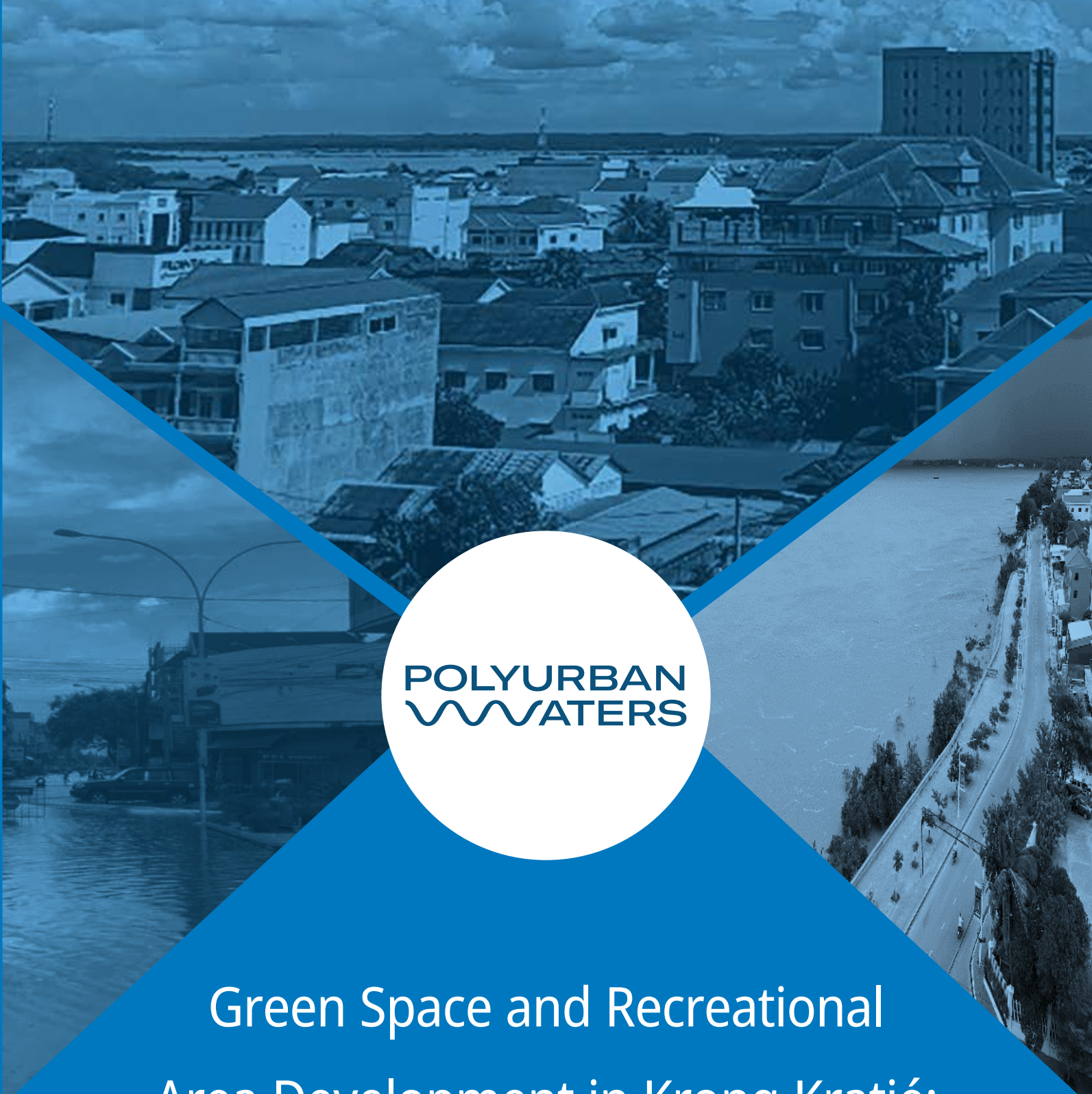

POLYURBAN WATERS

Green Space and Recreational Area Development in Krong Kratié: Final Report

Implementation of the Development Plan for Urban Wetlands

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Published by

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SUFO Sustainable Development of Urban Regions

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EXECUTIVE SUMMARY

Krong Kratié, a growing secondary city in northeastern Cambodia, faces mounting urban and environmental challenges, including frequent flooding, heat stress, and inadequate public space. Urban densification has led to the ongoing loss of green areas, further weakening the city's resilience to climate impacts. The PolyUrbanWaters project, funded under Germany's FONA framework, aims to support Kratié's transformation into a resilient, inclusive, and livable city through the strategic development of multifunctional green infrastructure.

This report presents the outcomes and outlines five priority interventions focused on urban green space and water-sensitive design. These interventions are the result of in-depth technical assessments, stakeholder engagement, and participatory planning processes. They reflect Kratié's commitment to integrating climate adaptation, community well-being, and ecological preservation in its urban development strategy.

The five final sites assessed are ranked by priority below:

1. **White Bridge Channel**
2. **30 Metre Street**
3. **O'Russey Market Side Streets**
4. **Wat Kratié Side Roads**
5. **Southern Lake Road**

Each project demonstrates the potential for applying a practical and scalable approach to enhancing urban resilience while improving public space accessibility and quality. The report also presents the underlying methodological framework used for site selection and planning.

1. Introduction and Context

Krong Kratié is a growing provincial capital located along the Mekong River in northeastern Cambodia. As a secondary city, it plays a vital role in the country's regional development, yet it faces mounting urban challenges: seasonal flooding, unmanaged solid waste, insufficient drainage systems, and a lack of multifunctional public spaces. In addition, climate change impacts such as rising temperatures and unpredictable rainfall patterns have begun to significantly affect both public health and infrastructure resilience.

Green space development, particularly when implemented systematically and strategically, is increasingly recognized as an essential urban planning tool - not only for beautification and livability but as a fundamental element of climate adaptation. In this context, the PolyUrbanWaters project, funded by Germany's Federal Ministry of Research and Technology and Space (BMFTR) under its FONA framework, was launched to assist cities like Kratié in making a sustainable transition toward resilient and inclusive development.

This report builds upon the outcomes of the project's Research and Development (R&D) Phase (2021–2025), during which local authorities, technical experts, and community stakeholders worked together to assess vulnerabilities, prioritize interventions, and design a long-term urban green space strategy. The Development Plan for Urban Wetlands of Krong Kratié 2024-2035 was approved, with a focus on integrating water-sensitive design, enhancing public space, and ensuring community participation in the planning processes.

Key Urban Water and Green Space Challenges

Strategic green space development is essential for Kratié to counter the ongoing loss of vegetated areas due to rapid urban densification. Without coordinated action, remaining green infrastructure will continue to be fragmented, reducing its ecological effectiveness and the city's overall resilience. A city-wide strategy enables Kratié to prioritize critical zones, integrate green infrastructure with transport and drainage systems, and ensure equitable access to public space across neighborhoods. Moreover, green space development must be understood as an integral component of modern urban development, shaping a more attractive, livable, and resilient Kratié.

Krong Kratié's urban environment is shaped by multiple interacting challenges that impact both the population's quality of life and the city's long-term sustainability. These include acute flood risks, ecological degradation of wetlands, increasing urban heat island effects, and the ongoing loss of green spaces due to unregulated densification. (See Annex 2 for further details)

1. Flood Vulnerability: Flooding is a recurring issue in Kratié, particularly during the monsoon season. The city's natural drainage corridors have been narrowed or obstructed by informal construction, sediment accumulation, and solid waste. Poorly maintained culverts and roadside drains exacerbate overflow during heavy rainfall events.

2. Poor Urban Wetland Management: Urban wetlands in Kratié historically served as natural buffers that helped retain rainwater and support biodiversity. Unregulated infilling and degradation have diminished their role in climate resilience, threatening water quality and flood absorption.

3. Increasing Urban Heat Island Effect: Urban expansion and deforestation have significantly reduced tree cover, intensifying temperature extremes and reducing livability. This has direct health and economic impacts on residents.

4. Shrinking Urban Green Space: Due to rapid densification and the absence of protective planning measures, Kratié is losing its limited green space base. This exacerbates heat exposure, reduces social space, and weakens ecosystem services essential for urban resilience.

2. Assessing Potential Green Space and Recreational Areas in Krong Kratié

In September 2024, following the identification of development challenges and related needs for the sangkats (urban districts) bordering the lake area, stakeholders participated in a transect walk and workshop for green space planning. This event identified five potential development sites and discussed enhancing green space connectivity. A subsequent meeting in December 2024 encouraged discussion among subnational authorities about their interests and support needs for implementing the green space interventions, covering site identification, incremental development, landowner engagement, and community awareness efforts.

