **Capacity Building:** Strengthening the capabilities of local and provincial government structures in planning and implementation through cross-sectoral cooperation and coordination, ensuring effective implementation and management of the plan's initiatives.
- **Participatory Planning:** Engaging relevant stakeholders in the planning and decision-making process through participatory planning and awareness campaigns, fostering active participation of communities, the private sector, and civil society development.

Aerial view of Kratié's wetland area *(Source: Smith, 2014)*

Example 21: From vision building to action – "Towards a Livable, Harmonious, and Sustainable Peri-urban Community of Rejodani" - Indonesia



Front page of Vision Building Report for Rejodani Sub-village *(Source: PUW & Partners Own Work, 2024)*

As a result of the baseline assessment and strategic planning in Sariharjo, community leaders from the sub-villages of Rejodani I and Rejodani II initiated a vision-building process in 2022. This process was a continuation of the baseline study conducted as part of a pilot project promoting sustainable, water-sensitive development in Sleman Regency. Rejodani, with a population of 1,288 in 2023, became the focal point for this initiative. To implement water-sensitive planning more effectively and create a cohesive, water-sensitive community, the vision-building process was scaled down from the village level to the sub-village level.

In 2023, the participatory vision-building process officially began, with three key objectives:

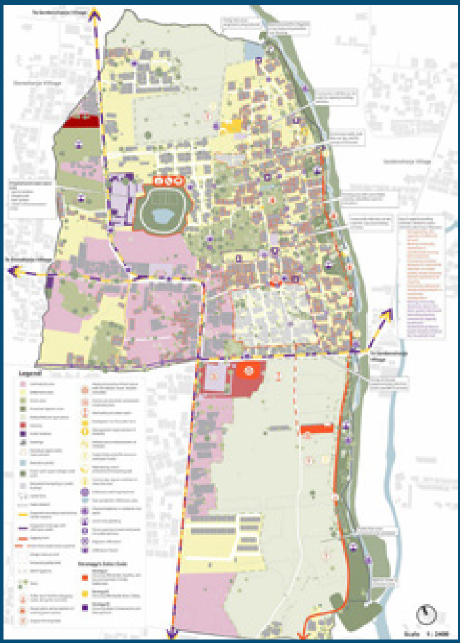
1. **Identifying Current Challenges and Opportunities:** This aimed to analyze existing conditions, issues, and potential areas of improvement to establish a foundation for strategic planning.

2. **Formulating Strategic Solutions and Future Visions:** This involved developing community-driven visions that incorporated sustainable, Nature-based Solutions (NbS).

3. **Supporting Policy and Implementation:** This goal focused on assisting local governments, at both village and regency levels, in creating policies and executing activities based on the strategic solutions devised.

The vision-building process generated several important outputs:

- **Mapping Key Features:** This step involved identifying sub-village characteristics, challenges, and opportunities, providing a clearer understanding of local needs and strengths.



Master Plan for water-sensitive interventions in Rejodani
(Source: PUW & Partners Own Work, 2023)

- **Vision Statements and Strategies:** These articulated the community's aspirations and proposed solutions, with a particular emphasis on Nature-based Solutions.
- **Water-Sensitive Action Plan/Transformation Pathways:** This outlined possible measures, regulatory frameworks, and a roadmap for implementing the vision, including timelines, budgets, and programs.

As part of an intensive consultation process, including discussions with the planning authority BAPPEDA and the local administration of Sariharjo, various options were identified across the areas of the sub-villages to improve water supply, wastewater management, septage management, water-sensitive green space development, water conservation, and flood vulnerability mitigation, such as rainwater infiltration and sustainable management of riparian zones.

These options were consolidated into a master plan for a "water-sensitive village“. This plan represents the action steps in a spatial context. The mapping of the spatial distribution provides a clear, actionable framework for a transformation toward water-sensitive urban planning, aligning the community's vision with government development strategies.

Example 22: Good practice of strategic planning – Leh, India

Front cover of Vision Building Report for the city of Leh, India
(Source: LAHDC, 2020)

Front page of Vision Building Report for the city of Leh, India
(Source: LAHDC, 2020)

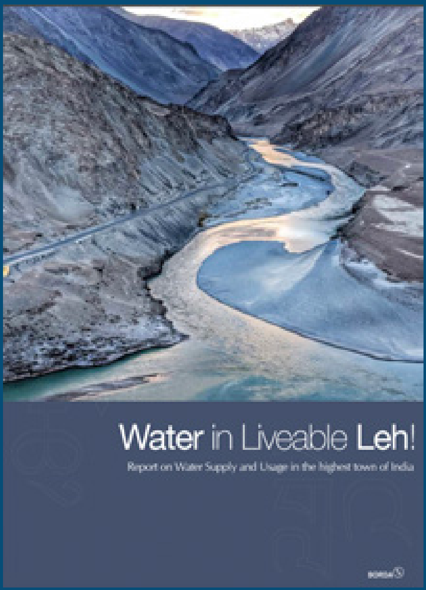
An illustrative example of framing strategic planning and vision building within political processes in Asia is the case of Leh, a mountain town in Ladakh, India. On August 7, 2018, the Ladakh Autonomous Hill Development Council (LAHDC) of Leh established a special committee to develop a strategic plan for the town. Its mandate was to identify and formulate planning strategies suitable for the town's unique climatic, physiographic, and socio-cultural conditions.

The committee recognized that the past decade had brought rapid transformations to Leh's economic, physical, socio-cultural, and environmental spheres. Unorganized and haphazard growth, particularly the unchecked proliferation of hotels and guesthouses, posed significant risks. Without proper control, the manageability of development could quickly deteriorate beyond recovery.

To address these challenges, the committee formed a formal Strategic Planning Committee (SPC) composed of three groups: 1) Governing Members: Responsible for overseeing all work and outputs of the committee. 2) Working Group Members: Eminent individuals from various fields active in Leh, ensuring the inclusion of all relevant stakeholders. 3) Secretariat: Administrators tasked with coordinating work between the Governing Members and Working Groups.

This structure aimed to facilitate a collaborative approach, engaging a broad spectrum of stakeholders in the planning process. During this process, the principal vision for Leh was defined as "**To restore and maintain a deep sense of happiness**". This overarching goal is to be achieved by focusing on eight strategic fields:

1. **A Thriving and Resilient Economy:** Promoting sustainable economic growth that can withstand external shocks.



Front page of strategic report on water management for the city of Leh
(Source: BORDA-India, 2019)

2. **Mobility of People and Goods:** Enhancing transportation networks for better connectivity and efficiency.
3. **Water, Sanitation, and Solid Waste Management:** Implementing effective systems to manage resources and waste sustainably.
4. **Social Infrastructure:** Developing facilities and services that improve the quality of life for residents.
5. **Environment and Climate Change:** Addressing environmental challenges and promoting climate resilience.
6. **Heritage Conservation:** Preserving cultural and historical assets integral to Leh's identity.
7. **Spatial Planning and Urban Design:** Designing urban spaces that are functional, aesthetic, and sustainable.
8. **Urban Governance:** Strengthening institutional frameworks for better management and service delivery.

In the context of these strategic fields, a detailed plan for improved water management was developed. This plan outlined specific actions, an activity schedule, performance indicators, and assigned responsibilities. Given Leh's unique environmental conditions and the increasing pressures from development, efficient water management is crucial for the town's sustainability. (BORDA/Ladakh Autonomous Hill Development Council, 2020)

6. Implementing Strategies for a Water-Sensitive Transformation

Key Messages of Section

- Successful implementation depends greatly on high-quality expertise in planning, technical design, and organizational structures.
- Countries are called upon to develop the expertise needed for a differentiated assessment of vulnerabilities and the potential of high-performance, integrated infrastructures.
- Initiating a water-sensitive transformation must be supported by strong commitment from the highest levels of government from the very beginning.
- Effectively implemented pilot projects can serve as starting points to build credibility and momentum for more complex processes.
- Public governance structures should develop and implement Standard Operating Procedures that ensure not only effective implementation but also sustainable maintenance and operation.
- Private investments and infrastructure developments can serve as strong catalysts, prompting effective public engagement.

This section provides guidance in how:

- An implementation process can be initiated through concrete and successful measures—an essential prerequisite for translating strategic goals into practice.
- Initial actions can serve to build institutional and technical capacities within cities, laying the groundwork for a broader water-sensitive transformation.
- The implementation of sustainable measures requires a high level of diverse technical and organizational expertise, particularly to provide insights to the potential for integrated infrastructure development.
- Practical examples illustrate how implementation measures must align with the legal mandates and responsibilities of municipal authorities in order to enable robust business models that support effective public service delivery.
- Pilot projects can be used to develop standardized procedures that ensure the long-term operation and maintenance of the newly established infrastructure.

6.1. Design and implement feasible pilot projects to start

Key Takeaways:

- **Implement Tangible Pilot Projects:** Begin with visible and feasible projects to make the concept of water-sensitive urban transformation tangible, providing real-world proof of its benefits to local stakeholders.
- **Align Projects with Stakeholder Interests:** Select initiatives that address specific problems and meet the expectations of key stakeholders to enhance support, engagement, and community ownership.

- **Use Pilot Projects as Learning Tools:** Leverage pilot projects for capacity building and to develop practical regulations and norms, ensuring that urban development is sustainable and aligned with community needs.
- **Strategically Select Projects:** Choose projects based on criteria, such as visibility, feasibility, direct problem-solving, community engagement potential, replicability, and effectiveness in addressing water management challenges.
- **Implement a Structured Framework:** Establish a comprehensive approach that includes stakeholder participation, leadership coordination, technical planning, integrated infrastructure development, secure funding, and ongoing monitoring and evaluation.

General Considerations:

Implementing strategically selected pilot projects for water-sensitive urban development is a nuanced process that goes beyond showcasing the benefits. Their own sustainability and their scalability should be major reference points for their design, planning and implementation.

Ensuring that the **selection of projects aligns with the interests and expectations of key stakeholders is important.** While stakeholders might not have a comprehensive interest in urban development, they expect solutions to specific problems. Tailoring projects to these expectations can enhance support and engagement.

Timing has to align with development planning activities at the local level and that pilot projects are developed to fit into this process - not as an afterthought or in anticipation that the process can be delayed to include these.

Pilot projects serve as crucial learning tools. By implementing, monitoring, and learning from these initiatives, governments and planners can develop well-informed regulations and norms that are both practical and effective. This iterative process ensures that urban development is sustainable, resilient, and aligned with the needs and interests of the community.

Criteria for Selection

- **Visibility and Feasibility:** Projects should be visible to the public and feasible within existing constraints, showcasing the practical benefits of water-sensitive urban development. Buy-in from senior decision-makers will be more assured when tangible results are generated within a rather short period.

- **Direct Problem Solving:** Prioritize projects that tackle specific urban water management issues, demonstrating the effectiveness of water-sensitive approaches in real-world scenarios. Focus on projects that offer direct solutions.

- **Stakeholder Engagement:** Choose projects with notable potentials for stakeholder engagement, such as community engagement, encouraging local participation and fostering a sense of ownership among residents.

- **Replicability:** Projects should serve as models that can be replicated in other areas, demonstrating the scalability of water-sensitive urban development solutions.

- **Addressing Challenges:** Prioritize projects that tackle specific urban water management issues, demonstrating the effectiveness of water-sensitive approaches in real world scenarios.

Pilot Projects as Learning Projects

- **Capacity Building:** Beyond addressing immediate challenges, pilot projects should initiate a capacity-building process. This involves training and collaboration mechanisms among all relevant stakeholders, including government departments, subnational governments, communities, and the private sector.

- **Cross-Sector Collaboration:** Focus on enhancing collaboration not only among different government departments but also between local government, communities, and the private sector. This integrated approach is crucial for the success of water-sensitive urban development.

- **Financial Involvement:** From the outset, involve city departments that control relevant budgets, such as public works. Their early involvement ensures that projects are backed by necessary financial resources and are aligned with broader city infrastructure investments.

Framework for Implementation

1. **Stakeholder Engagement and Participation**

    - **Initial Engagement:** Identify and involve stakeholders early in the planning process to ensure their input and needs are considered. This includes homeowners, residents, local businesses, investors, and community leaders.

    - **Participatory Design:** Organize workshops and meetings to gather input on infrastructure needs and preferences directly from the community, ensuring that the project design reflects local demands and enhances ownership.

2. **Leadership and Coordination**

    - **Technical Leadership:** Appoint a project leader who understands the community dynamics and can effectively bridge the gap between residents and technical teams. This ensures that both technical requirements and community needs are considered during implementation.

    - **Government Collaboration:** Coordinate closely with relevant government agencies to align the pilot project with broader urban development plans. This collaboration helps secure necessary approvals and funding, ensuring that the project adheres to local regulations and contributes to long-term goals.

    - **Private Sector Collaboration:** Engage with private sector stakeholders to foster partnerships that can provide technical expertise, financial resources, and innovative solutions. This collaboration can also help in scaling the project and ensure sustainable implementation through shared investments and responsibilities.

3. **Technical Planning and Capacity Building**

    - **Professional Teams:** Employ skilled professionals to translate infrastructural requirements and community needs into feasible technical solutions. This includes architects, engineers, and urban planners who can design and implement flexible and sustainable infrastructure.

- **Maintenance and Sustainability:** Plan for the long-term sustainability of infrastructure by involving the community in ongoing maintenance and management, ensuring they have the skills and resources to do so effectively

- **Capacity Building:** Conduct training programs to enhance the local community's understanding of technical aspects and maintenance requirements for new infrastructure systems.

4. **Funding and Resource Allocation**

- **Allocation of Funds:** Most identified measures have to be translated into the public planning and budget schemes such as Short- and Mid-Term Development Plans. Financial resources for maintenance and operations should be earmarked.

- **Matching Funds:** Leverage funds from multiple sources, including national schemes, local government budgets, and local stakeholder contributions if justified and possible.

- **Financial Incentives:** Provide incentives for private investments in property improvements and infrastructure enhancements, such as tax breaks or subsidies.

5. **Monitoring and Evaluation**

- **Continuous Feedback:** Implement mechanisms to gather ongoing community feedback on infrastructure use and satisfaction, allowing for adjustments and improvements over time.

- **Performance Indicators:** Establish clear metrics to measure the effectiveness of infrastructure improvements, community engagement, and environmental impacts.

Example 23: Pilot projects as a flagship initiative for water-sensitive transformation – an example from India

DEWATS system polishing pond at Aravind Eye Hospital
(Source: BORDA-India, 2015)

Innovative Water-Sensitive Architectural Concepts in South Asian Cities

In many South Asian and Southeast Asian cities, rapid urbanization and climate change are intensifying water scarcity and drought conditions. To address these challenges, private enterprises and institutions are adopting innovative, water-sensitive architectural concepts that conserve water while maintaining high-quality urban landscapes. These approaches combine eco-friendly technologies and horticultural solutions to reduce water consumption, promote water recycling, and create sustainable green spaces. Well-defined facility management ensures the sound maintenance and operation of these systems.

Case Study: Aravind Eye Hospital in Thavalakuppam, India

A prominent example illustrating the integration of decentralized wastewater treatment with sustainable landscape design is the Aravind Eye Hospital in Thavalakuppam, part of the renowned Aravind Eye Care System in Tamil Nadu. Confronted with regional water scarcity and the need to implement an effective system to address water pollution, the hospital implemented a Decentralized Wastewater Treatment System (DEWATS), showcasing how a modern medical facility can tackle environmental challenges while upholding high standards of care.

Key Features of the System:

1. **Rainwater Harvesting:** The hospital installed rainwater collection systems to store and use rainwater for landscape irrigation and non-potable purposes, including toilet flushing, significantly reducing the reliance on freshwater sources.
2. **Greywater Recycling:** Wastewater from showers and sinks is treated and reused, particularly for garden irrigation, conserving water resources and reducing wastewater discharge.

DEWATS system planted filter at Aravind Eye Hospital *(Source: BORDA-India, 2015)*

3. **Green Space Development:** The hospital developed extensive gardens featuring 300 avenue trees, 250 coconut trees, 50 mango trees, and 45,000 square feet of lawn with Korean grass and flowering plants. These green spaces improve the micro-climate, provide recreational areas, and enhance patient health and well-being.

4. **Reduced Energy Costs:** By utilizing natural hydrological flows, the system minimizes the need for energy-consuming pumping devices, thereby lowering energy costs and promoting sustainability.

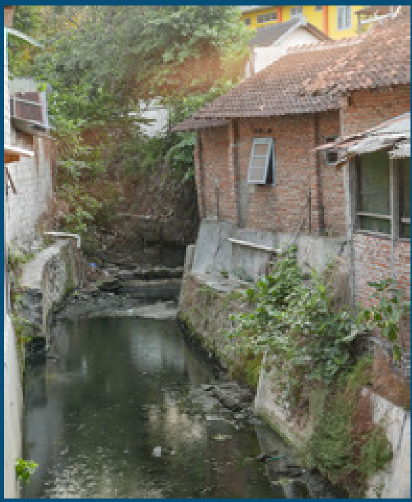
Factors Driving Sustainable Success:

- **Commitment from Hospital Owners:** The clear interest and commitment of the hospital owners in finding effective solutions to water-related challenges were crucial. Their focus on both technical and design aspects ensured the system's relevance and effectiveness.

- **Financial Resources through Public-Private Partnership:** The project was supported by necessary financial resources facilitated through a Public-Private Partnership, demonstrating substantial commitment and enabling high-quality implementation.

- **Integration into Facility Management Systems:** The entire system was incorporated into the hospital's existing management and facility operations. This integration ensures ongoing maintenance of the green spaces and the sustainable operation of the wastewater treatment system. (BORDA, 2015)

Example 24: Good practice of urban revitalization – Yogyakarta, Indonesia



Neighboorhood at Karangwuru River before restoration
(Source: PUW & Partners Own Work, 2023)

Neighboorhood at Karangwuru River after restoration
(Source: PUW & Partners Own Work, 2023)

The Karangwuru River Restoration project in Yogyakarta, Indonesia, presents a good practice on community-driven urban revitalization. (PolyUrbanWaters - Field Study 9/2019) Situated in Karangwaru, a kelurahan (urban village) within the Tegalrejo district, this initiative addresses the challenges of urban sprawl and pollution, aiming to transform the area into a more livable neighborhood with improved housing schemes, green public and private spaces and an effective infrastructure, such as energy, road and water services.

This good practice is a result of nearly a decade of a participatory planning and implementation process that involved the community and government agencies. The following factors contributed to the process:

- **Technical Leadership:** Central to the project's success is the leadership of a local architect, who has not only resided within the community but also managed to harness its self-help structures over an extended period.
- **Participatory Design:** The overall infrastructural design was elaborated on the basis of the needs and interests of communities, respectively residents. These design processes contributed significantly to ownership and acceptance of the overall project.
- **Matching Funding:** While the local government through national funding schemes allocated significant financial resources for infrastructure development, home owners did not only commit to invest in their own private premises, but after lengthy negotiations-, the homeowners agreed to make part of their land available for infrastructure development, such as a path and wastewater management system along the river.