The graphic below (Figure 1) shows the approximate steps embarked upon for conducting the assessment of potential Green Space and Recreational Sites.The final conceptual designs for the sites are presented in Chapter 3.

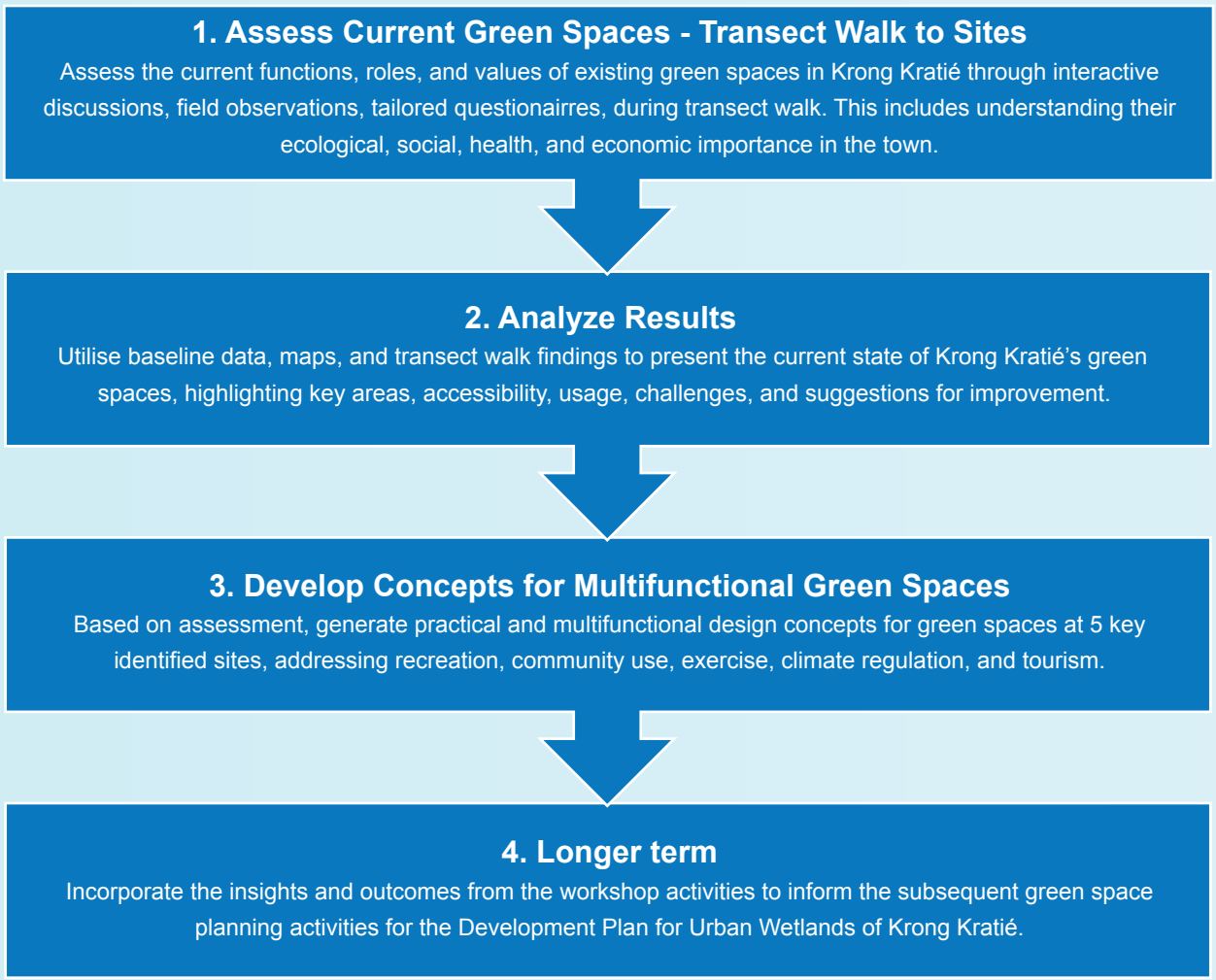


Figure 1 Green Space and Recreational Area Assessment Steps in Krong Kratié

The event introduced green space planning concepts, evaluated existing green spaces, and identified opportunities for new ones within a water-sensitive urban planning framework. Engaging stakeholders, including local officials and community leaders, the participants aimed to assess current usage patterns, challenges, and future needs related to green spaces, which are essential for public health and recreational benefits.

Figure 2 Conducting the Transect Walk in September, 2024 (Source: PUW Own Work, 2024)

Figure 3 Workshop Participatory Groups Reviewing Data, September 2024 (Source: PUW Own Work, 2024)

Summary of Key Results[1]

The transect walk and "Krong Kratié Green Space Planning Matrix" provided an on-the-ground assessment of key green spaces in Krong Kratié, establishing a baseline for decision-making. The sites visited during the transect walk are presented below in Figure 4.

Figure 4 Map of Preliminary Green Space and Recreational Area Sites Assessed as of September 2024 (Source: Own Work, 2024)

1. Current Usage

The assessed sites serve multiple functions, facilitating diverse socio-economic interactions. Roads function as vital access points for commuting and commercial activities, particularly in market side streets that connect various areas. While lake paths serve as transit routes, they also support recreational activities like exercising, fishing, and picnicking. Despite their potential, many spaces are underutilized due to poor conditions that limit social and economic opportunities.

[1] See Krong Kratié Green Space Assessment Matrix in Annex 5

Figure 5 Example of mobile “make shift” rest spot on flood area / new road passing west through Krong Kratié (Source: PUW Own Work, 2024)

2. Environmental Observations

A significant issue across the sites is the lack of vegetation and shaded areas, contributing to discomfort, particularly during midday. This scarcity affects the usability and attractiveness of these spaces for residents and tourists. The unshaded surfaces contribute to urban heat; moreover, poor drainage exacerbates runoff during rains. (See Figure 6 & Figure 7)

Figure 6 (above and previous page) Photos of O´Russey Market side streets, indicating lack of trees, high rate of sealed surfaces, and lack of drainage. (Source: PUW Own Work, 2024)

Figure 7 White Bridge Channel facing south towards Lake Romleach (Source: PUW Own Work, 2024)

Conversely, dirt roads around Lake Romleach face accessibility issues in the rainy season, although the lake offers cooling breezes. Proper management could transform these areas into inviting public spaces by establishing shaded zones and improving waste management.

Figure 8 South-west corner of Lake Romleach in Sangkat Roka Kandal (Source: PUW Own Work, 2024)

For example, up to 100 people visit the location in Roka Kandal daily after work hours for relaxation, exercising, cooling off in the water, and socialising, according to a vendor interviewee. (See Figure 8)

3. Community Needs

Community priorities focus on enhancing comfort, safety, and accessibility within green spaces. Key requests include introducing shade-providing trees, creating designated bicycle paths to connect urban areas, and ensuring pedestrian pathways, seating areas, and adequate lighting. Efficient traffic management and improved waste management solutions are also critical for maintaining cleanliness and enhancing the usability of these areas. Stakeholders envision green spaces that offer respite from urban heat through increased vegetation and improved amenities.

4. Challenges and Concerns

Key challenges affecting the usability and appeal of the sites include accessibility issues due to muddy roads during rainy seasons, the mixing of traffic without designated pathways, and a lack of amenities such as shaded seating and adequate lighting. The absence of waste management solutions and litter further detract from the spaces' visual and functional quality, underlining the need for improved infrastructure and environmental management.

5. Suggestions for Improvement

Enhancements should focus on improving the quality, accessibility, and connectivity of green spaces. Introducing shade-providing trees is crucial, as is developing a marked bicycle path along Lake Romleach's northern shore to promote active transportation. Creating pedestrian-friendly spaces with seating and adequate lighting will encourage social engagement. Effective waste management, including strategically placed rubbish bins, is also essential for maintaining cleanliness. By applying green space planning principles, the sites can be transformed into well-connected, inviting areas that support both community well-being and economic growth.

Figure 9 (top centre, bottom left and bottom right) Examples of Siem Reap Green Spaces, walking paths, exercise equipment as part of suggestions for improving green spaces (Source: PUW Own Work, 2023 - 2024).

Site 1: The White Bridge Channel

Context

The White Bridge Channel is an urban waterway currently suffering from severe vegetation overgrowth, sedimentation, and unmanaged waste deposits. These conditions significantly reduce its capacity to function as a critical drainage system. Despite its degraded state, the area surrounding the channel is highly visible, centrally located, and well-connected to schools and residential neighborhoods-making it a strategic starting point for green and water-sensitive transformation. Government departments responsible for this area include the departments of public works and transport, land management and water resources and meteorology. Sangkat officials and private companies are tasked with forms of operation and maintenance after construction is completed. The size of the infrastructure development will dictate who is responsible for maintenance tasks.

Hydrological and Urban Development Significance

The channel plays a vital hydrological role, especially during periods of Mekong River flooding, by guiding excess water into the adjacent lake area and relieving pressure on the urban drainage network. However, its current overgrown and obstructed state limits this function. Furthermore, the White Bridge area is designated in city and infrastructure plans as a key future development zone. The planning context underscores the urgency of upgrading both the channel and its surrounding road infrastructure as part of a cohesive urban expansion strategy.

Environmental observations indicate that the channel is lined with a significant amount of vegetation, contributing to its natural appeal and managing water flow between the northern and southern lake areas. Recently planted trees are present, but there is a need for more mature, shade-providing trees. The area can be quite hot due to the lack of shade although a fresh breeze often provides some relief.

Community needs include more trees for shade and aesthetic enhancement, dedicated walkways and exercise equipment for recreational activities, and seating areas to encourage social gatherings. Appropriate waste disposal solutions and improved lighting are required to maintain cleanliness and ensure pedestrian and driver safety at night.

Enhancing the area's aesthetic appeal may also attract more tourists.

Challenges include muddy patches on the access road, especially after rains. Insufficient lighting makes the area less safe at night, and a lack of rubbish bins leads to littering.

Intervention Objectives

- Restore and stabilize the channel to strengthen flood resilience across the wider urban area;
- Develop an accessible linear green corridor with walkways, seating, and shaded public space;
- Integrate microclimate-sensitive vegetation to reduce heat stress;
- Foster community participation through co-design processes and civic engagement.

Site 2: O'Russey Market Side Streets

Context

The side streets around O'Russey Market are narrow but are highly frequented as in the commercial heart of Krong Kratié. They serve both as a vehicular access route and an informal pedestrian path connecting vendors, customers, and nearby institutions. However, the street suffers from congestion, a lack of shading, unmanaged solid waste, and poor drainage, which reduces comfort, safety, and hygiene.

Government mandates are largely limited to the Department of Public Works and Transport in terms of construction of roads and forms of drainage. The local sangkat and the private sector are responsible for forms of operation and maintenance, such as solid waste management.

Urban Significance and Potential

Given its centrality and high foot traffic, the O'Russey Market side streets are well positioned to become a model of compact green infrastructure in a dense urban setting. As a key hub in the local market ecosystem, improvements here could directly benefit economic activity, health, and social interaction.

Environmental observations reveal a general lack of vegetation and shade, resulting in a hot environment. Roads are entirely paved with concrete, exacerbating water runoff and flooding during heavy rains. The absence of pedestrian sidewalks causes potential conflicts between pedestrians and vehicles, and streets are cluttered with rubbish due to the lack of proper waste disposal bins.

Community needs are street trees and vegetation for shaded areas, street lighting to enhance safety, designated seating areas, and strategically placed rubbish bins. Improved traffic management strategies, including pedestrian pathways, are needed to ensure safer navigation, along with a stormwater drainage system to handle water runoff and prevent street flooding.

Challenges include congestion with mixed traffic, a hot and unshaded environment, and rubbish accumulation contributing to an unappealing market atmosphere.

Intervention Objectives

- Enhance pedestrian safety and comfort through sidewalk improvements and traffic calming;
- Introduce vertical greenery and shade trees to mitigate heat stress;
- Improve local drainage through community-supported redesign and maintenance;
- Create a cleaner, more attractive micro-environment that supports commerce and daily life.

Site 3: The Southern Lake Road

Context

The Southern Lake Road borders the southern edge of Lake Romleach and connects emerging residential zones with more established urban areas. While it is a key connector, the road currently lacks basic green infrastructure, is vulnerable to seasonal flooding, and suffers from poor walkability and heat exposure. Informal settlements and roadside encroachments add further complexity to its development potential.

Mandates for this area cover the departments of land management, public works and transport and water resources and meteorology as this area borders the lake and includes private and public agricultural land. Potentially, there might be conflicts of interest in terms of local farmers being requested to relinquish use of some farm land although this land belongs to the state and loaned to the farmers for their long-term use.

Urban Integration and Risk Mitigation

As a transition zone between natural and built environments, this corridor is critical for flood protection, non-motorized transport, and local identity. Strengthening the Southern Lake Road contributes not only to mobility and resilience but also to the broader vision of linking green and blue infrastructure throughout Kratié.

Environmental observations note a constant cool breeze and "fresh air" from the lake. However, the road is only partially usable during the wet season due to flooding. The dirt surface leads to dust in dry seasons and mud in wet seasons, or is completely submerged. A lack of tree cover results in a hot environment, and the scenic potential is not fully utilized due to poor road conditions and lack of amenities.

Community needs include increasing the lake's significance for community residents with business opportunities for small-scale vendors. The introduction of vegetation, particularly trees, is needed to provide shade, especially at mobile rest stops. Simple seating should be installed to offer rest spots for those traveling around the lake, similar to other mobile rest stop locations on the lake.

Challenges include seasonal flooding preventing access and potential damage to permanent infrastructure. Appropriate trees and vegetation that offer shade without destroying the road or causing erosion are needed. Water pollution is also a concern from both agricultural and local domestic sources.

Intervention Objectives

- Improve stormwater drainage and surface water flow management;
- Reduce heat stress through tree planting and shading interventions;
- Enhance pedestrian mobility and access to lakeside areas;
- Support informal residents through inclusive design and participatory upgrading.

Site 4: Lake Romleach Northern Shore Road

Context

Lake Romleach serves as a key ecological feature and retention zone within Kratié's urban landscape. Its northern shoreline is bordered by a gravel road that currently lacks formal stormwater infrastructure, green shading, or pedestrian amenities. The area holds promise as both a climate buffer and a recreational corridor, particularly as urban growth encroaches further on the lake area. Similarly to the Southern Lake Road, mandates for construction of roads and forms of drainage rests with the Department of Public Works and Transport while management of the lake itself comes under the mandate of the Department of Water Resources and Meteorology and changes in land use is the proviso of the Department of Land Management and Construction.

Environmental and Urban Potential

This intervention focuses on enhancing the ecological and social functions of the lake's northern edge. As part of Kratié's broader water-sensitive urban development strategy, the site can demonstrate how peripheral zones can be integrated into the city's green and blue infrastructure network.

Environmental observations reveal that the road is bordered by natural landscapes but lacks vegetation and shade, resulting in a hot environment. The dirt surface creates dusty conditions in dry seasons and becomes muddy and difficult to navigate during the rainy season, and it is not possible to use when fully inundated. The scenic potential is not fully utilized due to poor road conditions and a lack of amenities.

Community needs include a raised road surface for better drainage and improved accessibility, especially during rainy seasons, and tree planting along the road for shade to make it more welcoming for locals and tourists.

Challenges include dirt road conditions, including muddy patches during rainy seasons, making navigation difficult. The absence of shade and amenities reduces the road's potential as a travel route and a tourism asset.

Intervention Objectives

- Stabilize the shoreline to prevent erosion and preserve water quality;
- Formalize the road alignment with permeable surfaces and controlled runoff paths;
- Introduce linear tree planting and green buffers to reduce dust and heat;
- Establish a continuous walking and cycling path to promote non-motorized access.

Site 5: Central Bus Station and Wat Kratié

Context

The area surrounding Wat Kratié and the adjacent Central Bus Station represents a confluence of spiritual, cultural, and transportation functions in the city. It serves as a landmark, transit hub, and communal gathering space. However, potential users of the space may suffer from heat exposure, limited seating, inadequate tree cover, and poorly defined pedestrian zones. The bus station's forecourt and the Wat's surroundings also experience occasional flooding and surface water accumulation. The bus station is privately managed and infrastructure improvements are not within the mandate of the Department of Public Works and Transport while the Wat is managed by the institution's management. The roads around the Wat, however, are under the mandate of the Department of Public Works and Transport and could be developed further.

Urban Role and Opportunity

This intervention aims to transform the area into a functional and symbolic green public space that improves urban comfort while honoring its civic and spiritual character. Due to its visibility and accessibility, this zone holds high potential for demonstrating integrated design in a multi-use, high-traffic location.

Environmental observations reveal that the roads are paved but have no designated pedestrian sidewalks, leading to potential conflicts between different traffic modes. Sparse vegetation and a lack of shade make the area hot and unwelcoming, especially during peak daytime hours. Concrete surfaces limit water absorption, increasing the risk of flooding during heavy rainfalls.