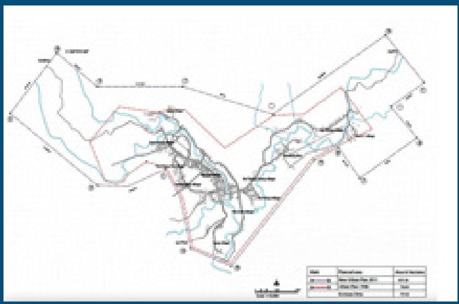
Public spaces developed under Karangwuru river restoration project (top & bottom)
(Source: PUW & Partners Own Work, 2023)

- **Community Structure:** This neighborhood is still characterized by community structures, which were part of the traditional governance structures in Java for a long time. Important decisions were negotiated at the community level, which is ultimately binding for the members. These community-based decision-making structures are increasingly being lost in today's urbanisation processes in Java.

- **Technical Planning and Implementation Capacity:** The requests of the community members could be checked for feasibility by professional technical teams and implemented within the framework of proven infrastructural and innovative development approaches. The participatory planning approach for infrastructure not only allowed the development of infrastructure in which grey and blue-green solutions complement each other, but also enabled good maintenance and operation through a high degree of community ownership.

- **Strong Support From Government Agencies:** The project was coordinated with governmental institutions from the start, which contributed to the planning and technical design and its implementation. Thanks to good communication and decision-making structures, significant public funds were made available.

Example 25: Water-sensitive master plan for two urban extension areas - Sam Neua, Lao PDR

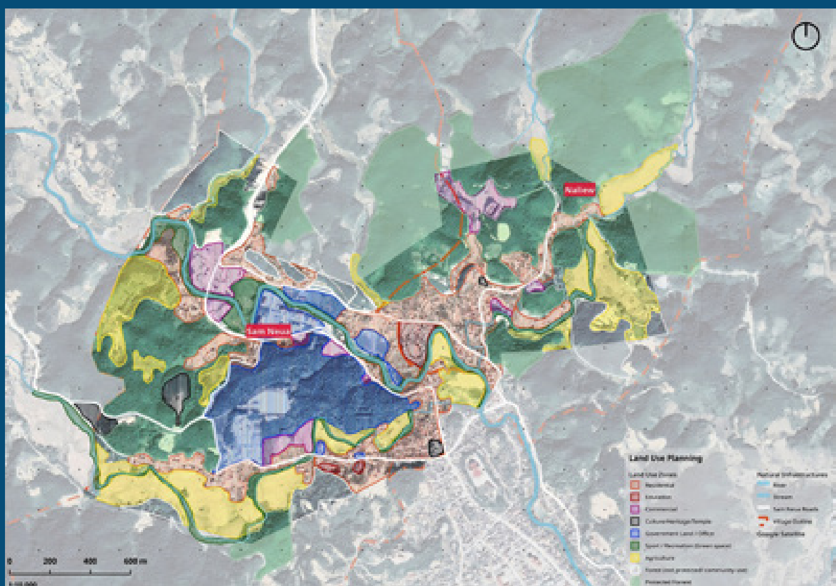


Official area infrastructure development plan for Sam Neua village and Naliew village *(Source: Municipal Government, Sam Neua, Lao PDR, 2011)*

Updating the Urban Master Plan for Sam Neua Town presents a significant opportunity to integrate water-sensitive modernization principles to address the town's rapid growth and emerging challenges. The town currently lacks an official, up-to-date urban planning map, limiting its ability to regulate development in the urban extension areas. The elaborated baseline assessment and current growth trends highlight the need for a strategic, future-oriented approach to address issues that include inadequate water management systems (stormwater, wastewater, water supply) and poor solid waste management. This was applied in two extension areas of Sam Neu where a Water-Sensitive Urban Master Plan has been elaborated that follows the following aims to create a livable, safe, and resilient urban environment that prepares the town for climate change and accommodates population growth. (Hodgson et all, 2024)

1. **Protection of Natural Systems and the Environment**
    - The natural environment is crucial for the town's resilience against challenges such as natural disasters.
    - Integrating natural resources into the urban fabric, including parks and water bodies (for example, floodplain parks), helps to protect these resources while enhancing urban livability.
2. **Mixed-Use Zones**
    - Implement mixed-use zoning to incorporate residential, commercial, educational, health, and recreational activities in single areas.
    - This strategy ensures the efficient use of land and prevents urban sprawl, which often results from single-use zoning approaches.

3. **High-Risk Zones: Construction Prohibited or Highly Controlled**
   - Designate high-risk areas, such as those prone to flooding or landslides, as no-build or strictly controlled zones to prevent risky development.
4. **Compact Urban Areas with Medium to High Density**
   - Develop densely populated urban areas to make efficient use of land and infrastructure, control unplanned urban expansion, and promote a local economy.
   - This compact design reduces the environmental footprint and supports sustainable infrastructure development.
5. **Participatory and Cross-Sectoral Stakeholder Engagement**
   - Following the Lao PDR Urban Planning Manual, engage stakeholders and key sectors early in the planning process to incorporate diverse perspectives and ensure collaborative decision-making.
   - Involve community members, government officials, property owners, developers, and investors to foster a sustainable urban development approach.



Water-sensitive area infrastructure development plan for Sam Neua village and Naliew village ***(Source: Hodgson, 2024)***

6.2. Design and implement polycentric stormwater management

Key Recommendations:

1. **Importance of Grey Infrastructure:** Grey infrastructure (pipes, drains, retention basins) remains crucial for handling large stormwater volumes in urban areas. However, it requires proactive implementation, regular maintenance and upgrades to stay effective and alone cannot handle the challenges of rapid urbanization.
2. **Limitations of Exclusive Grey Infrastructure:** Solely engineered grey solutions ("sewered city" model) cannot fully address stormwater challenges, especially in rapidly urbanizing Southeast Asian cities, and this needs to be combined with Nature-based Solutions.
3. **Integrated Hybrid Systems:** Combined grey and blue-green infrastructure (wetlands, green spaces, permeable pavements) may offer more resilient, cost-effective, and scalable solutions. Effective configuration has to be identified by expert teams. Further development of regulative frameworks and effective law enforcement are indispensable.
4. **Challenges for Nature-based Solutions:** Rapid urbanization, fragmented land ownership, maintenance, and high land prices make implementing large-scale Nature-based Solutions difficult. Maintaining and protecting existing blue-green spaces, often managed by communities or small farmers, is also a challenge in the face of development pressures.
5. **Stakeholder Engagement and Collaboration:** Active participation from communities, house owners and collaboration across sectors of urban development is essential. They have to see their self-interest and their contribution for effective stormwater management.

6.2.1. Considerations for polycentric stormwater management

Limitations of an Exclusive Grey Infrastructure Approach (Sewered City)

The rapid urbanization in secondary and tertiary cities of Southeast Asia has led to a significant increase in the frequency and intensity of flooding events. Massive changes in land use systems and extensive surface sealing have disrupted natural hydrological cycles, resulting in higher volumes of stormwater runoff and reduced infiltration than initially planned for when stormwater infrastructure was installed.

An exclusive **grey infrastructure approach**, often referred to as the "sewered city" model, relies heavily on engineered solutions, such as pipes, drains, and treatment plants, to manage water resources and wastewater. While this approach remains essential in modern urban planning, it is evident that the expansion of grey infrastructure alone is insufficient to address these complex stormwater management challenges in Southeast Asia.

Grey infrastructure, including drainage systems, retention basins, and canals, remains indispensable for handling large volumes of stormwater, especially during extreme rainfall events. Many cities face challenges that include undersized and poorly maintained systems, delayed infrastructure development, space limitations and high costs, and a dependence on capital-intensive pumping systems. Optimizing the efficiency of existing grey infrastructure through regular maintenance, hydraulic adjustments, and structural repairs is paramount. Ensuring a consistent technical layout is necessary to guarantee hydraulic flow. Innovative design solutions and integrating waste management can further improve system performance.

Towards Hybrid Approaches to Stormwater Management

Most countries in Southeast Asia have thus begun to legislate stormwater management as a comprehensive urban planning task. Regulations (for example, building codes), such as limiting impervious surfaces in settlements and promoting technologies for rainwater infiltration, are becoming more common. In some countries, green roof initiatives are observed. There is a growing recognition that **effective stormwater management** requires coordinated solutions that consider the **entire water catchment area** and integrate the **development of blue-green infrastructure**.

Stormwater management systems must therefore be multi-faceted, **cost-effective, scalable, and easy to maintain**. The planning and implementation of effective hybrid infrastructure approaches require a differentiated understanding that spans a wide range of expertise, including hydrology, hydraulic engineering, ecology, urban planning, and community development. Only through interdisciplinary collaboration can **meaningful complementarity between grey and blue-green infrastructures be established**. These comprehensive approaches ensure that the envisaged solutions are not only environmentally sustainable but also socially acceptable and economically viable.

Strategies include legally protecting existing wetlands, integrating decentralized rainwater management practices, such as infiltration areas, permeable pavements, and green roofs within private and public developments, and collaborating with local authorities, private landowners, and developers. Residents and investors have to understand that to maintain green spaces on their premises and follow respective regulations is in their own best interests. Multifunctional spaces like parks and sports fields can be temporarily used for water storage during intense rainfall events.

Climate change increases the frequency of extreme rainfall events and droughts. Stormwater systems must be designed to handle both scenarios. Implementing **green and blue space provides buffers against floods** and **reduces heat stress** during dry periods. Decentralized systems, such as infiltration trenches, and permeable surfaces, allow for effective stormwater management within urban areas and are particularly advantageous in cities with limited space.

Combining blue-green infrastructure with existing grey systems increases overall resilience. Examples of hybrid solutions include using wetlands for pre-treatment of stormwater before it enters grey infrastructure systems and managing floodplains by designing grey infrastructure to work in tandem with natural flood areas. The integration of blue-green infrastructure signifies a transformation to comprehensive urban planning that addresses stormwater management holistically. This requires cross-sector collaboration, strong policy frameworks, and commitment from all stakeholders.

By these means, stormwater management is **transformed from an exclusive focus of the water sector to a cross-sectoral task of urban development**. This shift encompasses the sustainable management of green spaces, agricultural lands, and riparian zones, with a particular emphasis on existing blue-green infrastructures like wetlands. Wetlands play a crucial role in the hydrological cycle by acting as natural sponges that absorb excess water during heavy rainfall and release it slowly during dry periods. They also improve water quality by filtering pollutants and provide habitats for diverse flora and fauna. The preservation and restoration of existing wetlands may be cost-effective strategies for enhancing urban resilience. Protecting these areas from development pressures is essential to maintain their ecological functions.

It should be outlined that **regular maintenance** is crucial for both grey and blue-green infrastructure. Natural systems can be degraded by pollution, invasive species, and human encroachment. Maintenance plans must be realistic and consider local financial and human resources. Involving the community in the upkeep of wetlands and other blue-green infrastructures can enhance sustainability and reduce costs.

Utilizing **existing natural systems**, such as wetlands, may reduce the need for expensive engineered solutions. Exploring alternative financing mechanisms, such as public-private partnerships and international funding for climate-resilient infrastructure projects, can support the preservation and enhancement of existing blue-green infrastructure.

Challenges for the Sustainable Development and Management of Blue-Green Infrastructure (Nature-based Solutions)

Rapid urbanization, high land prices, and complex ownership structures make large-scale land acquisition for extending blue-green infrastructure (Nature-based Solutions) particularly challenging. Public authorities often lack both the financial resources and the regulatory frameworks to purchase large areas for stormwater management or manage them effectively.

In peri-urban regions, large areas of existing blue-green infrastructure are **typically maintained by local communities or small-scale farmers**. However, rising land prices and low agricultural productivity are placing increased pressure on small-scale agriculture, leading to the dissolution of traditional management systems that help maintain these infrastructures. Public authorities face the challenge of sustainably managing these areas, even when they are designated as protection zones, and engaging communities to ensure long-term stewardship.

Engaging local communities in the planning, implementation, and maintenance of stormwater systems is essential for long-term success. Public participation not only ensures that systems are better understood, accepted, and maintained by residents, but also promotes a sense of ownership. Awareness campaigns can further highlight the importance of wetlands and encourage environmentally friendly land-use practices. Enforcing existing regulations while involving the community can enhance compliance and improve system effectiveness.

Example 26: Mitigating urban flood risks in the upstream water catchment - Sam Neua, Lao PDR

Deforestation in the water catchment of Sam Neua
(Source: PUW & Partners Own Work, 2023)

Existing situation at a creek in the Sam Neua water catchment
(Source: PUW & Partners Own Work, 2023)

In many areas, the resilience of urban environments to flooding is heavily influenced by factors outside the urban space itself. Changes in forested and agricultural land, along with shifts in land use in surrounding villages, significantly impact the runoff patterns of streams and rivers. A reduction in soil absorption capacity, loss of vegetation, and interventions, such as infrastructural straightening, can cause even small streams to swell into torrents during heavy rainfall events.

Small creeks, which in both the dry and rainy seasons have shown minimal runoff and were thus not seen as potential threats by communities and local administrations, can suddenly exhibit destructive power when prolonged, intense rainfall occurs. This risk is likely to increase with climate change, which is expected to bring more frequent and intense heavy rainfall events.

The loss of infiltration areas and runoff-delaying vegetation can cause increasingly severe floods along rivers and streams, from rural areas through peri-urban zones into cities. The loss of natural buffer zones, such as paddy fields, riparian vegetation, or fallow land, can lead to an exponential increase in flood intensity as unchecked runoff accelerates.

It is evident that appropriate measures to maintain the water absorption capacity of soils, such as sustainable agroforestry in the upstream areas of water catchments, should be a high priority for reducing flood vulnerability. Uncontrolled deforestation or unsustainable conversion of forest areas into agricultural land, as seen in cases similar to Sam Neua, can significantly increase flood risks.

To mitigate flood risks, which may go unrecognized for years due to urbanization and land use changes but can suddenly escalate into a major threat to lives and property, riparian communities and downstream cities should invest in upstream infrastructure development.

Potential low threshold measures for mitigation risks for flood flushes
(Source: PUW & Partners Own Work, 2024)

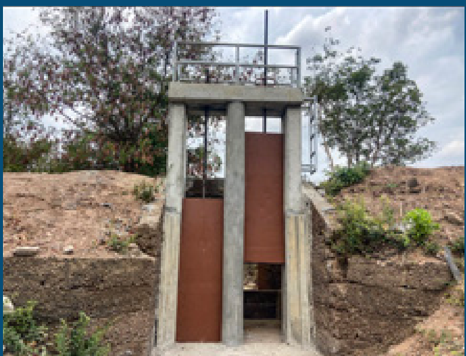
The construction of grey infrastructure, such as drainage systems and water retention basins, along with the preservation of riparian vegetation, strategic land plots, and the establishment of green zones, should be prioritized. Depending on the topography, the installation of multiple water retention basins will be necessary in many areas. However, the success of these structures relies heavily on proper planning, implementation, and, most importantly, efficient management. The retention basins must be regularly and strategically emptied to ensure they have the capacity to absorb large volumes of water during heavy rainfall events.

This requires strong institutional structures capable of ensuring the effective management of such systems. Given the high costs of construction and maintenance, these infrastructures should be integrated into a comprehensive plan of infrastructure and management measures, aimed at reducing the intensity of water runoff, particularly during extreme rainfall events.

It is important to recognize that excessive canalization of creek and stream courses can result in an accelerated runoff regime, exacerbating flood risks. Instead, low-cost, resilient solutions, such as bank stabilization with vegetation and adapted riverbed reinforcements, should be considered to slow runoff and mitigate flooding. This requires careful assessment by qualified professionals, such as hydraulic engineers, to identify strategic locations and appropriate measures in sensitive areas.

Example 27: Progressive water-sensitive urban modernisation and flood management – Kratié, Cambodia

Participatory assessment and planning at the White Bridge Channel of Kratié
(Source: PUW & Partners Own Work, 2024)



Rehabilitation of existing flood gates in the wetland area of Kratié
(Source: PUW & Partners Own Work, 2024)

The province of Kratié and its municipal administration, in collaboration with the central government in Phnom Penh, are making significant efforts to improve the livability of the city, particularly through a range of comprehensive infrastructure initiatives over the decades since the end of the Khmer Rouge regime in 1979 and the withdrawal of Vietnamese troops in 1989. Despite these efforts, the eradication of much of the country's technical expertise during this period still affects the relatively weak urban governance capacities.

Noteworthy infrastructure projects include the expansion of the road system, the planned fundamental overhaul and modernization of the drainage infrastructure dating back to the French colonial era, the design of a central wastewater treatment system, and the construction and operation of a new landfill. These projects coincide with the renovation of the city's riverside promenade. The city's residents, particularly the emerging middle class, are increasingly expecting attractive, safe public spaces similar to other areas in Southeast Asia, where new recreational activities are also possible.

However, the financial scope for both the province and the city remains very limited. The funding for urban renewal efforts comes primarily from international organizations such as the ADB, AFD, GIZ, BORDA, and the Chinese Government. Consequently, the provincial and municipal administration are focusing on relatively quick and achievable infrastructure improvements ("low-hanging fruit"), particularly in terms of flood protection. They also aim to integrate flood management into a broader urban modernization context.

A strategic site for both enhanced flood protection and the expansion of blue-green infrastructure, especially in response to climate change and the development of recreational spaces, is the so-called White Bridge

Channel. This channel plays a crucial hydraulic role in managing the inflow of Mekong River water into the "Lake Area." As part of immediate measures, with the support of BORDA, existing floodgates that had become non-functional were rehabilitated, which improved flood protection in certain areas of the city.

The provincial and municipal administrations have now initiated a planning process to ensure the flow of floodwater, protect the embankments from erosion, and develop the embankment and adjacent streets into green spaces for sports and other recreational activities. The goal is for the White Bridge Channel to become a strategic focal point for water-sensitive urban development, as urban planning in its vicinity includes the development of new residential areas, with some planning work already underway.

However, the feasibility of these plans depends on the economic recovery of the region, external investments, and the willingness of international organizations to finance the projects. Financing options, including discussions with the ADB, and development possibilities for the area will be explored in the near future.

Image of comprehensive water-sensitive infrastructure and neighborhood development at the White Bridge Channel of Kratié
(Source: PUW & Partners Own Work, 2024)

6.2.2. Key steps and phases for designing and implementing polycentric stormwater management

Effective stormwater management in rapidly urbanizing areas requires a comprehensive framework that integrates policy, planning, community engagement, and technical solutions. Below is a detailed guide to assist policymakers, urban planners, engineers, and community leaders in developing and implementing hybrid stormwater management systems that combine grey and blue-green infrastructure.

1. **Planning and Design**

   Assessment of Urban Landscape:

   - **Data Collection:** Conduct comprehensive analyses of hydrology, soil types, topography, existing infrastructure, and land use.
   - **Participatory Mapping:** Involve local communities in mapping existing blue-green infrastructures and translate this information into Geographic Information Systems (GIS) for better visualization and planning.