Community needs include street trees and greenery to create shaded areas and improve the overall attractiveness of the area. The installation of street lighting is necessary to ensure safety during the evening and night. The development of pedestrian-friendly spaces, including sidewalks and seating areas, is also desired, along with the introduction of rubbish bins to promote a clean environment.

Challenges include a lack of greenery and shade making it an uncomfortable area during the day, potentially reducing its attractiveness for visitors and locals and negatively affecting tourism. The current traffic management system creates safety concerns, particularly for pedestrians.

Intervention Objectives

- Create shaded waiting and seating areas around the bus station and Wat Kratié;
- Enhance stormwater drainage and surface water management;
- Introduce landscape buffers that define movement corridors and resting zones;
- Improve the aesthetic and functional interface between sacred and transit space.

Validation

In December 2024, stakeholders from Kratié's subnational provincial and municipal government gathered to validate the selection of potential green space sites assessed in September 2024.

Figure 10 Kratié key government partners validate the green space selection (Source: PUW Own Work, 2024)

Importantly, the validation process allowed local stakeholders to suggest additional areas for green space and recreational developments, leveraging insights from the recent PUW Symposium at the Asian Institute of Technology in Bangkok. (See Figure 11)

Figure 11 AIT Campus as inspiration for Kratié stakeholders (Source: PUW Own Work, 2024)

Results of the Validation Process

The discussion centered on the five sites based on their priority and feasibility as well as additional sites of stakeholder interest:

- Site 1: The White Bridge channel emerged as a priority site, with stakeholders interested in constructing a bridge, though it recognizes the substantial investment and long timeline required.
- Site 2: The O'Russey Market area, particularly adjacent streets, was prioritized despite limited space (only 1 meter-wide roads) that raises concerns about local business and resident reactions, and potentially, this would necessitate protracted public consultation to alay business owners' concerns over disruptions to their business operations.
- Site 3: Southern Lake Road is considered viable, but decisions must be made about the design concerning seasonal flooding and suitable tree species.
- Site 4: Northern Lake Road faces severe flooding challenges, prompting suggestions for finding an alternative for the proposed cycling route, which remains a favorable concept for the city.
- Site 5: The bus station is privately owned and the area has size limitations. However, there are opportunities for planting trees around Wat Kratié and nearby roads.

Proposed Replacement Sites - Site 6: 10 Metre Street and Site 7: 30 Metre Street

30 Metre Street is a wide but underutilized urban road located in a mixed residential and institutional area of Krong Kratié. It currently lacks tree cover, has minimal pedestrian infrastructure, and suffers from poor drainage. Despite these deficiencies, the street has strong potential to serve as a green mobility corridor and climate adaptation spine within the city. However, the nearby 10 Metre Street is narrow and would require considerable disruption to improve this road and so the preference is for 30 Metre Street as more conducive to development.

Urban Development and Climate Relevance

30 Metre Street lies in an area identified for future densification and infrastructure investment under Kratié's urban development plan. Its generous width and strategic location offer opportunities to integrate green infrastructure that supports microclimate regulation, pedestrian mobility, and stormwater infiltration. This corridor can also demonstrate how everyday infrastructure can become climate-adaptive and socially inclusive.

Intervention Objectives

- Establish shaded pedestrian walkways through tree planting and landscaping;
- Improve drainage through the introduction of permeable surfaces and bioswales;
- Create small-scale recreational zones with seating and greenery;
- Encourage private green contributions such as household gardens or plant boxes.

Figure 12 Map of 10 Metre and 30 Metre Street in O'Russey 1 Village (Source: PUW Own Work, 2024)

Figure 13 10 Metre Street in O'Russey 1 (Source: PUW Own Work, 2024)

Figure 14 30 Metre Street in O'Russey 1 (Source: PUW Own Work, 2024)

3. Multi-functional Green Space and Recreational Area Development in Krong Kratié

Following the validation process and with better management of climate change impacts, stormwater and wastewater as overarching objectives, a workshop to present the initial concepts for green space and recreational areas in Kratié was organised in April 2025 with key stakeholders from the city government and the private sector present. The event also provided an opportunity to discuss potential options for integrating improved flood and stormwater management as well as wastewater management.

This chapter provides an overview of the green space and recreational areas and sites as developed by the consultant urban planner. It also provides an overview of the potential flood and wastewater management solutions for these areas.

Green Corridor Concept for Krong Kratié

The city has been developing green corridors along main roads to the north and west of the city along Route 73 and the riverside promenade. These areas are adjacent to the Green Space and Recreational sites 1, 2, 4 and 5.

The Land Use Master Plan for 2035 indicates that much of the south, near to site 3, and east of the city will have improved road access and main roads and will need to be included as green corridors that will encircle the city as a whole in the future. (See Figure 15).

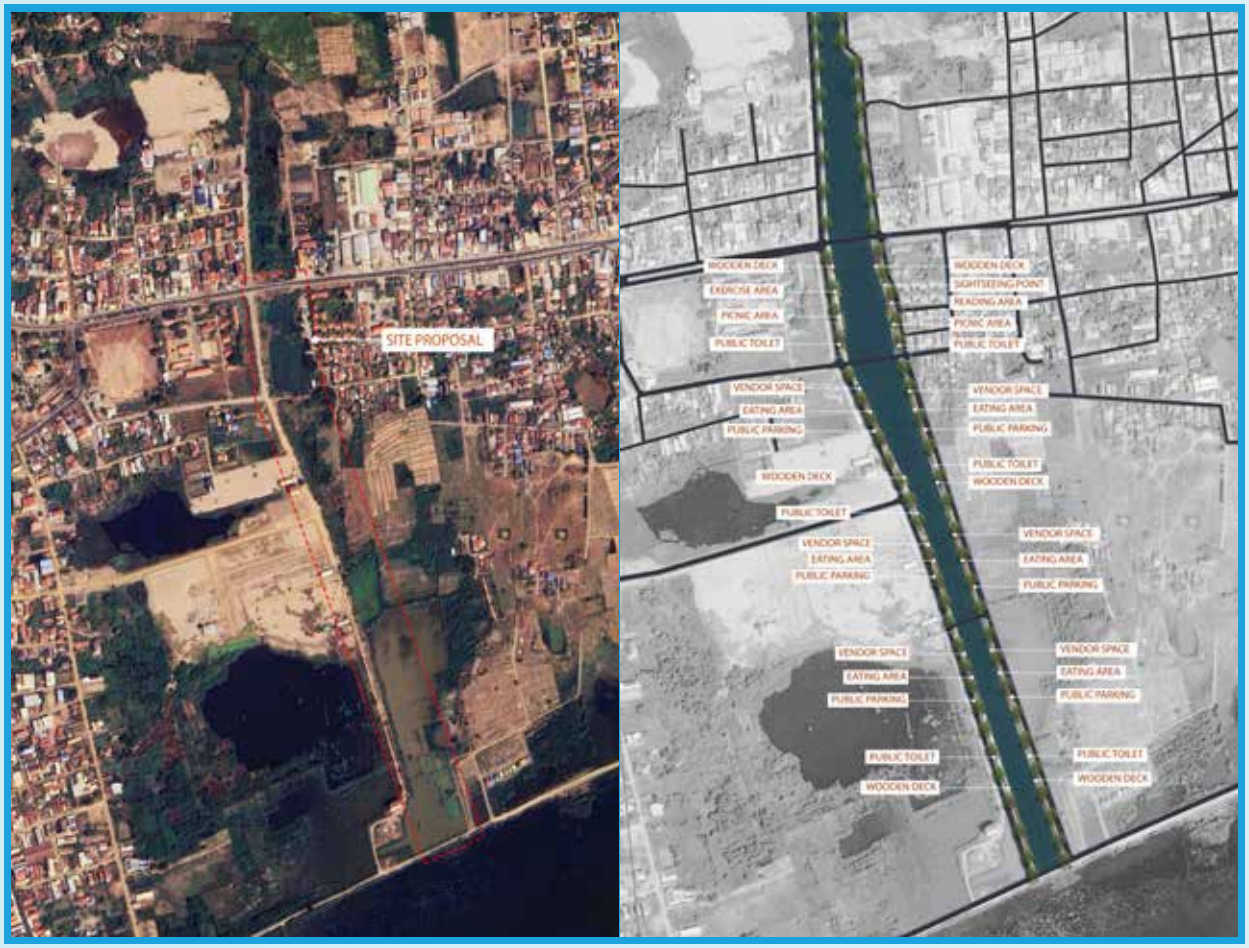
Figure 15 Land Use Master Plan Showing Proposed Development Expansion (Source: Own Work, 2025)

Green Space and Recreational Area Sites

This section presents visual concepts for Green Space and Recreational Areas in Krong Kratié based upon the participatory assessment and validation activities. Potential flood and wastewater management techniques are presented below. (See factsheets in Annex 7)

Key Intervention 1: White Bridge Channel (Site 1)

Site Proposal and Master Plan



Design Concept

This intervention merges technical rehabilitation with public space enhancement. The channel will be cleared and re-landscaped to re-establish its ecological and drainage functions, while also providing a walkable, green recreational space. Street-level improvements will be coordinated with the channel's development to support integrated urban mobility and infrastructure resilience.

To implement this vision, a stepwise and realistic approach is proposed, led by the local and provincial government and coordinated closely with the municipal government and council:

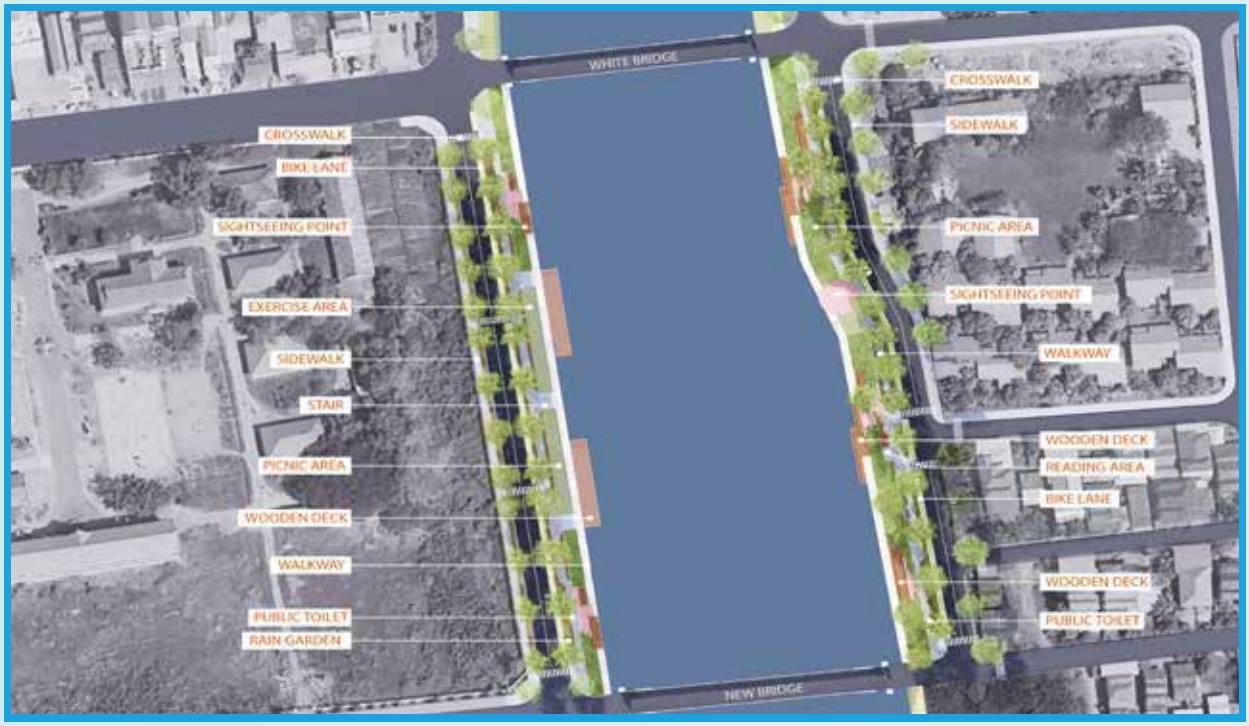
- Basic technical assessment of the current channel condition and surrounding infrastructure, including topography, flow barriers, and access points;

- Development of a simple, robust site layout, including zones for vegetation, walkways, and basic seating, aligned with available materials and maintenance capacity;
- Close coordination across local departments and planning units to ensure alignment with development strategies;
- Involvement of community members to identify local needs, informal uses, and preferences for public space functions;
- Mobilization of funding from international donors and the national government, as municipal budgets are not sufficient for full implementation;
- Gradual implementation in manageable phases, beginning with core flood resilience measures and expanding to include social and ecological functions.

This pragmatic, locally anchored approach ensures that the design is not only ambitious but also feasible and sustainable under current governance and financial conditions.

Visual Concepts

Before



Top View

Before

Before

Cross-section

Cross-section

Water-sensitive Elements

Flood Management

The first priority for flood management is a stormwater drainage system with infiltration, implementing an open drainage system that remains clean and aesthetically pleasing. Task feasibility is high with experienced personnel on hand locally. Community engagement is minimal due to few residents in the area. There is a need for more recreational areas, which aligns with government priorities. Funding should be utilized gradually from local budgets, as expedited efforts may require substantial investment.

The second priority is permeable paving, which is relatively simple to implement, practical, and would positively affect the community. While achievable by the local authority, quality standards may vary. The third priority is a wet detention pond, which is technically challenging and requires significant work.

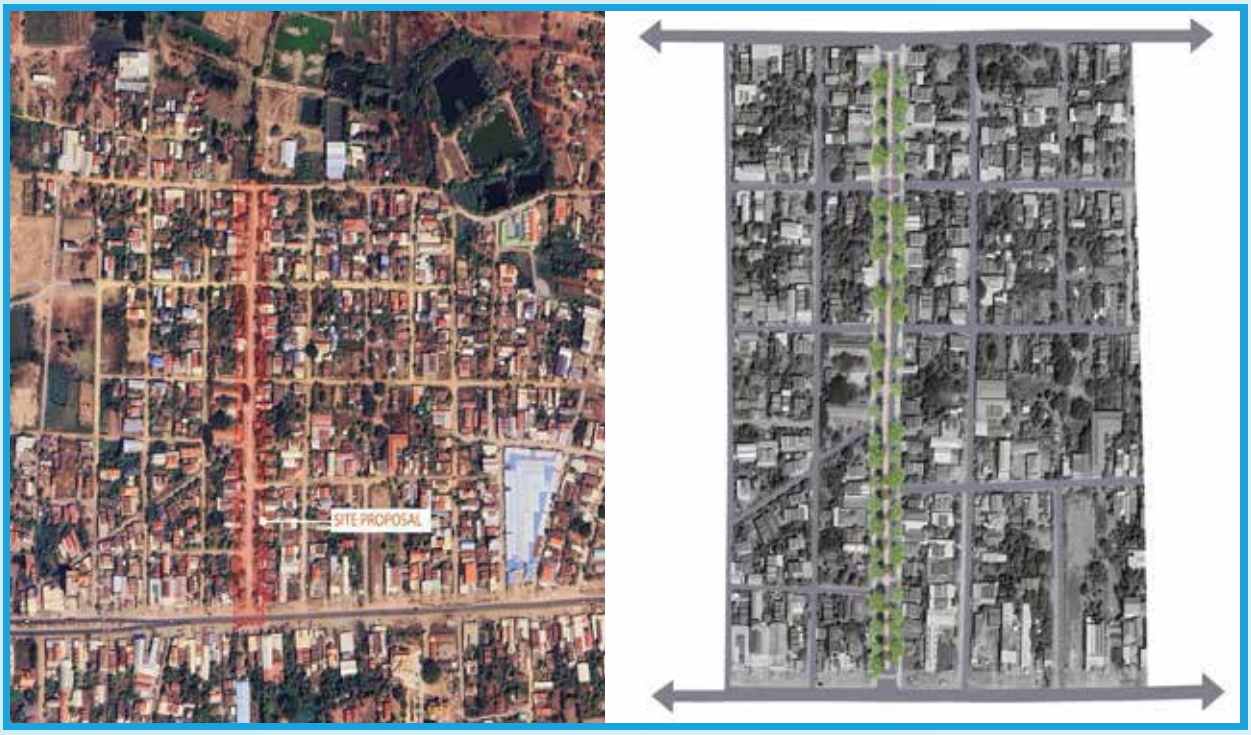
Wastewater Management

The proposed wastewater option are Decentralized Wastewater Treatment Systems (DEWATS). Numerous examples of this technology exist in Kratié and are suitable for the area's population density. The system can effectively store wastewater, which will generally please residents if well-managed. The system will reduce pollution and adhere to local regulations.

Given its small size, provincial and district budgets may be accessed. The system can generate revenue through user fees while occupying minimal land.