   Projection of Land Use Changes:

   - **Climate Change Impact Studies:** Assess the potential effects of climate change, including increased heavy rainfall events and their implications for stormwater runoff and infiltration.
   - **Master Plan Analysis:** Review existing urban master plans to understand future development trends and identify areas where stormwater management interventions are most needed.

   Consider Socio-Economic Parameters:

   - **Land Use Patterns:** Analyze trends such as the loss of agricultural green areas and changes in land ownership or management practices.
   - **Cost Considerations:** Evaluate land prices and economic factors affecting the feasibility of acquiring or utilizing land for blue-green infrastructure.

   Integrated Infrastructure Design:

   - **Holistic Approach:** Design systems that seamlessly integrate grey infrastructure (pipes, drains) with blue-green infrastructure (wetlands, green roofs, permeable surfaces).

- **Proactive Approach:** Adopt a forward-thinking strategy that integrates grey infrastructure (such as pipes, drains, and treatment plants) with blue-green infrastructure.
- **Customization:** Tailor designs to local conditions, ensuring that solutions are appropriate for the specific environmental and social context.
- **Engineering designs:** Integrate road construction with drainage systems and in alignment with the runoff regime of adjacent properties. This approach ensures that roads contribute to effective water management, preventing excessive runoff and reducing flood risks in surrounding areas

Cost-Benefit Analysis:

- **Comprehensive Evaluation:** Perform analyses that consider both direct costs and indirect benefits, such as groundwater recharge, microclimate improvement, and enhanced biodiversity.
- **Long-Term Savings:** Factor in the reduction of future expenses related to flood damage, water treatment, and health impacts.

2. Stakeholder Engagement

Community Involvement:

- **Early Engagement:** Involve community members from the outset to gather insights and foster a sense of ownership.
- **Knowledge Sharing:** Leverage local knowledge about existing blue-green infrastructures and historical land use.

Interdepartmental Collaboration:

- **Cross-Sector Coordination:** Facilitate collaboration among departments including public works, urban planning, environmental protection, and parks and recreation.
- **Unified Objectives:** Align departmental goals to support integrated stormwater management strategies.

Private Sector Collaboration:

- **Engagement with Businesses:** Encourage businesses and developers to participate by demonstrating the economic and social benefits of hybrid systems.

- **Shared Responsibility:** Promote partnerships where private entities contribute to the maintenance and enhancement of blue-green infrastructure.

3. Implementation Strategies

Phased Implementation:

- **Pilot Projects:** Start with small-scale projects to test approaches and demonstrate effectiveness.
- **Scalable Solutions:** Design interventions that can be expanded or replicated in other areas based on success.

Capacity Development:

- **Institutional Processes:** Establish mechanisms for continuous assessment and improvement of stormwater management practices.
- **Training Programs:** Provide education and training for stakeholders involved in implementation and maintenance.

Monitoring Systems:

- **Data Collection:** Implement systems to monitor performance metrics, such as water quality, runoff volume, and biodiversity indicators.
- **Feedback Loops:** Use monitoring data to make informed adjustments to strategies and designs.

Adaptive Management Techniques:

- **Flexibility:** Allow for modifications to plans based on new information or changing conditions.
- **Responsive Planning:** Be prepared to adjust strategies in response to community feedback or environmental changes.

4. Technical and Management Considerations

Engineering Standards:

- **Quality Assurance:** Develop standards that ensure the reliability and effectiveness of both grey and blue-green infrastructure components.
- **Encourage Innovation:** Stay updated with the latest technologies and practices in stormwater management.

Management Systems:

- **Local Capacity Building:** Design systems that align with the local workforce's skills and available resources.
- **Operation and Maintenance Plans:** Clearly define responsibilities for the upkeep of infrastructure components.

Maintenance Plans:

- **Routine Procedures:** Establish schedules and protocols for regular maintenance activities.
- **Resource Allocation:** Ensure that sufficient funding and personnel are dedicated to maintenance tasks.

5. **Funding and Incentives**

Financial Planning:

- **Budget Allocation:** Include stormwater management projects in municipal budgets, emphasizing both capital and operational expenditures.
- **Diversified Funding Sources:** Seek grants, loans, and investments from national governments, international organizations, and private investors.

Incentives for the Private Sector:

- **Economic Benefits:** Highlight cost savings from reduced flooding and enhanced property values.
- **Policy Incentives:** Offer tax breaks, subsidies, or expedited permits for projects that incorporate hybrid stormwater solutions.

Alternative Financing Mechanisms:

- **Public-Private Partnerships:** Collaborate with private entities to share costs and benefits.
- **Community Financing:** Encourage local investment through bonds or community funds dedicated to environmental projects.

6. **Maintenance and Monitoring**

Maintenance Plans:

- **Clear Responsibilities:** Define who is responsible for each aspect of maintenance, whether it is a government agency, private company, or community group.

- **Training and Support:** Provide necessary training and resources to those responsible for maintenance activities.

Performance Monitoring:

- **Regular Assessments:** Schedule periodic evaluations of system performance using established indicators.
- **Transparent Reporting:** Share results with stakeholders to maintain transparency and trust.

Community Involvement in Maintenance:

- **Volunteer Programs:** Encourage community participation through volunteer maintenance days or stewardship programs.
- **Educational Outreach:** Teach residents about the importance of maintenance and how they can contribute.

7. **Education and Outreach**

Public Education Programs:

- **Awareness Campaigns:** Use media, workshops, and events to inform the public about stormwater issues and solutions.
- **School Programs:** Integrate stormwater education into school curricula to foster early awareness.

Professional Training:

- **Capacity Building:** Offer workshops and certification programs for professionals involved in planning and implementing stormwater management systems.
- **Knowledge Exchange:** Promote forums for sharing best practices and lessons learned among professionals.

Awareness Campaigns:

- **Cultural Engagement:** Use culturally relevant messaging to resonate with local communities.
- **Success Stories:** Highlight successful projects to inspire and motivate stakeholders.

8. **Policy and Regulation**

Supportive Legislation:

- **Develop Policies:** Formulate policies that encourage the adoption of hybrid stormwater management systems, integrating both grey (engineered) and blue-green (Nature-based) Solutions.
- **Legal Instruments:** Enact laws and regulations that mandate sustainable stormwater practices, such as limiting impervious surfaces and requiring on-site water retention features in new developments.

Regulatory Frameworks:

- **Compliance Standards:** Establish clear standards and guidelines that developers and property owners must follow to promote effective stormwater management.
- **Building Codes:** Update building codes to include provisions for rainwater harvesting, permeable pavements, green roofs, and other blue-green infrastructure elements.
- **Standard Operational Procedures:** Elaborate SOPs to define processes for planning and implementation of hybrid stormwater systems and their translation into public planning and budgeting plans.

Public Procurement Standards:

- **Eligibility Criteria:** Develop procurement policies that prioritize projects incorporating hybrid systems, ensuring they are eligible for public funding and support.
- **Incentivize Innovation:** Encourage innovation by allowing flexibility in procurement processes for projects that demonstrate effective integration of grey and blue-green infrastructure.

Example 28: Integrated systems for stormwater management plans - Sam Neua, Lao PDR

Drainage system for recently developed central park of Sam Neua
(Source: PUW & Partners Own Work, 2023)

Sam Neua, the provincial capital, has undergone a remarkable transformation over the past two decades. What was once a primarily agricultural regional center has evolved into a modern urban hub, symbolized by the construction of large administrative buildings and the redesign of the city center.

At the heart of this transformation is the development of a new central park and stadium, which have become key landmarks of the city's modernization efforts. However, like many urban areas in Southeast Asia, Sam Neua faces a significant challenge during the monsoon season: flooding.

The city's topography plays a crucial role in its vulnerability to flooding. Sam Neua is naturally situated in a catchment area where rainwater from surrounding hills converges. The central park, designed as a recreational space and a visual enhancement to the city, becomes a collection point for stormwater runoff, particularly during heavy rainfall.

The park's sloping terrain is unable to retain all the incoming water, resulting in significant runoff that collects in the low-lying areas. This excess water not only affects the park but also spills into adjacent areas, contributing to wider urban flooding.

While the current drainage system may manage light to moderate rainfall, it struggles under the pressure of intense monsoon rains. Minor infrastructure adjustments, such as diverting rainwater from the sloping areas into the green spaces of the park, could improve water retention and reduce the amount of runoff. However, these small-scale improvements will not be sufficient to handle severe flooding events.

Flow regime of stormwater in the central park area of Sam Neua
(Source: PUW & Partners Own Work, 2023)

One potential solution lies in the redevelopment of the adjacent stadium area as an emergency water retention basin. The stadium's soccer field, which is relatively flat and centrally located, presents an opportunity to serve as a large-scale infiltration zone.

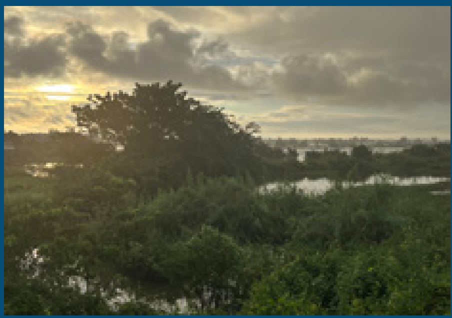
By integrating the stadium into a more comprehensive infrastructure setting to mitigate flood risks, the city would be able to better manage stormwater runoff during the monsoon season. This, in turn, would reduce the risk of flooding in the park and adjacent areas, protecting homes, businesses, and public infrastructure. (Linnea Foelster, 2024b)

To make this feasible, the field would need to be filled with approximately 35,000 cubic meters of gravel material, enabling it to absorb and manage a large volume of water.

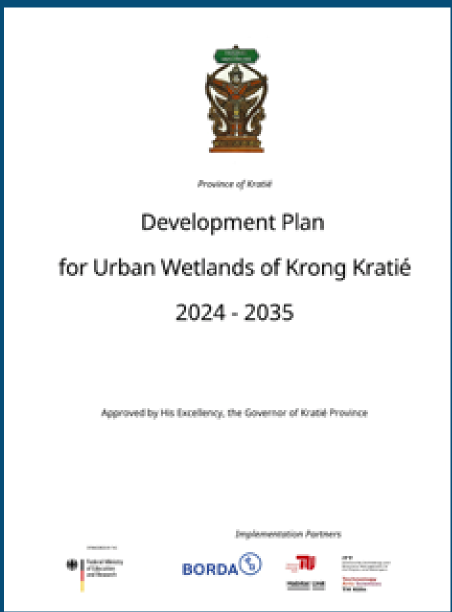
Sam Neua's potential solution draws inspiration from a successful model implemented in Hamburg, Germany. Faced with similar flooding challenges, Hamburg repurposed sports fields and public spaces to function as temporary water retention basins. (Hamburg Wasser/ RISA Project 2025)

Potential use of Sam Neua stadium area nearby the central park for stormwater capture *(Source: PUW & Partners Own Work, 2023)*

Example 29: Valuing the wetlands for the water security of the city, tourism development and the livelihoods of the communities – Kratié, Cambodia



Kratié's wetland area
(Source: PUW & Partners Own Work, 2023)



Province of Kratié

Development Plan

for Urban Wetlands of Krong Kratié

2024 - 2035

Approved by His Excellency, the Governor of Kratié Province

Implementation Partners

BORDA

Front page of the Development Plan for Urban Wetlands of Kratié
(Source: PUW & Partners Own Work, 2023)

The findings of the Kratié Baseline Assessment show the importance of the city's wetlands as a strategic asset for mitigation of flood vulnerability. Today, already the lake "Boeung Romleach" in particular, functions as a catchment basin for floods from the Mekong River during the wet season. Between 2015 and 2020 during the dry season, the length of Boeung Romleach was at most 2.26 km, while in the wet season, it varies with an average of 8.57 km. Kratié Province is known for its population of Mekong Irrawaddy dolphins, a primary tourist attraction. The local government is advocating for ecotourism in the region to attract more tourists and stimulate economic growth.

Kratié is home to several wetland ecosystems, including marshes, swamps, and floodplains. The lake and wetlands area south-east and south of the built-up municipal core hosts a wide variety of biodiversity - from fish, bird and plant species to essential micro-organisms.

Their sustainable management may contribute to development of the lake area as a strategic asset for tourism development. Bird-watching, hiking and biking may be some attractive activities for tourists and residents.

The area is already being used in different ways by the communities in the more rural sangkats to secure their livelihoods (agriculture, fishery, etc.).

In the same way, it serves as a recreational area for many residents. Notably, new restaurants are opening serving local food and frequented by locals at the weekends. The first eco-lodges are under development.

The development plan lays the foundation for systematic infrastructural development for strengthening the water safety of the city, tourism, and recreation. The plan addresses the following challenges and opportunities:

Restaurants contributing to the development of Kratié's wetland area for recreation
(Source: PUW & Partners Own Work, 2023)

- Ensuring the flow regime of waters throughout the whole area.
- Mitigating water pollution from urban waste waters and agriculture.
- Developing a good quality infrastructure for recreational and tourism purposes.
- Systematic integration of water-sensitive features into the master plan.
- Implementing settlement schemes that are part of a systematic blue-green infrastructure development scheme for the whole city.

From a governance perspective, such a plan has to meet the following challenges:

- Lack of planning and implementation mechanisms for participatory processes involving government bodies, communities and the private sector.
- Limited planning and implementation capacities of local government bodies.
- Potentially conflicting interests between communities, the private investors and public administration.
- Incoherent regulatory framework with respect to local and provincial government bodies.
- Limited financial means for development activities.

Options for infrastructure development for recreational and tourist activities in Kratié *(Source: PUW & Partners Own Work, 2024)*

Example 30: Towards zero-runoff: developing effective stormwater infiltration – Sariharjo, Indonesia

Flooding in urban area of Sariharjo
(Source: PUW & Partners Own Work, 2023)

Infiltration wells in Sariharjo
(Source: PUW & Partners Own Work, 2023)

As in most city's in Southeast Asia, the predominant drainage concept in Sleman/Indonesia is to drain excessive surface water (mainly stormwater) to the nearest waterbody that ultimately will end up in nearby rivers. In 2020, the total drainage volume in Sleman Regency reached 198.813,83 m^3. Sariharjo has a total built drainage of 16.234,44 m^3 (8.16% of the entire drainage in Sleman). However, almost half of the drainage is in a poor condition (75%), with 93.442,5 m^3 (47%) heavily damaged and 55.667,87 m^3 (28%) moderately damaged.

Limited drainage capacity, unequal development of drainage systems through-out the village area, a planning layout that insufficiently takes into account the flow regime of water, poor connectivity between different drainage systems, absence of main drainage channels, blockage of drainage systems through structural modifications (often by residents) and blockages by mud, plastic waste, wood/leaves, and volcanic eruption dust are widely observed. Furthermore, in some areas drainage with a pollution load is channeled to the agricultural irrigation systems causing contamination of the paddy fields.

In recent years, there is a progressive shift in approaches from meeting rainwater and stormwater challenges in Sleman Regency towards more integrated approaches. Currently, the Ministry of Public Works and Public Housing is campaigning for rainwater management with the concept of conservation by harvesting, infiltrating, draining, and maintaining. TRAP (Tampung-Resapkan-Alirkan-Pelihara) is an effort to infiltrate stormwater for stabilizing groundwater aquifers and reduce inundation, flooding, and other environmental hazards.

Recently developed infiltration area in Sariharjo
(Source: PUW & Partners Own Work, 2023)

With support of the government, infiltration wells are built in drainage channels, roads, and house yards. The village government primarily funds the construction; a part of the cost is borne by the community or by private Corporate Social Responsibility (CSR) initiatives (Tegalwaras sub-village). Currently there are thousands of infiltration wells in the village. Each sub-village has hundreds of wells, varying from a depth of 1.5 meters to 5 meters or more. The local government conducts drainage maintenance works periodically, such as removing waste and sediment that clogs the drainage. In addition, the communities perform monthly services to clean the environment and drainage systems.

As in other parts of Sariharjo, the drainage infrastructure implemented years ago in Rejodani sub-village is defective in places or in rather poor technical condition. Together with public authorities, the community has developed an approach to place infiltration wells throughout the sub-village. In doing so, it has succeeded in developing a learning process that is essential for effective infrastructure development. In addition to identifying technical solutions in terms of the durability of the hardware, it has been able to significantly improve the system design (here an elongated infiltration system along the local cemetery) and to position the systems themselves more effectively in the sub-village area.

Example 31: Improving the permeability of built-up areas: experiences from concept to effective implementation – Sariharjo, Indonesia

Sealing of surfaces in recently developed restaurant area of Sariharjo
(Source: PUW & Part-ners Own Work, 2022)

Sealing of surfaces in recently developed gated communities of Sariharjo
(Source: PUW & Part-ners Own Work, 2022)

The sealing of surfaces and reduction of green areas in Sariharjo and its surrounding catchment area have significantly diminished the ability to manage runoff waters. Presently, the built-up area in Sariharjo comprises approximately 45 percent of the total land. Projections based on population growth and the development trends of the past decade, including the expansion of commercial structures like hotels, restaurants, and shops, suggest that by 2030, this built-up area could increase to around 60 percent.

Indonesian Law No. 26/2007 on Spatial Planning mandates that cities and urban areas maintain a minimum of 30 percent green open spaces. Regency Regulation Number 11/2020 concerning Green Open Spaces requires that in urban areas, at least 30 percent of these spaces should be public, with an additional 10 percent being privately owned. Ensuring this target is a complex, iterative process. New developments, including gated communities and commercial zones, are predominantly characterized by extensive surface sealing, with green spaces relegated to minimal areas.

In addition to the challenge of enforcing the legal regulations, there are also technical challenges as to how land infiltration in bulit-up areas can be improved. Permeable pavement stones, also known as permeable pavers, are a popular choice for creating eco-friendly, water-permeable surfaces. They are designed to allow rainwater to pass through the surface and into the ground below, reducing runoff and aiding in groundwater recharge.

Practical experience with permeable pavement stones has highlighted the need for technical advancements. It has been found that some types of paving stones are not adequately resistant to heavy loads, such as those from large vehicles, leading to rapid deterioration.

Infiltration stones in settlement area of Sariharjo
(Source: PUW & Partners Own Work, 2022)

Additionally, these stones tend to fill up with sediment quickly, which significantly reduces their water permeability. A major challenge lies in the research and development of more durable materials for both the stone structure and the filling material. The goal is to find solutions that prevent clogging with minimal maintenance, while also being cost-competitive, to ensure the long-term effectiveness of the implemented systems.

This experience is an example of the need for capacity building in planning authorities, professional organisations and research institutions. Closely linked to this is the benefit of effective knowledge management, which is made possible by professional networks, among other things. In the Southeast Asian and global context, there are numerous designs, standards and documented experiences of how such systems can be utilised effectively and sustainably.