Key Intervention 2: 30 Metre Street (Site 5)

Site Proposal and Master Plan



Design Concept

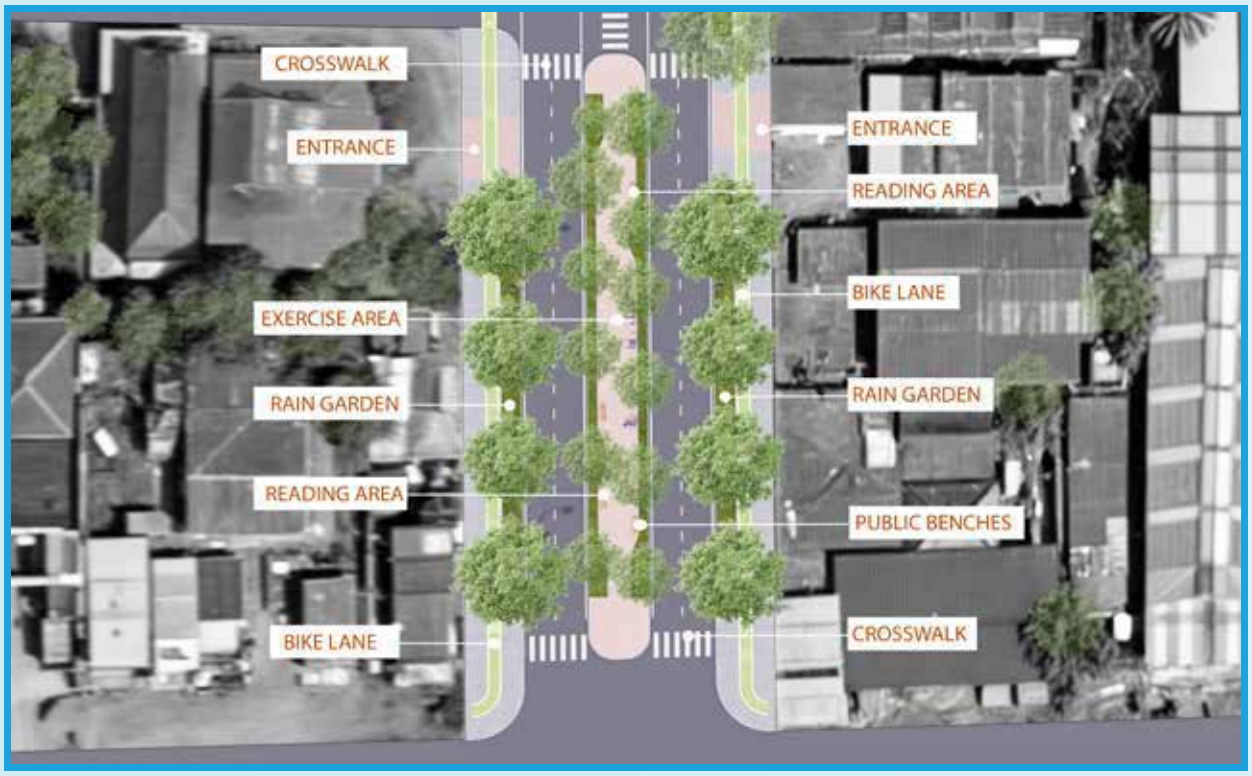
The intervention aims to transform 30 Metre Street into a multifunctional urban corridor that addresses both climate and social needs. Tree-lined sidewalks, green buffers, and water-sensitive paving will enhance comfort and resilience. Small public resting areas and shade structures will increase usability, especially during hot and rainy periods.

To implement this concept, a phased and locally driven approach is recommended, led by the local and provincial government and coordinated closely with the City Council:

- Conduct a baseline assessment of the street's physical condition, drainage issues, and potential planting zones;
- Develop a basic, modular design that aligns with available resources and long-term maintenance capacity;
- Coordinate with urban planning units to ensure consistency with road network improvements and surrounding land use planning;
- Engage local households and institutions to support and maintain adjacent green elements;
- Seek financing from national government programs and development partners, as municipal funding alone is insufficient;
- Roll out implementation gradually, beginning with tree planting, seating zones, and selected drainage features.

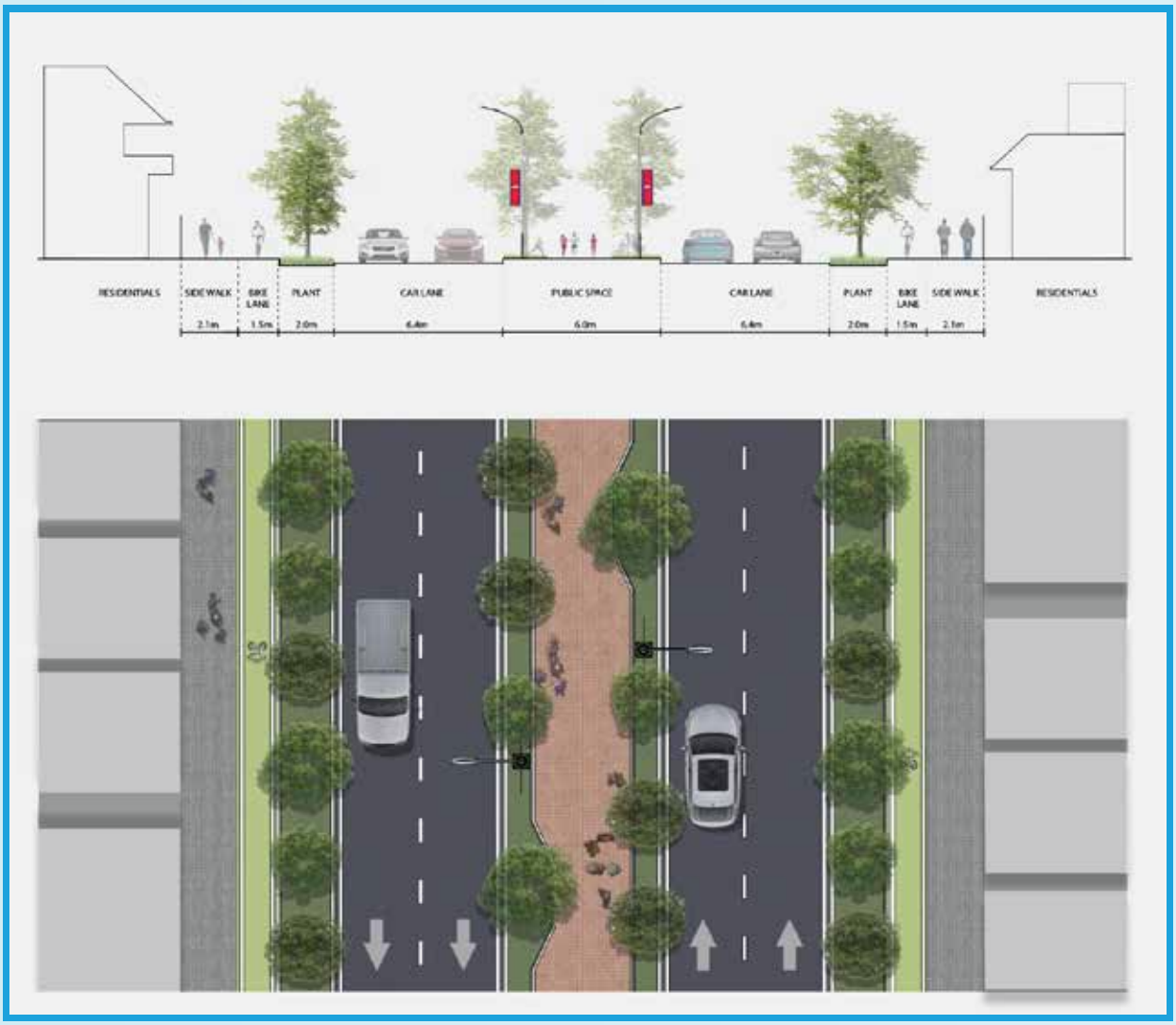
This intervention demonstrates how secondary streets can be redesigned as accessible, climate-resilient public infrastructure with both ecological and social value.

Visual Concepts



Top View

Before



Cross-section

Water-sensitive Elements

Flood Management

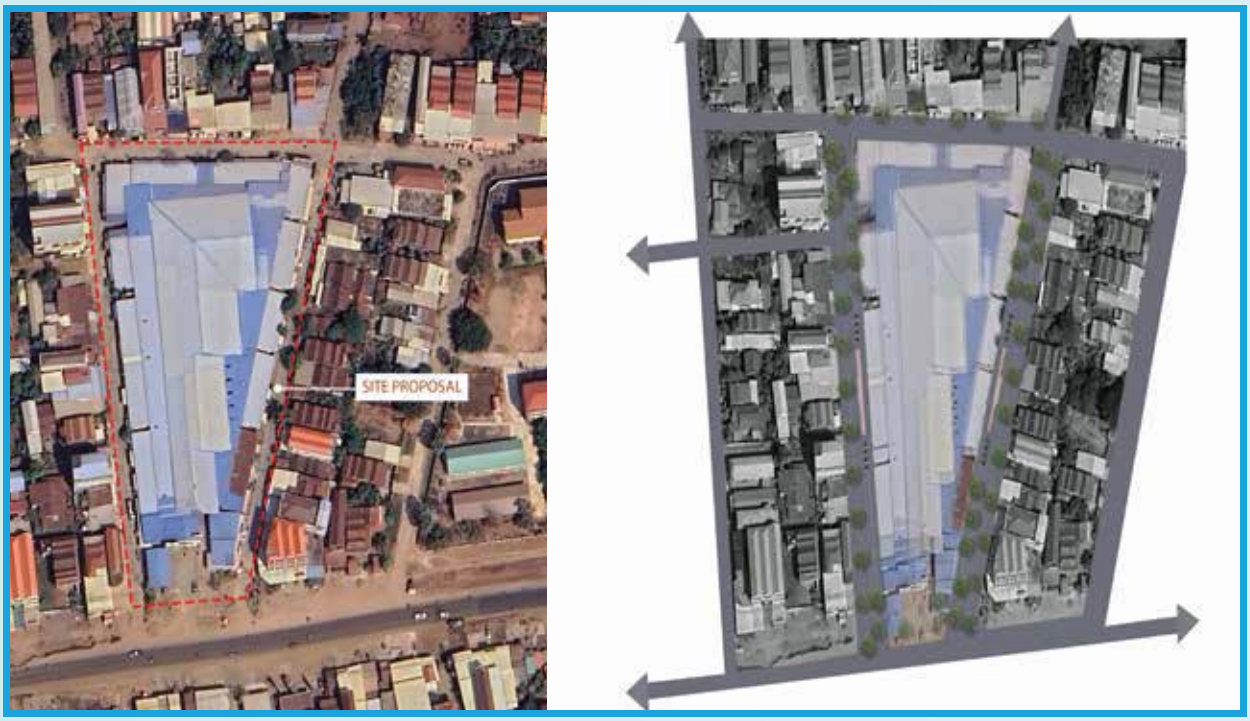
The priority is a stormwater drainage system with infiltration and constructing a quality road to improve both the road and the city. Inputs from in-house expertise will be important to ensure effective and cost-efficient implementation. There may be discontent among some residents due to potential negative impacts during construction. The local authority (Sangkat) will oversee the budget allocation and available budget is significant due to O'Russey's large population.

Wastewater Management

The wastewater option is DEWATS (Decentralized Wastewater Treatment System). Since the road has households and a primary school, wastewater generation is expected, and toilets must be present in some locations on this residential road. There is no negative impact on residents, and they are likely to support the initiative if it reduces health risks associated with flooding.

Key Intervention 3: O'Russey Market Side Streets (Site 2)

Site Proposal and Master Plan



Design Concept

The concept focuses on low-cost, high-impact improvements that can be implemented within tight spatial and financial constraints. Elements include:

- Narrow planting strips or tree wells for shade trees along pedestrian paths;
- Climbing plants on facades and structures to increase green surface area without occupying street width;
- Benches and small sitting areas for market-goers and passersby;
- Improved drainage systems such as small-scale gutters and covered drains, with integrated bins and water flow guidance.

Given the highly localized nature of this intervention, implementation must be carried out in close collaboration with market management, vendors, local households, and the municipal authorities. Community involvement will be essential to:

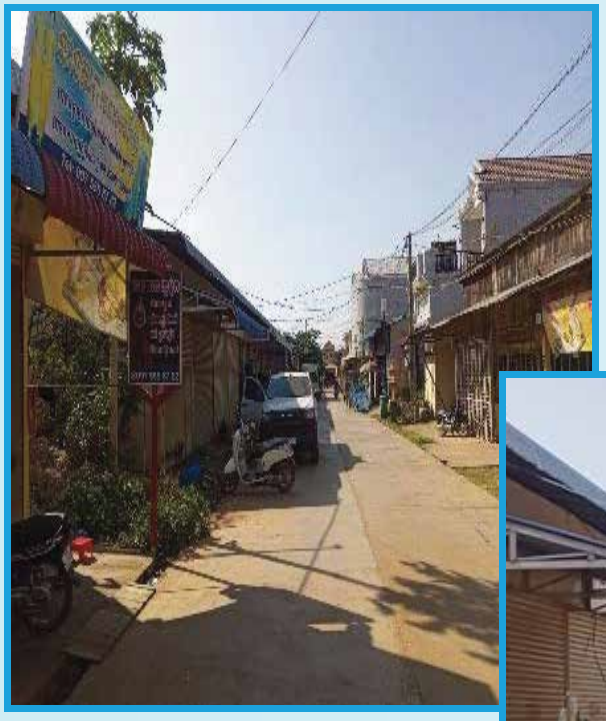
- Identify flood-prone areas and current blockages or waste disposal issues;
- Co-design practical and maintainable drainage solutions;
- Establish agreements for regular maintenance and shared responsibilities.

Initial steps include mapping pedestrian flows and drainage patterns, designing modular, low-maintenance green and grey infrastructure elements, and securing small-scale funding or NGO support for pilot upgrades.

The O'Russey Market side street demonstrates how even narrow urban spaces can be upgraded to serve environmental, economic, and social goals within the heart of the city.