Infiltration stones in settlement area of Sariharjo
(Source: PUW & Partners Own Work, 2022)

Example 32: Learnings from the Road Improvement and Storm Drainage System Construction Project - Phum Samnang, Krong Chbar Mon, Cambodia

Side road Chbar Mon before water-sensitive development *(Source: BORDA Cambodia)*

Planning design for improved drainage system *(Source: BORDA Cambodia)*

The Road Improvement and Storm Drainage System Construction Project, led by BORDA, Cambodia, aims to address pressing infrastructure issues in the city. Specifically, it seeks to enhance the road network and implement a comprehensive stormwater drainage system to tackle problems such as frequent flooding, poor road conditions, and uncoordinated urban development. These improvements are expected to result in better mobility for the residents, more effective water management, and a long-term solution to infrastructure sustainability. (BORDA, 2024)

A major issue identified at the onset of the initiative was the lack of an adequate drainage system, which had resulted in regular flooding, especially during the rainy season. This not only disrupted daily life but also weakened the existing road infrastructure. Additionally, the road conditions, particularly the laterite roads, were highly susceptible to damage, leading to frequent transportation challenges and posing safety risks for the community.

To address these issues, several key technical solutions were proposed. First, raising the existing laterite roads by 1 meter to improve their durability and reduce the risk of damage from flooding. Concrete curbs were installed to better manage water flow and protect the road edges. Additionally, a new stormwater drainage system was constructed to handle heavy rainfall, significantly reducing the flood risks. A stone bed filter system was also installed to prevent solid waste and debris from entering the drainage system, thereby enhancing water quality and preventing blockages. Lastly, sidewalks were built to improve pedestrian safety and accessibility, creating a more walkable urban environment.

Since the project's completion in May 2024, there have been notable improvements. Flooding is no longer a major issue, thanks to the effective stormwater management system. The stone bed filter has performed well in maintaining water quality and ensuring that the drainage system remains free of blockages. Overall, the

Construction of improved drainage system *(Source: BORDA Cambodia)*

project has significantly improved the town's capacity to manage stormwater and maintain the integrity of its road infrastructure.

However, the project did face some challenges. Local authorities were sometimes slow in providing necessary information, and there was limited cooperation from residents living along the project route. Additionally, delays in grass turfing by local authorities affected the landscaping efforts, and there was some uncertainty regarding future budget allocations for concrete roadwork.

Several lessons were learned from the project's implementation. The involvement of local stakeholders, particularly local authorities, was crucial for the project's success, especially in clearing the existing roads. However, it became clear that the laterite road surface remains vulnerable to damage, prompting the need to explore more durable materials in future projects. Nevertheless, the stone bed filter system proved to be an effective solution for improving water quality and preventing waste from clogging the drainage system.

Local authorities will continue improving the road surfaces using more durable materials. Additionally, efforts will be made to engage the community in future maintenance activities to ensure the infrastructure's longevity. Securing additional funding and clarifying budgetary plans for upcoming roadworks will be key priorities, along with fostering better cooperation with local residents in subsequent phases of the project.

Final improved drainage system *(Source: BORDA-Cambodia)*

6.3. Design and implement polycentric green space development

Key recommendations

1. **Clarify Land Ownership and Secure Long-Term Use:** Clearly define who owns the land to prevent future disputes or conflicts. Secure the land's long-term use as green space by formalizing it in zoning plans and policies.
2. **Design Multifunctional Green Spaces:** Create green areas that serve multiple purposes like recreation, biodiversity, flood control, and air quality improvement. This maximizes benefits and efficiently uses limited urban space.
3. **Define Maintenance Responsibilities and Institutional Support:** Clearly assign who is responsible for the upkeep of green spaces to ensure they remain well-maintained. Public institutions should have defined roles and receive support from city authorities.
4. **Engage Communities and Stakeholders in Participatory Planning:** Involve residents, investors, and NGOs in the planning process to meet diverse needs and foster a sense of ownership. Participatory planning leads to more accepted and sustainable solutions.
5. **Implement Cost-Effective Strategies and Innovative Financing:** Use affordable methods and explore public-private partnerships due to limited financial resources. Consider sponsorships programs to fund development and maintenance. Investors may be interested to have green areas in upcoming developments.

6.3.1. Considerations for polycentric green space development

Challenges of Urban Densification and High Land Prices

Cities in Southeast Asia are experiencing rapid and often unplanned growth, leading to a significant decline in green spaces in both inner-city and peri-urban areas.

The competition between urban densification and the preservation of green spaces is intensified by high land prices and the limited enforcement of existing regulations. Secondary and tertiary cities, in particular, face financial and institutional challenges that hinder large-scale green space development. Given these challenges, a strategic approach to green space planning is essential to ensure quality of urban life.

Strategic and Incremental Approach to Green Space Development

The successful development of urban green spaces in Southeast Asia requires a strategic and incremental approach. Pilot projects in key locations can serve as starting points to demonstrate the benefits of green spaces and gradually lead to larger projects.

Importance of Decision-Making Support and Integration into Planning

The validity and feasibility of the overall strategic approach should be acknowledged by decision-making bodies, such as local government, city councils, and community forums. These strategies must be integrated into spatial and land use planning.

Securing Land for Long-Term Green Space Use

Land ownership must be clarified. Its long-term use as green space needs to be secured and formally established in zoning plans. Publicly owned land is crucial for green space development. However, even municipally-owned land often faces usage conflicts. Long-term leasing to investors is frequently an important source of income for municipal finances, which can conflict with the use of the land for parks. If green spaces are to be developed on privately-owned land, public funds must be allocated for purchasing or leasing.

Multi-functionality as a Key Criterion in Green Space Planning

One of the key criteria for green space planning is multi-functionality. Green spaces should not only serve as recreational areas but also contribute to biodiversity, flood risk reduction, and air quality improvement. A practical example is the design of parks that also function as flood retention basins. Another important element is the greening of streets by planting trees to improve the microclimate and provide shade.

Addressing Maintenance and Responsibility

Additionally, green space planning must address questions of maintenance and responsibility. Who is responsible for the upkeep of public green spaces outside private properties? The role of public institutions, such as green space management departments, must be clearly defined to ensure sustainable upkeep. Implementation plans need to be supported and accepted by city councils and municipal authorities to be effective.

Participatory Planning and Stakeholder Involvement

Another essential aspect is participatory planning. Involving the population and key stakeholders, such as investors and non-governmental organizations, in the planning process is crucial. Only through consultation and broad participation can sustainable solutions be found that meet the needs of different groups. A progressive approach is recommended: small-scale strategic projects, such as developing smaller green spaces, can serve as starting points for broader urban greening initiatives. These specific projects could potentially be funded by international organizations, helping cities build capacity in green space planning and management.

Connectivity and Ecological Networks

Connectivity is another central criterion. Creating green corridors that connect existing green spaces is critical to strengthening ecological networks and providing continuous recreational pathways for residents. Riverbanks, former railway lines, or underutilized public land can serve as linear parks or walkways.

Equity and Accessibility in Green Space Planning

A key aspect of green space planning is equity and accessibility. Green spaces should be evenly distributed across the city and accessible to all social groups. To achieve this, underserved or disadvantaged areas should be prioritized when planning new green spaces.

Public Participation and Ownership

Public participation plays a central role in the planning and maintenance of green spaces. Local communities and stakeholders should be involved in the process to foster a sense of ownership. Workshops and participatory planning processes can help identify the needs of the population and secure their active involvement.

Cost-Efficiency and Sustainable Development

Another important criterion is cost-efficiency. Given the limited financial resources of many Southeast Asian cities, it is necessary to develop green spaces in a financially sustainable way. This can be achieved through low-cost interventions or public-private partnerships. Companies could, for instance, sponsor the maintenance of parks, or "Adopt-a-Park" programs could be established.

Climate Resilience and Adaptation

A forward-thinking approach is to design green spaces that promote resilience and climate adaptation. Green spaces should be designed to contribute to a city's resilience against the effects of climate change, such as heatwaves and flooding. This can be achieved by integrating native vegetation and blue-green infrastructure, such as rain gardens and permeable pavements.

Enforcement of Existing Regulations

One crucial aspect of successful implementation is the enforcement of existing regulations. Ensuring compliance with laws requiring green space provision in private developments is essential. Municipalities should regularly review and update these regulations to better integrate green space planning into broader urban development plans.

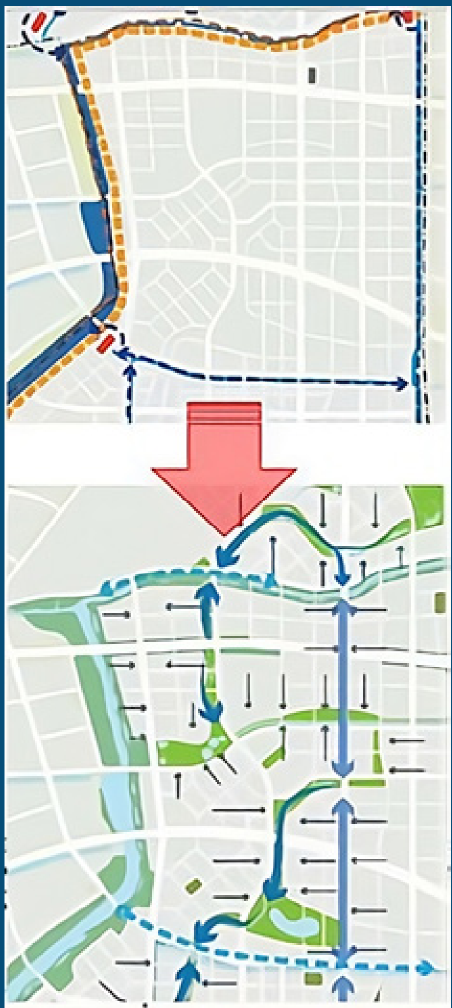
Utilizing Unused Spaces for Green Space Creation

Utilizing unused spaces is another promising method of creating urban green spaces. By repurposing vacant lots, rooftops, or derelict areas for greening projects, green spaces can be created with minimal investment. Green roofs and vertical gardens offer an additional opportunity to create green areas in densely built-up cities without taking up valuable building land.

Integration of Green Spaces into Urban Water Management

A comprehensive approach includes integrating green spaces into urban water management. Waterfronts, wetlands, and other water bodies should be incorporated into the city's green space network to support ecological functions and enhance green spaces as natural flood barriers.

Example 33: Green spaces as integral part of water security and livability – Bangkok, Thailand



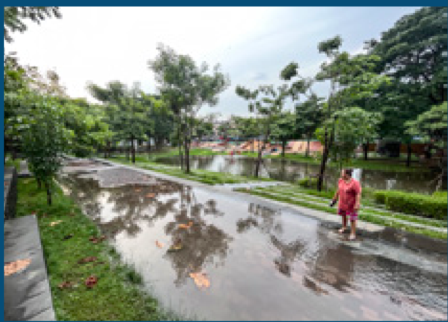
Conversion of "classical drainage system" to integrated system
(Source: PUW & Partners Own Work, 2023)

Traditional urban drainage systems are engineered to quickly divert stormwater into bodies of water like rivers, wetlands, and other waterways to prevent local flooding. These systems typically include a network of efficient gutters, large pipes, and non-absorbent surfaces, leading to a higher volume and speed of stormwater runoff during rainfall events.

Conversely, the design and implementation of integrated hybrid systems, combining grey and blue-green infrastructure for stormwater management, can enhance water resource protection and improve neighborhood livability. Such systems strive to replicate natural water cycles as much as possible, aiming to enhance water quality and efficiency, green and naturalize urban areas, and provide cooling effects. Key strategies include:

- Reducing impermeable surfaces to decrease the amount of water flowing off-site into stormwater systems.
- Slowing down stormwater runoff to allow for natural filtration, on-site detention, and infiltration.

While megacities such as Bangkok differ significantly in financial and institutional capacities when compared to secondary or tertiary cities, there are valuable lessons to be learned for locally adapted similar solutions. Over recent decades, Bangkok has experienced remarkable growth, leading to a very dense urban structure with limited green spaces. This development has resulted in more frequent flooding due to inadequate infrastructure. However, recent initiatives aim to reintroduce green spaces in urban areas.



Views of Chulalongkorn University Centenary Park with drainage system
(Source: PUW & Partners Own Work, 2023)

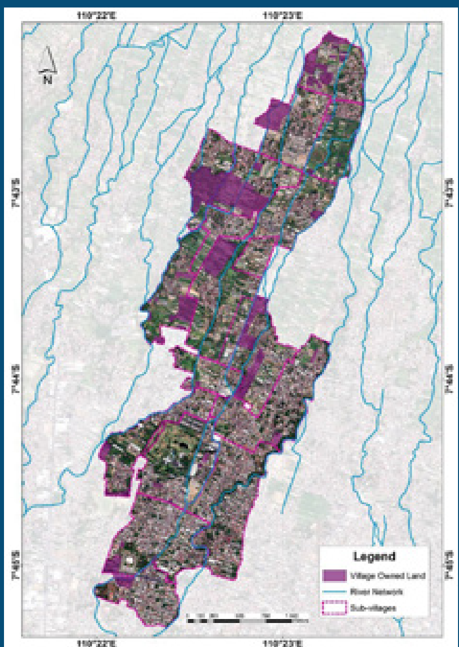
A notable example is the Chulalongkorn University Centenary Park, opened in 2017. This project showcases the advantages of multifunctional green spaces. The park cleverly utilizes gravity to gather, treat, and store water, thereby mitigating flood risks in nearby areas and offering protection against a 50-year flood event. It features constructed wetlands with native plants and a sizable detention pond, ensuring efficient use of water for park irrigation, including rainwater and roof runoff. Additionally, the park is likely to provide a cooling effect to its surroundings.

This offers crucial direction for the design and ongoing upkeep of more modest grey and blue-green infrastructure endeavors:

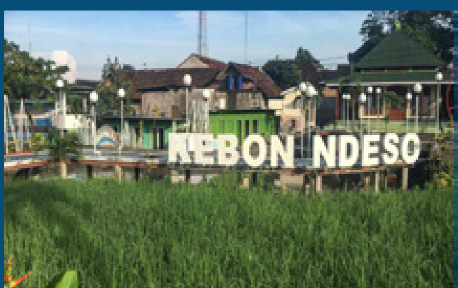
- Emphasizing resilient engineering design is essential. It's important that the layout of the area and the structures permanently support adequate water drainage and infiltration.
- Engineered Nature-based Solutions often call for competent management and ongoing financial support for their upkeep. Accordingly, ensuring the engagement of public or private institutions, communities, or service providers is as vital as securing funding for the services they provide.

Example 34: Strategic public green space development to ensure good livability – Sariharjo, Indonesia

Public Green Parks in Sariharjo
(Source: PUW & Partners Own Work, 2023)



Map of community owned land in Sariharjo
(Source: PUW & Part-ners Own Work, 2024)



Public Green Parks in Sariharjo
(Source: PUW & Partners Own Work, 2023)

The New Urban Agenda - endorsed by the United Nations in 2016 during the Habitat III Conference - advocates for the universal access to safe, inclusive, accessible, green, and quality public spaces. Apart from their environmental benefits, public green spaces are seen as drivers of social cohesion and inclusion, promoting health and well-being, fostering community identity and a sense of belonging, and encouraging people to adopt sustainable lifestyles. The agenda calls for the integration of green public spaces into broader urban and territorial planning strategies to ensure their preservation and enhancement as cities grow and develop.

In many cities, public green spaces are gradually disappearing along with urban growth. Settlement pressures without comprehensive spatial planning or its implementation are pushing many traditional public spaces into unsuitable niches in many places. Public green spaces are gradually disappearing as urban growth progresses. Rising land prices are even increasing the competition over publicly owned land. Nevertheless, it will hardly be feasible to convert them back into green spaces at a later date. All the more reason for cities to proactively develop these green spaces.

These conflicts of interest are also reflected in Sariharjo, where the villages and communities with the so-called village-owned land nominally still have considerable room for manoeuvre. In 2022, the area of this type of land was still 83.98 hectares (about 12 percent of the total village area). According to the public regulations, this land must be used for the benefit of village development and its residents. Income generated from this land is mainly used to run the government respectively to cover the salaries of the village and sub-village apparatus plus incentives for village heads, village officials, and hamlet heads. Furthermore, income is used for village development activities.

“Kebon Ndeso” is a good example of how village owned land has been transformed into an attractive public park including recreational area with a swimming pool, a community meeting building, and a restaurant that is widely used by the local community. However, Kebon Ndeso is rather an exception; numerous similar projects have failed. Lack of strategic planning, of good leadership and of good asset management paired with vested real estate interests to use and develop the land for profit without any long-term planning have been contributing factors.

6.3.2. Key steps and phases for designing and implementing polycentric green space development

The planning and development of urban green spaces require a systematic and coordinated approach, covering various phases from analysis to implementation and long-term maintenance. Below is a detailed planning process that cities and municipalities can follow to successfully implement green space projects.

1. **Preparation Phase**

   Needs Assessment and Goal Setting:

   - Begin with a needs assessment to evaluate the current state of green spaces, the demand for new green areas, and potential challenges within the city. This should include assessments of population density, climate conditions, urban heat islands, and flood-prone areas.
   - Establish specific goals for green space development, such as improving quality of life, promoting biodiversity, creating recreational areas, adapting to climate change, and reducing flood risks.
   - Set indicators for measuring progress in green space development. These indicators should be clear, quantifiable, and aligned with the established goals.

   Data Collection and Urban Landscape Analysis:

   - Collect data on hydrology, soil composition, topography, and existing infrastructure.
   - Map unused or underutilized spaces, flood-risk zones, and existing green corridors. Utilize GIS (Geographic Information Systems) for efficient mapping and visualization.
   - Develop a city structure plan to identify potential conflicts between planned developments and the creation of green spaces.
   - Identify green spaces of strategic value that are owned by government, communities, etc. or that may be purchased by the government.

2. **Stakeholder Engagement and Planning Phase**

   Stakeholder Involvement and the Participatory Process:

   - Engage local communities, investors, NGOs, and other stakeholders early in the planning process.
   - Hold workshops and public consultations to gather input, suggestions, and concerns from citizens.
   - Establish a planning committee with representatives from urban planning, environment, transportation, and public health sectors to ensure green space development aligns with broader urban plans.

   Drafting Design Plans:

   - Based on the needs assessment and stakeholder feedback, create initial design plans that incorporate recreational and functional aspects (for instance, stormwater management through rain gardens and permeable surfaces).
   - Prioritize the use of natural processes such as water infiltration and microclimate regulation to ensure sustainability.
   - Design multifunctional spaces, such as parks, that serve as flood retention areas or tree-lined streets that provide shade and improve air quality.

3. **Approval Phase**

   Review and Approval by Authorities:

   - Submit design plans to municipal and governmental authorities for review, ensuring compliance with all legal requirements and regulations (for example, environmental protection, and zoning laws).
   - Coordinate with other urban development projects, such as infrastructure and transportation, to avoid conflicts and leverage potential synergies.
   - Develop a legal framework to ensure the long-term protection of green spaces, including zoning laws or agreements with private landowners.

   Financial Planning and Procurement:

   - Create a financial plan that accounts for the development costs as well as long-term maintenance and operational expenses.

- Secure funding sources from municipal budgets, environmental grants, and public-private partnerships (PPP).
- Consider alternative financing mechanisms, such as private investment, to support the project.

4. Implementation Phase

Phased Rollout and Pilot Projects:

- Implement the project in phases, starting with pilot projects to test methods and showcase the benefits of green spaces to the public.
- Choose strategic locations for pilot projects, such as unused public spaces or vacant lots that can be easily transformed into green areas.

Technical Implementation:

- Construct green infrastructure based on the approved designs, including planting, installing rain gardens, and creating permeable pavements.
- Collaborate with construction firms and landscape architects experienced in environmentally sustainable techniques.
- Integrate smart water management systems for rainwater retention and infiltration to minimize flood risks.

5. Operation and Maintenance Phase

Long-Term Maintenance Plans:

- Develop a detailed maintenance plan with clearly defined responsibilities (for example, municipal authorities, private contractors, or community groups) for the upkeep of green spaces.
- Ensure regular inspections and repairs to maintain the functionality of green spaces and maximize the lifespan of plants and infrastructure.

Community Engagement in Maintenance:

- Promote volunteer programs and community-led initiatives for maintaining green spaces (for instance, "Adopt-a-Park" programs).
- Organize educational events and workshops to raise public awareness about the value of green spaces and encourage active community involvement.

6. Monitoring and Evaluation

Performance Monitoring:

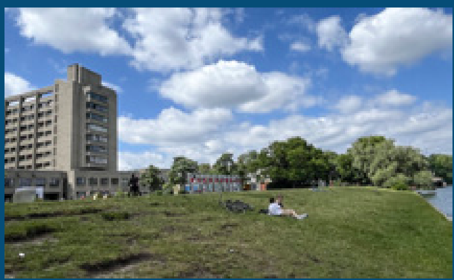
- Develop a monitoring system to regularly assess the condition and functionality of green spaces. This includes evaluating plant growth, soil moisture, biodiversity, and the effectiveness of water infiltration systems.
- Use indicators such as water quality, air quality, and social usage to measure the success of the green spaces.

Continuous Improvement:

- Based on the monitoring results, make adjustments to the design, maintenance, and management of green spaces.
- Establish feedback loops with the community and municipal authorities to continuously improve the planning, management, and use of green spaces.

Example 35: Participatory planning for water-sensitive green space development: A practice – Kreuzberg in Berlin, Germany

Map of Urbanhafen Area, Berlin
(Source: Google, 2025)



Current uses of green area
(Source: PUW Own Work, 2024)

With the growing population and the resulting increased pressure on public spaces, the utilization of urban open spaces in the Kreuzberg district of Berlin is also rising. The evident climate changes, including frequent extreme weather events, underscore the need for a modern concept for the existing open spaces in the district.

In the "Urbanhafen" neighborhood, new utilization concepts for green areas are to be developed, focusing on improved rainwater management and sustainable use of green spaces for the recreational needs of the population. Primarily, the green space serves as a water-side recreational area for residents and visitors.

The development of the concept follows a structured process, culminating in concrete measures to be financed and implemented under government funding programs such as "Living Centers and Neighborhoods".

The planning process was prepared by an interdisciplinary steering committee of local government agencies. Following the conclusion of a public tendering process, an agency was commissioned with the development of the initial rough planning, the facilitation of stakeholder processes through to the preliminary planning in close cooperation with respective government agencies.

The existing functions, structures, qualities and deficits of the individual open spaces were examined with the help of a comprehensive assessment of the existing situation and possibilities for strengthening the spaces were analyzed. Discussions were held with involved authorities and local stakeholders – including the local hospital operator, the Waterways New Construction Office, and Berlin’s water operator. A preliminary concept was developed for rainwater management for the open spaces at Urbanhafen and adjacent street areas.

Street planned for water sensitive transformation
(Source: PUW Own Work, 2024)

Public participation processes for water-sensitive transformation
(Source: PUW Own Work, 2024)

Building on citizen participation conducted at the beginning of the project through www.meinBerlin.de as part of the open space development concept, there were further opportunities for participation throughout the planning process. Since then, regular information events, site visits, and online surveys have been conducted, informing citizens about the current planning status and offering opportunities for comments. Here, the designs of the planning offices could be commented on, and especially usage conflicts could be identified. While visitors prefer expansive green spaces, the increasingly high frequency of cyclists and pedestrians leads to overuse and compaction of the green areas. This reveals a goal conflict in urban planning: the public and political desire for a shift from car drivers to cyclists as part of improved climate protection leads to higher bicycle traffic at Urbanhafen.

As one of the most important measures proposed in the open space development concept, the district office has initially begun planning the green spaces at Urbanhafen. A rainwater management plan envisages the unsealing of adjacent streets by installing permeable materials to improve or ensure the drainage of the entire green area. By improving the pathway system adjacent to the green space for bicycles, traffic loads on the facility are to be reduced, thus making a significant contribution to the safety and sustainable use of the area. (Bezirksamt Friedrichshain-Kreuzberg, 2025)

6.4. Design and implement polycentric urban sanitation schemes

Key Takeaways

1. **Strategic Choice between Centralized and Decentralized Systems Considering Long-Term Urban Development:** Evaluate both centralized and decentralized wastewater systems in the context of medium- and long-term urban development scenarios. Decentralized systems may offer flexibility and lower upfront costs for rapidly growing or peri-urban areas, while centralized systems might be more efficient for established urban centers.

2. **Ensure Sustainable Financing and Maintenance Capacities:** Develop financing models that cover both initial construction and long-term operation and maintenance costs. This includes exploring funding sources like government budgets, tariffs, donor funds, and public-private partnerships.

3. **Improve Sludge Management and Septic Tanks in Peri-Urban Areas:** Prioritize improved septic tanks and implement effective sludge management practices to prevent environmental contamination. Improved septic systems and regular desludging services are crucial where centralized sewage systems are unavailable.

4. **Strengthen Law Enforcement and Regulatory Compliance:** Elaborate a consistent regulatory framework. Enhance the enforcement of environmental and sanitation laws to ensure compliance from industries and households. Provide adequate resources and relevant authority to regulatory bodies for effective monitoring and enforcement. Penalties for non-compliance encourage adherence and support sustainable business models.

5. **Build Local Capacity and Engage Communities:** Invest in training and capacity building for local authorities and water operators to manage wastewater systems effectively. Skilled personnel are essential for the operation and maintenance of both centralized and decentralized systems.

6.4.1. Considerations for polycentric wastewater management

Wastewater management in Southeast Asia faces numerous challenges, which put the achievement of the **United Nations Sustainable Development Goal 6 (SDG 6)**—ensuring the availability and sustainable management of water and sanitation for all by 2030—at risk. These challenges are diverse and complex, including inadequate infrastructure, environmental pollution, health risks, industrial wastewater discharges, and weak regulatory frameworks.

Infrastructure and Service Gaps

In many cities across Southeast Asia, **sewer networks and centralized wastewater treatment plants** are either lacking or insufficient. Existing infrastructure often serves only a small percentage of the population. Even newly built systems frequently underperform due to inadequate **maintenance, operation,** and **sustainable financing.** In **rural and peri-urban areas**, access to formal wastewater services is even more limited or entirely absent. In urban areas, basic **sanitation practices**, such as soak pits and septic tanks are common, but these are often poorly designed, constructed, and maintained, leading to the seepage of pollutants into **groundwater and surface waters**, with resulting environmental contamination and public health risks.

Environmental and Health Impacts

The **direct discharge** of untreated or inadequately treated wastewater into **rivers, lakes**, and **coastal areas** is widespread, leading to **eutrophication** and damaging aquatic ecosystems. This practice increases the risk of **waterborne diseases** such as cholera, typhoid, and diarrhea among local populations. Additionally, the discharge of **pharmaceuticals** and **pathogens** contribute to the development of **antimicrobial resistance**, posing further public health risks.

Industrial Wastewater and Pollution

Industrial wastewater discharges exacerbate the problem, as companies release **heavy metals, chemicals,** and other **toxic substances** into the environment without adequate treatment. This leads to significant environmental degradation and further health risks for the population.

Weak Legal Frameworks and Informal Settlements

Weak **legal frameworks** and a lack of **enforcement** allow environmental laws to be ignored. Informal settlements, often arising from unplanned urbanization, rarely have access to adequate sanitation services, exacerbating the problem. The lack of effective enforcement also undermines efforts to improve sanitation and wastewater management in these areas.

Institutional Fragmentation and Lack of Capacity

Institutional fragmentation and the absence of capable **water operators** complicate wastewater management. Responsibilities for water and wastewater services are often spread across various government agencies, leading to **inefficiencies** and **overlaps** in service delivery. Many regions also suffer from a lack of trained personnel and organizations capable of managing wastewater systems effectively. **Financial constraints** further prevent the establishment and maintenance of necessary infrastructures.

Decentralized Solutions and Their Challenges

While **decentralized wastewater solutions** can be an effective alternative in areas without central infrastructure, they are not widely implemented or managed effectively. **Technical challenges**, lack of **standardization**, and financial risks hinder their success. Effective management of decentralized systems is critical to overcoming these barriers.

Law Enforcement and Investment Issues

Weak **law enforcement** is a key factor contributing to the ongoing wastewater management issues. The inconsistent application of **environmental** and **sanitation regulations** undermines investor confidence, making it difficult to develop sustainable business models for services like **sludge management**. Without strong enforcement, there are few incentives for private investments, and revenue streams for wastewater services remain unstable.

Solutions and Strategies

To address these challenges, several strategies must be implemented:

- **Strengthening Law Enforcement:** Updating legal frameworks and establishing clear penalties for non-compliance is crucial to improving regulation and accountability.
- **Capacity Building:** Providing technical training and promoting institutional development can enhance the effectiveness of both authorities and operators in managing wastewater systems.
- **Decentralized Solutions:** Tailoring decentralized wastewater solutions to local needs is particularly helpful in areas without central infrastructure. These solutions must be managed effectively to ensure long-term success.
- **Financing Schemes:** Engaging communities in the planning and implementation process ensures that solutions are tailored to local needs and can be sustained in the long term.
- **Public-Private Partnerships (PPP):** Leveraging PPP models can bring in expertise and financing to improve wastewater infrastructure. Financial incentives and subsidies may further encourage investments and make services more affordable.
- **Institutional Reforms:** Clarifying responsibilities and reducing institutional fragmentation through reforms will improve coordination and service delivery in the sector.

6.4.2. Key steps and phases for designing and implementing polycentric improved wastewater management schemes

Government bodies addressing the challenges of urban wastewater management require a multifaceted approach that combines policy reform, technological innovation, community involvement, and strong governance. By following this comprehensive guideline, cities can progressively build the necessary technical, institutional, and financial capacities to manage urban wastewater effectively, protecting public health and protecting the environment.

1. **Regulatory and Policy Framework – creating an enabling environment**
    - Develop and enforce a comprehensive sanitation framework that addresses waste collection, treatment, disposal, and recycling.

- Establish clear guidelines for sludge management and safe disposal.
- Implement policies that encourage the relocation of polluting industries to designated zones with adequate wastewater treatment facilities.
- Set up robust mechanisms for monitoring the performance of sanitation systems to ensure compliance with environmental standards.
- Regularly review and update sanitation strategies to reflect the dynamic nature of urban development and technological advancements.

2. Public Awareness and Political Will

- Launch public awareness campaigns to educate citizens on the importance of sanitation and proper waste disposal.
- Engage political leaders to secure commitment and support for funding sustainable sanitation infrastructures.

3. Infrastructure Development

- **Sanitation Plans:** Elaborate strategic and comprehensive sanitation plans that consider an effective combination of centralized and decentralized solutions.
- **Decentralized Solutions:** Promote the installation of improved septic tanks, DEWATS and on-site treatment systems, especially in areas not served by centralized systems.
- **Centralized Solutions:** Address the development of infrastructure considering aspects such as long-term treatment efficiency, financing, maintenance and operation.
- **Innovative Technologies:** Apply advanced technologies to the treatment of specific waste streams, such as hazardous waste.
- **Wastewater Treatment Plants:** Assess and redesign centralized wastewater treatment plants (WWTPs) to match actual urban needs and prevent over-capacity issues.
- **Develop Capacity:** Build the capacity for regular maintenance and operation of sanitation systems.

- **Good Quality Sludge Treatment:** Develop infrastructure for sludge treatment that is accessible and efficient.

4. **Integrated Waste Management**

- Promote the segregation of waste at the source to facilitate effective recycling and reduction of waste streams.
- Implement decentralized solutions including community-managed septic tanks and local treatment systems for areas where centralized WWTPs are not feasible.
- Incorporate advanced technologies for treating hazardous waste, particularly from hospitals and industries.

5. **Water Reuse and Recycling**

- Develop systems for the safe reuse and recycling of treated wastewater for non-potable purposes, such as agriculture, industrial cooling, or landscape irrigation.
- Establish guidelines and standards for water quality to ensure safety and public health are not compromised.

6. **Financial Models and Incentives**

- Introduce tariff systems that reflect the true cost of sanitation services to ensure the financial sustainability of wastewater management infrastructures.
- Provide incentives for households and businesses to install improved septic systems and participate in waste recycling programs.

Example 36: Elaborating a strategy for effective wastewater management – Kratié, Cambodia

Animal husbandry in peri-urban area of Kratié
(Source: PUW Own Work, 2022)

Kratié, as with many krong (secondary and tertiary cities) in Cambodia, grapples with the complex task of developing an efficient wastewater management system for a modern city with an increasing population long after the urban area has been developed. The key challenges are predominantly regulatory, administrative, financial, and technical in nature.

Kratié, as with other urban areas in Cambodia, took advantage of the existing natural water bodies and wetlands to efficiently process its wastewater prior to population increases and changes to local land use and water bodies making such solutions ineffective.

The Krong's existing sewer system, a combined network handling both sewage and stormwater, only covers approximately half of Krong Kratié. This system discharges untreated waste directly into the lake,"Boeung Romleach" to the south-east and south of the main urban core, posing considerable health and environmental risks.

Most households have constructed some form of non-standard unsealed soak-pit – reports of infrequent desludging indicate that existing septic tanks are likely leaking into the environment and maybe contaminating water bodies.

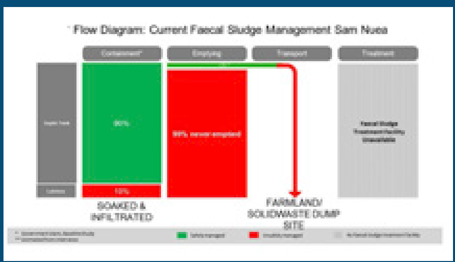
There is a tabled proposition for funding from the Asian Development Bank to establish a centralized treatment plant. However, this proposal faces various hurdles, including issues around management, operation, and maintenance. Additionally, there might be resistance from households reluctant to pay for sanitation services.

Strategic planning, potentially through a City Sanitation Plan, is a valuable tool for addressing these issues. This plan should be designed with a clear understanding of Kratié's distinct spatial characteristics, socio-economic conditions, and financial capacities. It should also explore a combination of centralized and decentralized solutions that can be progressively introduced, allowing for flexibility and adjustment based on actual needs and responses.

Timeline	Strategy Proposed
Baseline (2024)	Wastewater from city center flows via drainage system to wetlands without prior treatment. No open defecation practiced currently. However, the prevailing situation is characterized by unsanitary on-site systems and open discharge of greywater (GW), unregulated fecal sludge (FS) collection and no treatment systems.
Short-term (1-3 years, 2025-28)	Establish centralized treatment systems for high density areas in the city core, compliment with decentralized wastewater management (DWWM) and FSM. Improve on-site systems and curb open discharge of GW, scale-up FS collection and establish FS treatment systems. Establish on-site and DWWM systems for suitable areas including hotspots. Start to implement mandatory fee collection system. Build up individuals and capacities for managing centralized wastewater management system. Conduct comprehensive awareness campaigns in all sangkats, schools and social media.
Mid-term (4-8 years, 2028-32)	Achieve 'Zero-Discharge' status and 100% collection and treatment of FS with resource recovery. Effective and sustainable financing systems are in place.

Example 37: Protecting freshwater resources by a clustered approach to decentralized wastewater treatment systems

Wastewater released from homes in Sam Neua town area
(Source: PUW & Partners Own Work, 2022)



Overview of wastewater management practices in Sam Neua
(Source: PUW & Partners Own Work, 2023)

New water supply scheme in Sam Neua
(Source: PUW & Partners Own Work, 2022)

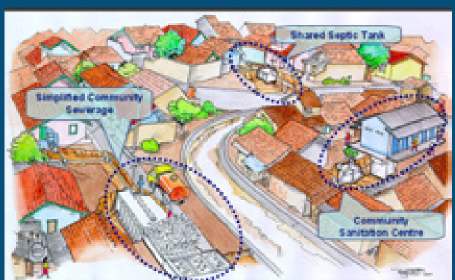


Image of options for effective sanitation in suburban area of Sam Neua
(Source: PUW & Partners Own Work, 2023)

As Sam Neua town grows, more water will be used and significantly more wastewater will be generated. Already today, inadequate management of wastewater (septage, household greywater, and agricultural/industrial wastewater) contributes to increasing risks of contamination, water resource pollution and potentially higher rates of water-borne disease infections.

The widely used septic tanks are poorly designed and rarely emptied indicating potential pollution of the environment, and when emptied, faecal sludge is disposed untreated in paddy fields, on roadsides and at solid waste dumpsites. There is no mechanism for greywater retention and treatment. This results in pollution of surface and groundwater.

Law enforcement at the household level and monitoring of adequate disposal of sludge at treatment sites is lacking for effective sludge management. 99 percent of septic tanks are never emptied and consequently safely treated.

Due to the limited financial and institutional capacities, for the foreseeable future Sam Neua will not be able to finance and maintain a high-tech sewage system.

The ADB supports the rehabilitation and upgrade of Sam Neua's water supply system. In order to contribute to the long-term safety of the water supply, a new water intake has been developed upstream at the Xam River.

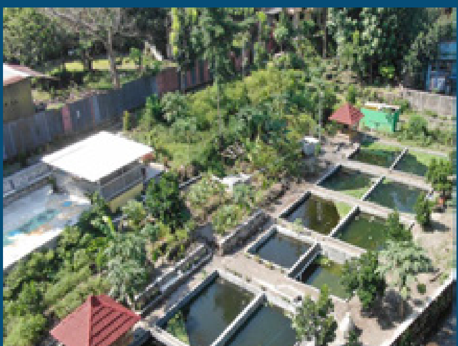
However, urban development occurs much more rapidly than predicted.

Today important settlement activities are observed above the water intake that may contribute to water pollution due to poor wastewater and sludge management.

In order to mitigate these threats to public health and ecosystems, a water safety plan is being developed. As infrastructural measures, the development of a DEWATS cluster is planned connecting the buildings through simplified sewers and a small sewerage treatment facility. Infiltration areas are being considered to mitigate the pressure on the sewage system caused by stormwater runoff. Regular emptying and adequate disposal of sludge will be closely monitored by the local government.

Example 38: Creating an enabling environment for effective water services - Sleman Regency, Indonesia

Fecal sludge collection in Sariharjo
(Source: PUW & Partners Own Work, 2022)



DEWATS communal wastewater management scheme in Sariharjo
(Source: PUW & Partners Own Work, 2022)

As in many urban areas of Southeast Asia, the existing sanitation infrastructure in most parts of the Sleman Regency is inadequate, leading to significant public health, environmental, and water resource challenges. As fresh water consumption increases, wastewater generation is also set to rise.

Due to the high investment costs, the costs of maintenance and operation and a still unclear institutional setup for its water operator, the construction and operation of a centralised wastewater system is not a viable option in the medium term, especially in the peri-urban transition zones.

The still very fragmentary legal and institutional framework is an obstacle to the development of an efficient wastewater sector. Indonesia has no specific and comprehensive current wastewater management law. The most important legal instrument that governs wastewater management at the local level is Law No. 23 from 2014 on Local Government, which attributes to provincial, regency, and/or municipal administrations the responsibility to cover, on a mandatory basis, the so-called basic services that include health, public works and spatial planning.

The Government of Sleman Regency aims to reach 100 percent universal access to sanitation by 2025, with 33.5 percent having access to safely managed sanitation, 66.5 percent having access to improved sanitation and 0 percent accessing poor/unimproved sanitation.

Currently, the prevalent use of soak-pits in Sleman Regency is insufficient for the needs of a modernizing village and fails to meet national standards. A gradual development of sanitary infrastructure is vital, starting with the compulsory implementation of improved

Fecal sludge management plant in Sleman
(Source: PUW & Partners Own Work, 2022)

septic tanks and decentralized sewerage systems such as DEWATS. These systems are seen as crucial for a progressive transition towards an integrated approach that combines both decentralized and centralized solutions. Additionally, decentralized solutions can be applied in water protection zones through cluster solutions.

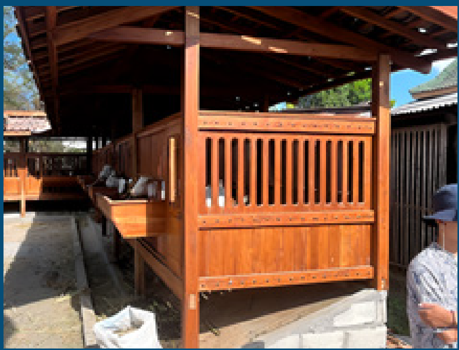
The Sleman Regency has made it mandatory for new settlements to install sealed septic tanks in accordance with the national standard SNI 2398-2017 for septic tanks. Various measures were supported and implemented: 1) Provision of "improved" sealed septic tanks to 4,157 households to date. 2) Construction of 1000 sealed individual septic tanks for low-income households in each district of the Regency. 3) Construction of 170 communal gravity-fed water treatment plants serving 12,156 households (between 50 and 100 households each), and 4) Establishment of a sludge treatment plant.

There are also considerable challenges when it comes to setting up and operating decentralised solutions and effective septage management.

- An effective sludge management system hinges on a fee-based, regular septic tank emptying service.
- This necessitates not only widespread awareness campaigns,
- But also strict enforcement by the respective authorities.

Example 39: Reducing water pollution from animal farming through structural improvements

Existing animal husbandry structure in peri-urban area of Sariharjo
(Source: PUW & Partners Own Work, 2022)



Improved goat shed in peri-urban area of Sariharjo
(Source: PUW & Partners Own Work, 2023)

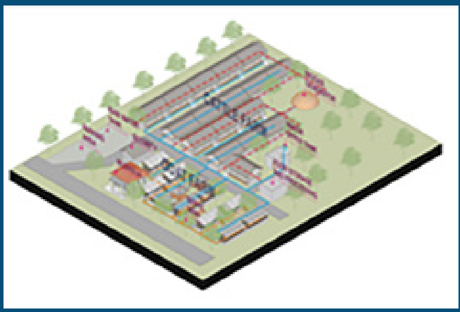
Agriculture is rapidly losing importance in the peri-urban areas of cities. Despite these socio-economic transformation processes, agricultural activities will still be important for many communities, probably less as full-time farmers and more as part-time farmers and for their own subsistence. Farms will come under pressure to modernize, especially in the vicinity of settlements, not least due to hygiene and environmental regulations.

It is unlikely, for example, that animal husbandry will be allowed to continue in the village centers in the long term. Water pollution and odor nuisance will increasingly be addressed by public authorities and neighborhoods.

Taking into account worldwide experiences, it can be predicted that such animal husbandry will tend to be located on the outskirts of villages in a modernized settlement. The same will apply to small and medium enterprises that are active in fields such as metal fabrication, and tofu or batik production

Modernization in this context means, above all, fundamentally overhauling the structural elements of the farms. This will require the construction of new stables, more species-appropriate animal husbandry and integrated environmentally friendly manure management, which is based on principles of waste recycling.

In Rejodani, livestock farming is still widely practiced today in very simple sheds and stables. There are still traditional farmhouses, with husbandry stables on the property. A co-operative located in Rejodani practices animal husbandry in two dozen stables.

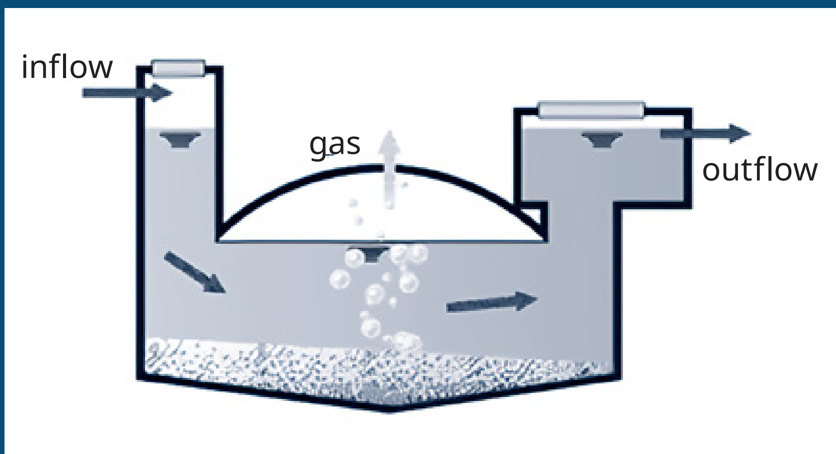


Technical design for improved animal husbandry structure with waste management system
(Source: PUW & Partners Own Work, 2023)

However, steps are already being taken to replace traditional goat sheds with ones that are more suited to the animals' needs. In these new structures, goat manure is no longer left inside the sheds but instead falls through a grating system for easy collection and disposal, representing a move towards more efficient and sustainable farming practices.

The co-operative's agricultural facilities also need a complete overhaul of the building stock and the introduction of an effective waste and wastewater treatment system. Cleanable floors are designed to allow manure to be channeled directly into a biodigester where a biological process breaks down the organic matter in the absence of oxygen respectively in an anaerobic process.

The product methane (CH4) can be used as energy for cooking or agricultural processing. The other main product of the anaerobic digestion is a high quality organic fertilizer that can be used for a more sustainable agriculture that allows organic farming, mitigates chemical induced water pollution and safeguards the soil structure.



Technical design of biodigester for treating high BOD load
(Source: PUW & Partners Own Work, 2023)

Example 40: Relocation of polluting industries and development of water-sensitive industrial zones - Rejodani in Sariharjo, Indonesia

Chemical waste at Batik Processing Unit in Sariharjo
(Source: PUW & Partners Own Work, 2022)

Tofu production in Sariharjo
(Source: PUW & Partners Own Work, 2022)

In the context of stricter law enforcement, relocating water-polluting industries into designated areas, special zones or industrial areas is a strategic approach to mitigate environmental degradation within the framework of water-sensitive urban transformation. Industries such as tofu production, dyeing, and metal processing significantly contribute to the pollution of urban water bodies by discharging untreated or inadequately treated wastewater containing organic matter, dyes, heavy metals, and other harmful substances into the environment. Water-sensitive technological and infrastructure upgrades in residential zones are often economically not feasible.

Special zones in urban developments allow centralized waste management, where shared wastewater treatment facilities become economically viable, reducing the overall environmental footprint. Concentrated industries allow for effective monitoring and enforcement of environmental laws, and improved infrastructure supports both environmental goals and economic activities.

- Tofu manufacturing produces wastewater rich in organic compounds like proteins and fats. When released untreated, the high oxygen demand harms water bodies, harming aquatic ecosystems. Governments are encouraging tofu producers to move into designated industrial zones, facilitating efficient waste management and aligning with water-sensitive urban planning by protecting water resources. Indonesia has implemented programs to relocate tofu producers to centralized facilities equipped with wastewater treatment systems. For instance, in Java, local governments have established tofu industry clusters where shared treatment plants are available.

Current practices of small metal production
(Source: PUW & Partners Own Work, 2022)

- Dye industries use various dyes and chemicals. Without proper treatment, these substances contaminate waterways, affecting human health and the environment. Establishing batik-specific industrial clusters enables shared resources for waste treatment and ensures compliance with environmental regulations, supporting sustainable urban development. Vietnam has encouraged foreign and domestic investment in eco-industrial parks that comply with international environmental standards.
- Metal processing industries release heavy metals like lead, mercury, and cadmium into water sources, posing serious health risks. Relocating metal processing plants to designated industrial areas allows for the installation of necessary pollution control infrastructure and observance of stricter environmental standards, contributing to the sustainable growth of cities. In Malaysia, the government has pushed industries to move into designated areas with proper waste management facilities. In the Philippines, the establishment of metalworking zones with access to treatment plants helps in monitoring and controlling pollution levels.

Nevertheless, challenges remain: many of the industries are small and medium enterprises that lack the capital to invest in new premises to cover investments and operation costs in industrial zones. Important investment support from the government for infrastructure development is needed. Challenges such as noise pollution management of these zones, community displacement, distance to travel to work for the workforce and the potential shift of environmental problems to new locations may occur.

6.5. Design and implement standard operating procedures for establishing effective management schemes

6.5.1. Considerations for the functions and uses of SOPs

The **Standard Operating Procedures** (SOPs) for water-sensitive urban transformation should provide a **structured framework** for planning, executing, and managing initiatives. These SOPs are designed to guide the integration of **sustainable water management practices** into urban development and ensure effective collaboration among **government departments, communities**, and the **private sector**.

Establishing Clear Frameworks

SOPs should create a **clear, step-by-step framework** that outlines the entire process, from the initial planning to the final execution of water-sensitive urban projects. By clearly defining the **roles and responsibilities** of all stakeholders—including public authorities, private entities, and the local community—these procedures ensure that each participant knows their duties in implementing water-sensitive solutions.

Alignment of SOPs with **local government** work is needed. If SOPs are not within the department's mandate, they cannot be followed.

Promoting Efficient Collaboration

One of the primary goals of SOPs is to promote **efficient collaboration** across various sectors such as **urban planning, infrastructure development**, and **water management.** SOPs help integrate water-sensitive principles into all relevant sectors, ensuring these principles are not implemented in isolation but as part of a comprehensive urban development strategy.

Incorporating Sustainable Water Management

A key function of SOPs is to ensure that every urban development project includes **sustainable water management practices.** This includes strategies such as for **stormwater management, wastewater treatment**, and **water conservation**. By embedding these practices into the urban development process, SOPs promote **long-term sustainability**.

Emphasizing Maintenance and Operation

Beyond implementation, SOPs should put a strong emphasis on the **maintenance and operation** of water-sensitive infrastructure. Regular **inspections, monitoring**, and **repair schedules** should be clearly outlined to guarantee the ongoing functionality of these systems and prevent infrastructure failures. For instance, regular cleaning of drainage systems has to be ensured.

Ensuring Community and Private Sector Involvement

To ensure **community and private sector support and buy-in**, SOPs should mandate **participatory planning**. Their engagement throughout the project lifecycle, from planning to execution and beyond, is critical. SOPs should establish mechanisms for **community feedback**, ensuring that the local population is actively involved in shaping the water-sensitive initiatives that affect them.

Monitoring and Evaluation

SOPs should also incorporate a robust **monitoring and evaluation framework** to track the performance of water-sensitive initiatives. This ensures that the projects adhere to established **standards**, and allows for the collection of data to make informed decisions and adjustments over time, ensuring **continuous improvement**.

6.5.2. Considerations for incorporating SOPs into public administration procedures

Integration with Existing Policies

For successful implementation, SOPs must be aligned with **existing urban planning and water management policies**. This will ensure consistency across different departments and avoid potential conflicts between water-sensitive initiatives and other city development goals.

Training and Capacity Building

It is essential that public administrators and other key stakeholders are equipped with the necessary knowledge and skills. SOPs should mandate **training programs** that familiarize staff with water-sensitive urban practices, enabling them to effectively implement these initiatives.

Cross-Departmental Collaboration

Effective water-sensitive transformation requires **interdepartmental coordination**. SOPs should promote regular **communication and collaboration** among various governmental agencies, ensuring that all relevant sectors are working together to achieve the objectives of sustainable water management.

Budgeting and Resource Allocation

SOPs should be integrated into the **budgetary planning** of public administrations. Dedicated **funding** for the implementation and maintenance of water-sensitive initiatives must be secured, ensuring the financial sustainability of these projects.

Legal and Regulatory Support

To ensure long-term success, water-sensitive practices outlined in the SOPs should be incorporated into the **legal and regulatory framework**. This will make sustainable water management practices a **mandatory part of urban development**, ensuring compliance and promoting widespread adoption.

6.5.3. Key steps and phases for designing and implementing SOPs

1. **Process Design and Planning**
   - **Project Initiation:** Identify project needs based on urban water management challenges. Formulate project goals, scope, and outcomes.
   - **Feasibility Study:** Conduct environmental impact assessments, resource availability studies, and community needs assessments.
   - **Design and Planning:** Develop detailed project plans including timelines, budgets, resource allocations, and design specifications tailored to local conditions.
2. **Stakeholder Identification and Engagement**
   - **Government Departments:** Engage relevant departments such as Urban Planning, Environment, Water Resources, and Public Works. Define their roles for approvals, oversight, and support.
   - **Community Involvement:** Formulate strategies for community engagement through public consultations, workshops, and feedback mechanisms to incorporate local knowledge and preferences.
   - **Private Sector Participation:** Identify potential private sector partners and define their roles in providing technical expertise, funding, and operational support.
3. **Implementation**
   - **Contracting and Procurement:** Follow transparent procedures for contracting and procurement to ensure quality and cost-effectiveness.
   - **Construction and Development:** Oversee the construction phase to ensure compliance with technical specifications and environmental guidelines.
   - **Quality Control:** Implement stringent quality control measures at each stage of the project to ensure standards are met.
4. **Maintenance and Operation**
   - **Operational Plans:** Develop comprehensive operational plans that include routine and preventive maintenance schedules, cost estimates, and staffing requirements.

- **Training and Capacity Building:** Provide training for local government staff and community members on the operation and maintenance of installed systems.
- **Community Roles:** Integrate community roles in the maintenance and monitoring of projects to foster ownership and sustainable practices.

5. **Monitoring, Evaluation, and Reporting**
   - **Performance Monitoring:** Establish indicators to regularly monitor the performance of water-sensitive infrastructures.
   - **Impact Evaluation:** Conduct evaluations to assess the environmental, social, and economic impacts of projects.
   - **Reporting:** Implement a reporting system to inform stakeholders about progress, challenges, and outcomes.

6. **Roles and Responsibilities**
   - **Government:** Ensure regulatory compliance, provide funding, and monitor project execution.
   - **Project Team:** Manage day-to-day operations, stakeholder coordination, and deliver on project milestones.
   - **Communities:** Participate in planning and feedback, assist in maintenance activities, and advocate for sustainable practices.
   - **Private Sector:** Provide technical solutions, co-finance projects when applicable, and assist in technology transfer.

7. **Community Involvement in Management**
   - **Community Management Committees:** Establish committees to involve communities in decision-making processes.
   - **Feedback and Adaptation:** Regularly gather community feedback to adapt project approaches according to changing needs and circumstances.

8. **Sustainability and Adaptation**
   - **Long-term Planning:** Incorporate considerations for future expansions, technological upgrades, and changes in environmental conditions.
   - **Sustainability Measures:** Ensure that projects are environmentally sustainable, economically viable, and socially beneficial.

Example 41: Using pilot projects for testing scalable SOPs - Sam Neua, Lao PDR

SOS School area in Sam Neua regularly flooded during monsoon season
(Source: PUW & Partners Own Work, 2022)

Blocked drainage close to SOS School
(Source: Foelster, 2024a)

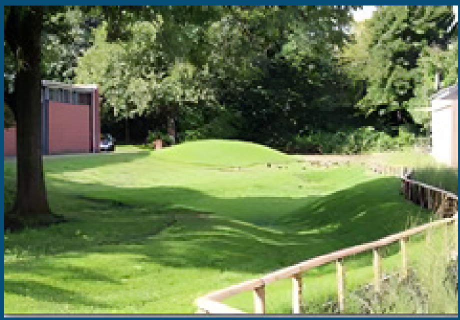
The neighborhood around the SOS Children's School in Sam Neua is facing persistent flooding and severe water pollution issues. The neighborhoods in this area are located on sloping terrain, and during the rainy season, large amounts of stormwater is washed downhill along the roads. Some houses and infrastructure were built into the slopes using the cut-and-fill method and were not properly stabilized against erosion.

Analysis reveals several causes: erosion from nearby slopes clogs the drainage system, which is inadequately maintained, and overall poor infrastructure exacerbates the issue. Frequent flooding is worsened by wastewater being discharged into the same open drains used for drinking water pipes.

An integrated strategy combining physical infrastructure improvements and management reforms is recommended. To prevent soil erosion into the drains, private properties along the drainage lines should install barriers. Property owners could also modify land gradients or implement rainwater retention methods. On the school grounds, a stormwater infiltration area should be implemented.

Effective solid waste management is essential to prevent drains from being blocked by debris. Regular maintenance of the drainage system is crucial, including cleaning, removing debris and solid waste, and repairing any damage. The roles and responsibilities of the local government, communities, and households for the management of these infrastructure services must be clearly defined and implemented in a binding manner.

Documenting the existing drainage network is critical for effective planning. Mapping the flow directions will help in designing retention basins, infiltration trenches, or redirecting flow paths.

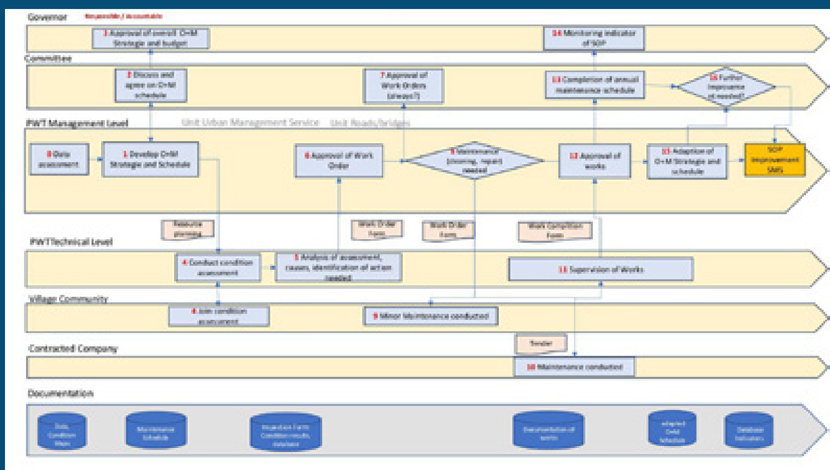


Potential area for stormwater infiltration at SOS School
(Source: PUW & Partners Own Work, 2023)

Enhancing green spaces and increasing the drainage diameter could also prove beneficial. Introducing trees and creating a green retention area, possibly integrated with a playground or seating area, would make these spaces more attractive and contribute to the overall livability of the area.

In addition to the development of a technical and management design, the pilot project was used to develop exemplary Standard Operating Procedures (SOPs) for effective stormwater management in a Sam Neua neighborhood, defining the roles of public authorities, the community, and the school's operators. (Linnea Foelster 2024a)

Besides assessing the reasons for regular flooding, standard processes for infrastructure development and system maintenance were elaborated as a reference model for further SOPs that describe the procedures for assessing, analyzing, and solving stormwater infrastructure issues in the urban development of Sam Neua at the village, district, and provincial levels. It includes the definition of responsibilities, activities, communication, and stakeholder involvement.



SOPs for effective stormwater management in the neighborhood of SOS School
(Source: Foelster, 2024a)

7. Methodological Aspects for Data Collection and Data Management


DEPOT TELA
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This section provides guidance in:

- Working more effectively with the DPSIR framework (Drivers, Pressures, State, Impact, Response),
- Making better use of local knowledge for collecting primary data and generating robust, context-specific information,
- How to access and utilize secondary data sources,
- Gaining a clearer understanding of the importance of remote sensing data and the necessity of on-ground verification to ensure accuracy and relevance.

Working with the DPSIR Framework

Elaboration of the DPSIR Framework

- To effectively capture the complexities of urban development and water resource management, the DPSIR framework should be elaborated by an interdisciplinary team.
- Given the complex nature of urban transformation, it is essential to move **beyond oversimplified cause-and-effect models.** For example, understanding flood events requires acknowledging a variety of contributing factors, such as changes in land use, inadequate infrastructure, and weak management structures. The DPSIR framework should comprehensively address these main factors and their interconnectedness.
- While developing the **DPSIR framework on a city level**, it is essential to maintain a balance between detail and the bigger picture. It is crucial not to become overly immersed in local details because significant local-level changes often stem from broader, higher-level drivers. These can include alterations in the regulatory framework and socio-economic transformations within the region. Thus, the DPSIR framework should be structured to

identify and focus on the most relevant factors, maintaining a balance between detailed local insights and overarching, systemic influences.

- Indicators must be "**filled**" with data: with numerical (quantitative) information such as BOD content of surface waters in a given area, number of residents in a given area or the percentage of the built-up area in a given urban location or/with descriptive (qualitative) data such as the perception of residents of the damages from flood events or of the performance of the quality of services provided by water operators.

- To optimize the use of limited resources, it is essential to extensively utilize already existing data, known as **secondary data** (desk studies). This includes information from public databases, studies, publications, geo-portals, and other sources. It is crucial, however, to assess the validity and relevance of these secondary data sources to ensure they are suitable and reliable for the specific analysis or decision-making process.

- **Primary data** can be collected to meet specific data needs through various methods, depending on the context and objectives. Among others, methods for data collection may be:

  - ***Transect Walks*** where data are collected while walking through an area to observe and gather direct information about the environmental and social conditions. It is useful for collecting spatial and visual data.

  - ***Focus Group Discussions*** may provide qualitative data through group interactions, capturing diverse perspectives and opinions on a particular issue or topic.

  - ***Semi-Structured Interviews*** with key stakeholders may be an effective way to gather opinions and insights from experts and knowledgeable individuals at the local level.

  - ***Drones*** can be used for aerial surveys and mapping, offering detailed visual and spatial data.

- **Engaging local stakeholders** in the collection of primary data is essential for gaining a deep understanding of the local context and formulating effective strategies. Residents, community leaders, farmers, and local government representatives typically possess a thorough and nuanced comprehension of the area's current state, historical changes, and both existing and evolving challenges. Their involvement is key to obtaining a detailed and accurate perspective of the situation at the local level.
- Indicators that are currently **unfilled** due to data unavailability should not be disregarded, as neglecting them could introduce significant bias into the assessment. It is important to acknowledge and consider these gaps in data to maintain the integrity and accuracy of the assessment.

Example 42: Methodology – Data collection: Local knowledge and capacities provide key information

Community members map observed water risks in Sariharjo
(Source: PUW & Partners Own Work, 2023)

The knowledge held by local stakeholders and communities is a crucial resource for the successful planning of water-sensitive urban development. Their insights go beyond what is typically captured in official records, providing a deeper understanding of land and water use patterns at the local level. Community members are often aware of current and emerging vulnerabilities, such as those associated with flooding, and have a thorough understanding of groundwater flow regimes that may result in raising the seasonal water table. This understanding is vital for the development of new housing estates and for building resilient structures

Furthermore, local communities are well-informed about water-related risks and risk zones, particularly in areas undergoing rural-urban transformation. This knowledge is especially valuable when it comes to the functioning and management of blue-green infrastructures, contributing to their effective planning and maintenance.

Local knowledge also plays a crucial role in understanding the unique ecological conditions of an area. This includes insights into the function of vegetation, soil types, rainfall patterns, water table levels, and property ownership, all of which are essential for planning water-sensitive urban development.

Additionally, local residents often propose practical and innovative solutions to water-related challenges, drawing from their direct experiences. These community-driven solutions tend to be more sustainable and well-received within the community than top-down approaches, offering a critical perspective in the development of water-sensitive urban environments.

One effective method of collecting information based on this local knowledge is through mapping exercises. Basic spatial information, which can be significantly augmented through platforms like Google Maps, can be

Government stakeholders map observed water risks in Sam Neua
(Source: PUW & Partners Own Work, 2023)

visualized on maps for discussion. Villagers can annotate these maps with their experiences and observations. The collected data and findings can then be further processed and visualized using GIS tools, allowing for deeper interpretation and informed decision-making.

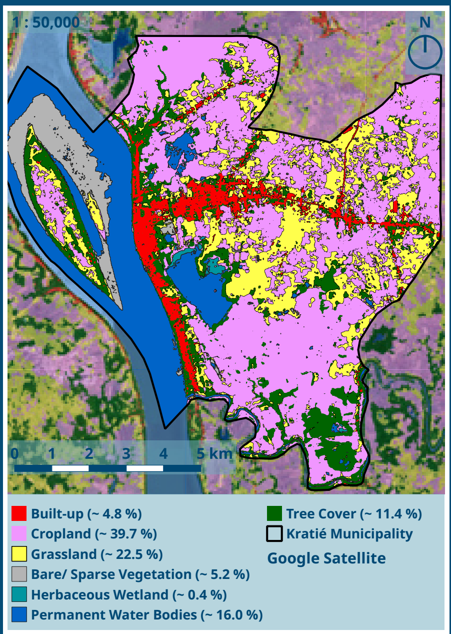
The willingness of local stakeholders and communities to share their knowledge is greatly influenced by their perception of personal benefit. In the context of sustainable development, it is crucial that these local participants are not merely viewed as sources of information, but as active contributors and beneficiaries of the development process.

Building a trusting relationship with local stakeholders can be fostered by clearly communicating the objectives of the study and explicitly outlining the potential benefits for the community from the overall process.

This includes:

- Transparency on the goals, methodologies, and expected outcomes of the study or project. This helps in building trust and ensuring that community members feel respected and valued.
- Clearly demonstrating how the project will benefit the community, whether through improved infrastructure, services, or enhanced livability of a district or neighbourhood.

Example 43: Methodology – Data collection: Using remote sensing data for water-sensitive urban planning



Map using remote sensing data indicating land use patterns in Kratié
(Source: PUW & Partners Own Work, 2022 & 2023)

In the countries of Southeast Asia, capacities are increasingly being built up to utilize remote sensing technologies for sustainable urban development. The providers of remote sensing services for urban development are likely to be a mix of government agencies, private companies, and international organizations.

The use of remote sensing technologies can significantly contribute to improved understanding of the water challenges and the elaboration of effective response measures. Technologies including satellite-based or drone-based data collection systems can collect comprehensive data on various water bodies, such as rivers, lakes, and reservoirs, as well as information on land use, vegetation cover, and urban infrastructure. This capability to monitor changes over time is essential for assessing water availability, quality, and dynamic changes. They are instrumental in detecting flood prone areas and to establish respective early flood warning systems.

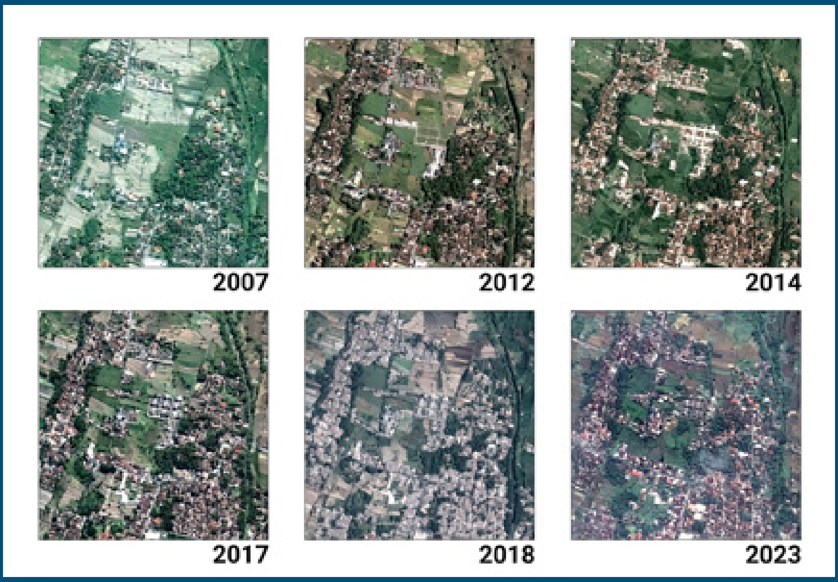
However, many countries and cities in the region do not yet have the technological, institutional, and financial capacity to utilise such data and integrate it into corresponding (geo)information systems. Making effective use of databases, such as NASA Earthdata or the European Space Agency's Earth Online, require adequate institutional, technical and financial resources are available.

For conducting baseline assessments and to prepare maps for spatial planning, the cloud-based platform Google Earth Engine offers access to a massive archive of satellite imagery and geospatial datasets. This geobrowser combines satellite imagery, aerial photography, GIS (Geographic Information System) data, and other sources to create a comprehensive 3D model of the Earth.

The Google Earth feature Google Timelapse allows users to explore changes to the Earth's surface over time. It is a tool that utilizes satellite imagery to create a dynamic, time-lapse visualization of various locations around the world, covering several decades (in many cases from the 1980s).

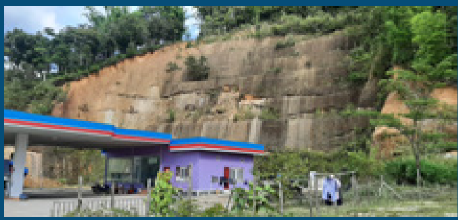
The use of drones can contribute to obtaining detailed and current information at a local level. They offer a cost-effective, flexible, and accurate method for data collection in urban areas, making them ideal for small-scale studies. Drones provide high-resolution images, and the data collected can be effectively integrated with other geospatial data in GIS systems.

Remote sensing data should be validated at the local level whenever possible, especially when addressing crucial informational needs on the ground and in interaction with local stakeholders. It is important to emphasize that remote sensing data have limitations in representing social and socio-economic processes, thus only partially reflecting urban realities. Therefore, remote sensing data should always be used in conjunction with other data sources and integrated into broader datasets to provide a more comprehensive understanding of urban environments.



Land use changes in Sam Neua *(Source: Google Earth 2023)*

Example 44: Methodology – Data collection: Using local information systems for vulnerability assessments of localized floods and landslides



Building practices in Sam Neua in risk area for landslides
(Source: PUW & Partners Own Work, 2022)

Participatory assessment of land-slide risks in Sam Neua
(Source: PUW & Partners Own Work, 2023)

Urban growth often encounters natural limits. With rising land prices, settlement activities are taking place in existing and emerging risk zones. For example, construction activities can increasingly be observed in riparian zones or on mountain slopes without any prior risk assessment.

This applies to both capital-intensive construction activities and informal settlements among poorer population groups. They are largely carried out because of their investment requirements without infrastructural safety measures such as the stabilisation of slopes or without adequate protection of riverbanks. Landslides and flooding can cause the destruction of individual buildings or entire rows of houses.

These risks are often not immediately foreseeable. Changes in land use patterns over longer periods of time and the associated changes in the runoff regime can turn even seemingly small streams into torrential rivers during heavy rainfall events. Slopes can be destabilised by construction activities, changes in vegetation cover and water erosion. These are effects that can be significantly exacerbated by the increased intensity of heavy rainfall events caused by climate change.

Spatial planning of secondary and tertiary cities rarely identifies such risk zones. The dynamic development of this risk potential is even more rarely reflected. Risks are often only identified after damage has occurred. Risk mitigation measures such as the prohibition of construction activities in risk zones are often only introduced selectively

Cities and their supporting institutions at the provincial or national level are required to develop the institutional and technical capacity to carry out comprehensive risk assessments, including detailed analyses of settlement patterns, river flow patterns, topography, morphology and climate data. Tools such as Geographic Information Systems (GIS) are indispensable for mapping and analysing flood and landslide risks.

Today, these professional and technical prerequisites for comprehensive data collection, data selection and data interpretation are still lacking in many places. Nevertheless, municipal administrations of smaller cities should also be able to compile initial systematic overviews of obvious risks. Employees and members of various city, district and village administration departments and community members have generally made formal and informal observations of damage that has already occurred and of existing risks. At the same time, they can also project trends based on their local experience.

This knowledge can be systematised in workshops and community meetings and verified or supplemented through joint site inspections. This information can then be processed manually or with simple programmes for informed decision-making, even without the use of sophisticated software.

Field observations to be mapped using GIS tools
(Source: PUW & Partners Own Work, 2022)

Example 45: Methodology – Data management: Working with secondary data for assessing flood risks

Damage from flooding in Kratié in 2019
(Source: PUW & Partners Own Work, 2022)

Given resource constraints, the quantity of data that can be collected for baseline assessments is often limited. Therefore, it is advisable to utilize secondary data as much as possible, especially for more complex issues.

However, the challenge is that many countries, cities, and provinces are still in the process of developing comprehensive databases, which are essential for informed decision-making and effective urban management. Additionally, key insights derived from various secondary data sources, including existing studies, may not always align consistently, potentially leading to uncertainty for the reader.

Even statements from key government documents leave decision-makers uncertain due to the range of possible scenarios. A critical evaluation of the information base is required here as was the case after the floods that affected Kratié in 2019 with the city's administration requesting more robust information on future flood risks for elaborating an adequate mitigation strategy.

In its "Summary of the basin-wide assessments of climate change impacts on water and water-related resources in the Lower Mekong Basin", the Mekong River Commission projected significant changes in the river flow regime of the Mekong River at Krong Kratié for the year 2060. (Mekong River Commission, 2018) But the range of effects of the possible scenarios was so considerable that they seemed almost contradictory.

Station	Trend (% per year)
River flow	-38% and +28%
Water level	-1.95m and +1.29m
Flood peak season flow	-30% and +43%
Flood season peak	-2.83m and +2.96m
Minimum 1 day water level	-0.18m and +0.90m
Minimum 1 day flow	-21% and +79%

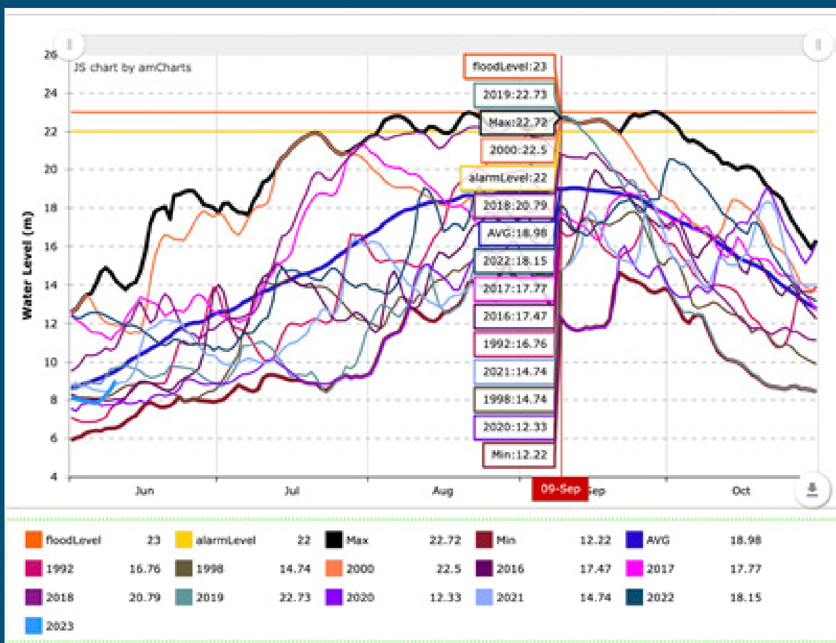
Estimates for range of Peak Flows in Kratié
(Source: Mekong River Commission, 2018)

A critical evaluation of all available data and studies actually showed considerable possible scenarios for the relevant parameters that influence the flow regime of the Mekong:

- The predictable nature of the River’s hydrological regime is now uncertain as it has been undergoing increasingly dynamic development, especially since the 1980s.
- Changes in land-use patterns due to urbanization, large-scale conversion of the River’s wetlands and forests, the use of river water, especially for hydrological infrastructure and climate change are significantly altering the ecosystems and flow regime of the Mekong River.
- The development of these contributing factors and their interactions are difficult to predict in the medium- and long-term and, therefore, also their impact.

The uncertainties in these forecasts should not deter the relevant government authorities from immediately implementing measures to strengthen resilience against the Mekong’s changing flood regime. This primarily includes enhancing infrastructural and urban measures to build resilience against flooding events.

Furthermore, without appropriate safeguards, these changes could significantly affect the primary livelihoods of already vulnerable populations residing in the Lower Mekong Basin, such as those in and around Kratié.



Historical data of Peak Flows of the Mekong River in Kratié
(Mekong River Commission, 2024)

8. The PolyUrbanWaters Project

In collaboration with:

BORDA e.V.

ITT
Institute for Technology and Resources Management in the Tropics and Subtropics

TUB /Habitat Unit
Technische Universität Berlin
Habitat Unit

Partners

PolyUrbanWaters is a research and project network funded by the German Federal Ministry of Education and Research/German Federal Ministry of Research, Technology and Space that consists of academic institutions, municipalities, local and national government agencies, civil society and private-sector stakeholders from Indonesia, Cambodia, Lao PDR, Thailand, Vietnam and Germany.

The project is implemented under the lead of BORDA e.V., Technical University of Berlin, Habitat Unit and University of Applied Sciences Cologne between 2019 and 2027.

The overall project goal is defined as:

> "Polycentric approaches to the management of urban water resources contribute to the water-sensitive transformation of secondary and tertiary cities in SEA towards resilient, inclusive and livable urban areas, thus contributing to the fulfillment of national and global sustainability agendas."

The specific project goal is defined as:

> Elaboration of an empirically proven conceptual framework "polycentric approaches to the management of urban water resources for secondary and tertiary cities in SEA", with development of relevant instruments for its implementation and scalability.

Government Project Partners are:

- Ministry of Public Works and Transport, Lao PDR
- Regional Development Planning Agency (BAPPEDA), Indonesia
- Government of Kratié Province, Cambodia

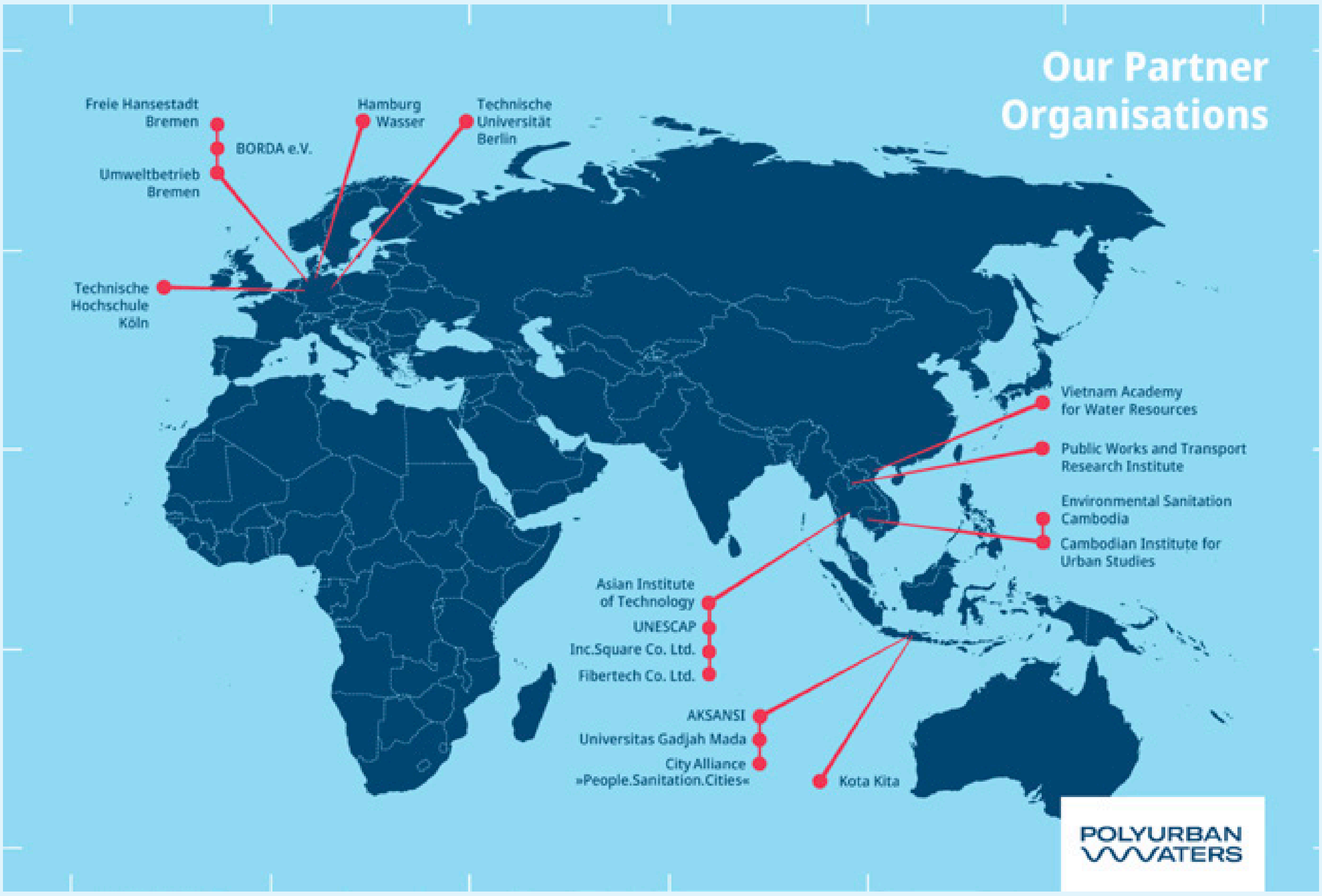


Figure 5. The PolyUrbanWaters Network
(Source: PUW Own Work, 2023)

9. List of Abbreviations and Acronyms

ADB	Asian Development Bank
AFD	Agence Française de Développement
AIT	Asian Institute of Technology
BAPPEDA	Badan Perencanaan Pembangunan Daerah, Regional Development Planning Agency, Indonesia
BMBF	Bundesministerium für Bildung und Forschung/Federal Ministry of Education and Research
BMFTR	Bundesministerium für Forschung, Technologie und Baumfahrt/Federal Ministry of Research, Technology and Space
BOD	Biological Oxygen Demand
BORDA	Bremen Overseas Research and Development Association e.V.
CDIA	Cities Development Initiative for Asia
CIUS	Cambodian Institute for Urban Studies
COD	Chemical Oxygen Demand
DEWATS	Decentralized Wastewater Treatment Systems
DHUP	Department of Housing and Urban Planning, Lao PDR
DLR	Deutsches Zentrum für Luft- und Raumfahrt/German Aerospace Center
DPSIR	Driving Force, Pressure. State, Impact, Response Framework
EIA	Environmental Impact Assessment Report
ESC	Environmental Sanitation Cambodia
FONA	Forschung für Nachhaltige Entwicklung/Research for Sustainability
FSM	Fecal Sludge Management
GDP	Gross Domestic Product
GIS	Geo-Information Systems
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HH	Households
IPCC	Intergovernmental Panel on Climate Change
ITT, Cologne	The Institute for Technology and Resources Management in the Tropics and Subtropics of University of Applied Sciences, Cologne
IWA	International Water Association

IUWRM	Integrated Urban Water Resource Management
KISS	Keep It Specific and Simple
Lao PDR	Lao People’s Democratic Republic
LADHC	Ladakh Autonomous Hill Development Council
LEED	Leadership in Energy and Environmental Design
MDG	Millennium Development Goals
MRC	Mekong River Commission
NASA	National Aeronautics and Space Administration
SMART	Specific, Measurable, Attainable, Relevant, Time-bound
PUW	Polycentric Approaches to the Management of Urban Waters
SDG	Sustainable Development Goal
SEA	Southeast Asia
SEZ	Special Economic Zone
SOP	Standard Operational Procedures
SURE	Sustainable Development of Urban Regions Programe
TU Berlin	Technical University Berlin
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
WWTP	Wastewater Treatment Plant

10. Terminology and Definitions

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects. (IPCC, 2022).

Adaptive capacity: The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities (IPCC, 2012).

Baseline/reference: The baseline (or reference) is the state against which change is measured. It might be a 'current baseline,' in which case it represents observable, present-day conditions. It might also be a 'future baseline,' which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines (IPCC, 2012).

Biochemical Oxygen Demand (BOD): Describes how much oxygen is required for the oxidisation of matter, which can be oxidised biologically with the help of bacteria (Ulrich et al., 2009).

Blue infrastructure: Blue infrastructure includes bodies of water, watercourses, ponds, lakes and storm drainage, that provide ecological and hydrological functions including evaporation, transpiration, drainage, infiltration and temporary storage of runoff and discharge (IPCC,2022).

Catchment: An area that collects and drains precipitation (IPCC, 2012).

Chemical Oxygen Demand (COD): The most common parameter for measuring organic pollution. It describes how much oxygen is required to oxidise all organic and inorganic matter found in water (Ulrich et al., 2009).

Cities: Open systems, continually exchanging resources, products and services, waste, people, ideas and finances with the hinterlands and broader world. Cities are complex, self-organising, adaptive and constantly evolving. Cities also encompass multiple actors with varying responsibilities, capabilities and priorities, as well as processes that transcend the institutional sector-based approach to city administration. Cities are embedded in broader ecological, economic, technical, institutional, legal and governance structures that enable or constrain their systemic function, which cannot be separated from wider power relations (IPCC, 2022).

Climate change: A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2012).

Climate: In a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (IPCC, 2012).

Community-based adaptation: Local, community-driven adaptation. Community-based adaptation focuses attention on empowering and promoting the adaptive capacity of communities. It is an approach that takes context, culture, knowledge, agency and preferences of communities as strengths (IPCC, 2022).

Deforestation: Conversion of forest to non-forest (IPCC,2022).

Development pathways: Development pathways evolve as the result of the countless decisions being made and actions being taken at all levels of societal structure, as well as due to the emergent dynamics within and between institutions, cultural norms, technological systems and other drivers of behavioural change (IPCC,2022).

Disaster management: Social processes for designing, implementing, and evaluating strategies, policies, and measures that promote and improve disaster preparedness, response, and recovery practices at different organizational and societal levels (IPCC, 2012).

Disaster risk: The likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2012).

Drought: A period of abnormally dry weather long enough to cause a serious hydrological imbalance (IPCC, 2012).

Drainage: Artificial lowering of the soil water table (IPCC, 2013).

Ecosystem: A functional unit consisting of living organisms, their non-living environment and the interactions within and between them. The components included in a given ecosystem and its spatial boundaries depend on the purpose for which the ecosystem is defined: in some cases, they are relatively sharp, while in others they are diffuse. Ecosystem boundaries can change over time. Ecosystems are nested within other ecosystems, and their scale can range from very small to the entire biosphere. In the current era, most ecosystems either contain people as key organisms or are influenced by the effects of human activities in their environment (IPCC, 2022).

Ecosystem services: Ecological processes or functions having monetary or non-monetary value to individuals or society at large. These are frequently classified as (1) supporting services such as productivity or biodiversity maintenance, (2) provisioning services such as food or fibre, (3) regulating services such as climate regulation or carbon sequestration and (4) cultural services such as tourism or spiritual and aesthetic appreciation (IPCC, 2022).

Evapotranspiration: In reference to evaporation (E) from soil, plant surfaces and water bodies and the transpiration (T) through plant canopies. The term is useful in regards agriculture where the actual evapotranspiration relates to the Crop Water Requirements.

Exposure: The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas ([UNDRR] United Nations Office for Disaster Risk Reduction, 2020).

Flood: The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods (IPCC, 2012).

Governance: The structures, processes and actions through which private and public actors interact to address societal goals. This includes formal and informal institutions and the associated norms, rules, laws and procedures for deciding, managing, implementing and monitoring policies and measures at any geographic or political scale, from global to local (IPCC, 2022).

Green infrastructure: The strategically planned interconnected set of natural and constructed ecological systems, green spaces and other landscape features that can provide functions and services including air and water purification, temperature management, floodwater management and coastal defence often with co-benefits for human and ecological well-being. Green infrastructure includes planted and remnant native vegetation, soils, wetlands, parks and green open spaces, as well as building and street-level design interventions that incorporate vegetation (IPCC, 2022).

Grey infrastructure: Engineered physical components and networks of pipes, wires, roads and tracks that underpin energy, transport, communications (including digital), built form, water and sanitation, and solid waste management systems (IPCC, 2022).

Greywater: The total volume of water generated from washing food, clothes and dishware, as well as from bathing, but not from toilets. It may contain traces of excreta (e.g., from washing diapers) and, therefore, also pathogens. Greywater accounts for approximately 65 % of the wastewater produced in households with flush toilets (IWA, 2016).

Hazard: A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation ([UNDRR] United Nations Office for Disaster Risk Reduction, 2020).

Hydrological/water cycle: The cycle in which water evaporates from the oceans and the land surface, is carried over the Earth in atmospheric circulation as water vapor, condenses to form clouds, precipitates again as rain or snow, is intercepted by trees and vegetation, provides runoff on the land surface, infiltrates into soils, recharges groundwater, and/or discharges into streams and flows out into the oceans, and ultimately evaporates again from the oceans or land surface. The various systems involved in the hydrological cycle are usually referred to as hydrological systems (IPCC, 2012).

Infrastructure: The designed and built set of physical systems and corresponding institutional arrangements that mediate between people, their communities and the broader environment to provide services that support economic growth, health, quality of life and safety (IPCC, 2022).

Integrated Water Resource Management (IWRM): A process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP, 2011).

Land use and land use change: Land use refers to the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation). Land use change refers to a change in the use or management of land by humans, which may lead to a change in land cover (IPCC, 2012).

Landslide: A mass of material that has moved downhill by gravity, often assisted by water when the material is saturated. The movement of soil, rock, or debris down a slope can occur rapidly, or may involve slow, gradual failure (IPCC, 2012).

Livelihood: The resources used and the activities undertaken in order for people to live. Livelihoods are usually determined by the entitlements and assets to which people have access. Such assets can be categorised as human, social, natural, physical or financial (IPCC, 2022).

Low-threshold approaches: Strategies and actions that enable cities to rapidly and effectively plan and implement measures toward water-sensitive urban transformation. These approaches are pragmatic and feasible within the constraints of existing regulatory frameworks, institutional structures, and financial capacities. By focusing on actionable, adaptable, and resource-efficient interventions, low-threshold approaches help cities initiate meaningful change without requiring large-scale reforms or high-cost infrastructure.

Nature-based Solution (NBS): Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits (IPCC,2022).

Polycentric management of urban waters: A strategic development concept and urban management practice that recognizes water as a cross-cutting theme in urban development. Inspired by frameworks such as water-sensitive urban design (WSUD), this approach emphasizes the need for cities to progressively build institutional, technical, and social capacities to plan and implement coordinated, mutually reinforcing centralized and decentralized measures. To achieve this, grey and blue-green infrastructures are effectively aligned and integrated, ensuring both conventional systems (e.g., sewer networks) and Nature-based Solutions (e.g., wetlands, bioswales, green roofs) complement one another to improve resilience and livability. In selecting interventions, effectiveness and affordability are key criteria, but particular emphasis is also placed on ensuring sustainable financing as well as long-term maintenance and operation. Rather than relying solely on top-down systems, polycentric management promotes multi-level governance, inclusive stakeholder collaboration, and the integration of water considerations across all dimensions of urban planning and development such as housing, mobility, public space, and climate adaptation.

Resilience: The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning, and transformation (Sutton et al., 2011).

Risk: Potential for adverse consequences for human or ecological systems as a result of dynamic interactions between hazards, exposure and vulnerability of the affected human or ecological system (IPCC, 2022).

Runoff: That part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water (IPCC, 2022).

Scenario: A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Scenarios are neither predictions nor forecasts, but are used to provide a view of the implications of developments and actions (IPCC,2022).

Settlements: Places of concentrated human habitation. Settlements can range from isolated rural villages to urban regions with significant global influence. They can include formally planned and informal or illegal habitation and related infrastructure (IPCC, 2022).

Standard: Set of rules or codes mandating or defining product performance (for example, grades, dimensions, characteristics, test methods and rules for use). Product technology or performance standards establish minimum requirements for affected products or technologies (IPCC, 2022).

Transformation: A change in the fundamental attributes of natural and human systems. Deliberate transformations. A profound shift towards sustainability, envisioned and intended by at least some societal actors, facilitated by changes in individual and collective values and behaviours, and a fairer balance of political, cultural and institutional power in society (IPCC, 2022).

Transition: The process of changing from one state or condition to another in a given period of time. Transition can occur in individuals, firms, cities, regions and nations, and can be based on incremental or transformative change (IPCC, 2022).

Urban heat island: The relative warmth of a city compared with surrounding rural areas, associated with changes in runoff, the concrete jungle effects on heat retention, changes in surface albedo, changes in pollution and aerosols, and so on (IPCC, 2012).

Urbanisation: Urbanisation is a multi-dimensional process that involves at least three simultaneous changes: (1) land use change: transformation of formerly rural settlements or natural land into urban settlements, (2) demographic change: a shift in the spatial distribution of a population from rural to urban areas and (3) infrastructure change: an increase in provision of infrastructure services including electricity, sanitation, etc. Urbanisation often includes changes in lifestyle, culture and behaviour, and thus alters the demographic, economic and social structure of both urban and rural areas (IPCC, 2022).

Urban waters: A concept of sustainable urban water management. Urban waters within the city (including reservoir and aquifer water, desalinated water, recycled water and stormwater) are managed in a way that maximises the achievement of urban liveability outcomes and resilience to unexpected social, economic or bio-physical shocks (IWA, 2016).

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC, 2022). The characteristics and circumstances of a community, system, or asset that make it susceptible to the damaging effects of a hazard (UNEP, 2019).

Wastewater: The mixture of urine, faeces and flushwater along with anal cleansing water (if water is used for cleansing) and/or dry cleansing materials. Wastewater contains the pathogens of faeces and the nutrients of urine that are diluted in the flushwater (IWA, 2016).

Water security: Defined here as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UNU- INWEH, 2013).

Water-sensitive Urban Development (WSUD): An integrated planning and design approach that supports cities in transforming toward ecologically based urban water systems capable of addressing the challenges of climate change, urbanization, and population growth. Since the 1990s, WSUD has been evolving and applied in both new and existing developments across the globe—including in Asia—using a range of tools and technologies that integrate natural elements such as water, vegetation, and soil. By preserving or restoring the natural water cycle, rather than simply channeling runoff from impervious surfaces into waterways, WSUD delivers multiple co-benefits: improved stormwater quality, enhanced water supply and flood control, healthier ecosystems, and more livable urban environments. It promotes the use of alternative urban water sources, reduces pressure on central treatment systems, and encourages re-naturalization of urban streams and riparian zones. Furthermore, the implementation of vegetated infrastructure—such as rain gardens, swales, and green roofs—not only improves water quality but also enhances urban aesthetics and public spaces. Indirect economic benefits include increased property values and growth in tourism and commercial activity (Sharma et al., 2018; IWA, 2016).

Wetland: Land that is covered or saturated by water for all or part of the year (for instance, peatland) (IPCC,2022).

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Polycentric approaches to the management of urban waters represent a strategic urban development concept that enables cities to progressively transition toward water-sensitive practices, thereby effectively addressing increasingly complex water challenges.

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ISBN 978-3-00-082577-4