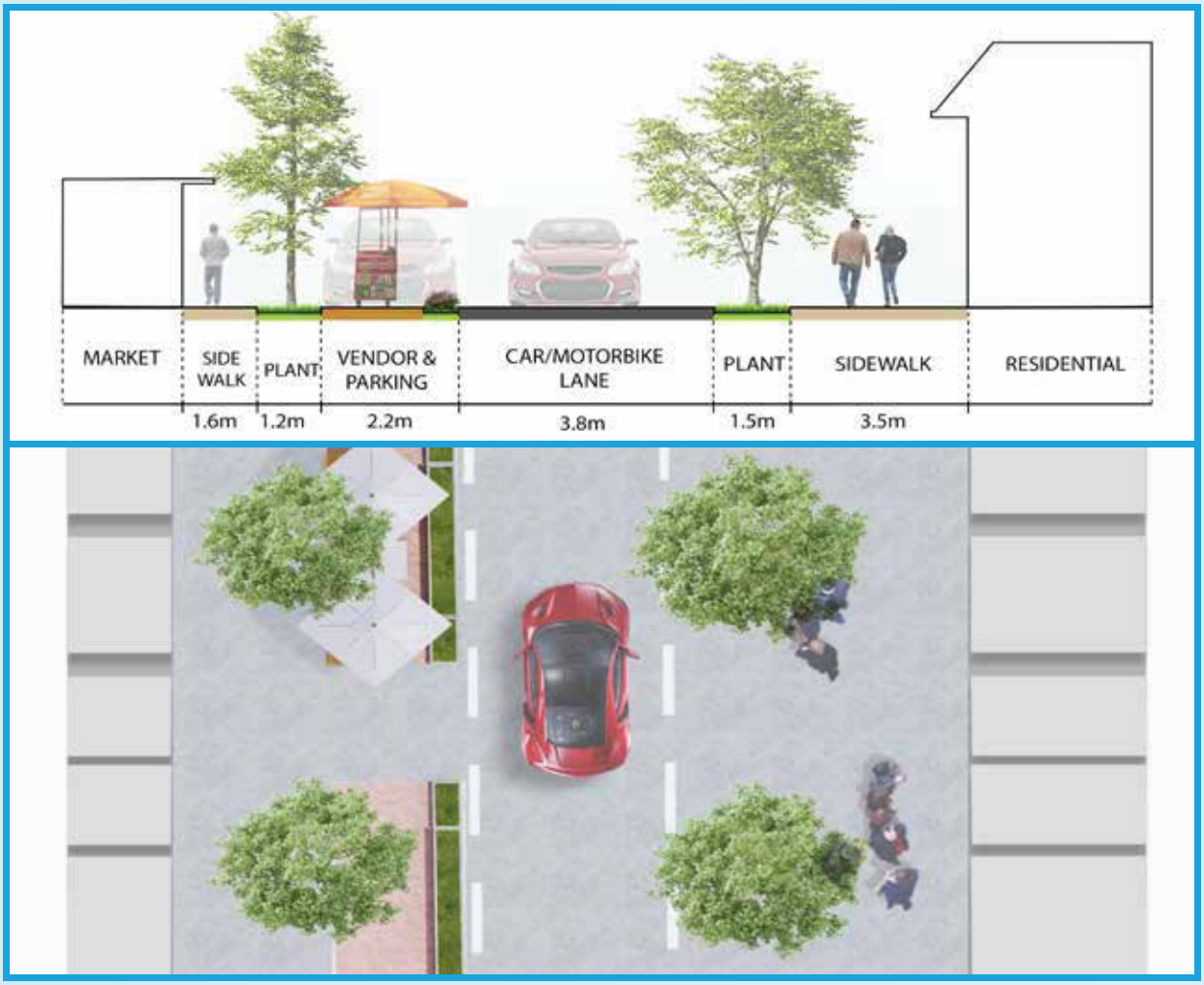
Visual Concepts

Before



Before

Top View



Cross-section

Water-sensitive Elements

Flood Management

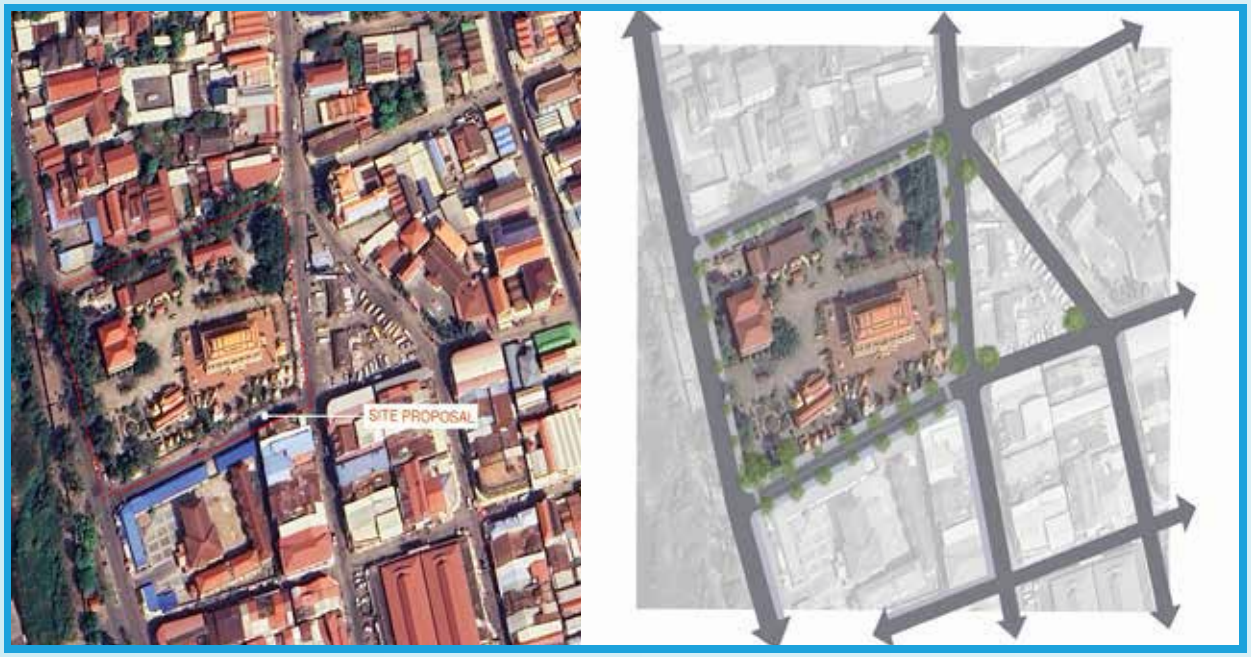
Infiltration trenches are prioritized for flood management. Technical support from municipal and provincial teams is available upon request. Community engagement is essential, acknowledging that while some improvements will satisfy individuals, others may not be satisfied. The project aligns with government development priorities in terms of supporting economic development. Contributions will be limited to the local authority's budget, necessitating additional funding from other sources.

Wastewater Management

A Decentralized Wastewater Treatment System (DEWATS) is the proposed wastewater option. This system will be limited to the market and its businesses, as households will not connect. The Public Works Department has the necessary capacity to implement this solution. As some local businesses may choose not to participate, a robust conflict resolution mechanism needs to be in place. Prior to construction, a mechanism should be established to ensure proper system maintenance post-construction. Currently, there is no budget available for this initiative from the municipal or sangkat levels.

Key Intervention 4: Wat Kratié Side Roads (Site 4)

Site Proposal and Master Plan



Design Concept

This multifunctional intervention seeks to enhance both urban mobility and spiritual experience. Proposed measures include:

- Tree planting and canopy structures to reduce heat exposure for passengers and worshippers;
- Bioswales and permeable paving to manage stormwater in front of the station and temple;
- Public benches, low hedges, and directional paving to organize flows and prevent congestion;
- Landscaping with culturally sensitive plant species and shaded courtyards that respect the temple setting.

Implementation will require close coordination between the **municipality and sangkat authorities, religious leadership, and transportation authorities.**

Specific steps include:

- Joint site planning to balance circulation, ceremony, and daily use;
- Inclusion of informal vendors and transport users in the planning process;
- Identification of small-scale infrastructure improvements that can be phased and funded through national programs or public-private partnerships.

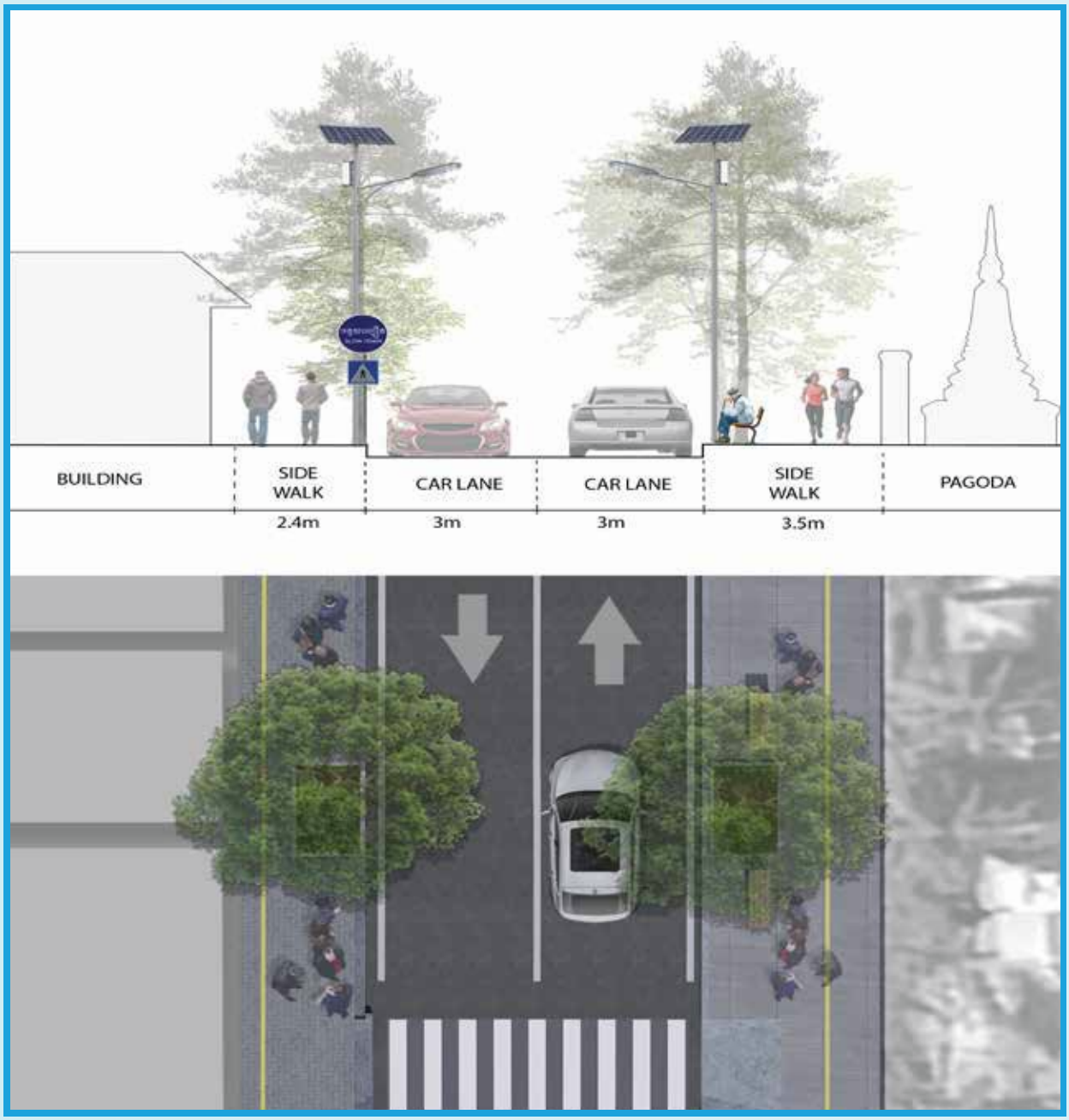
The project better connects the bus station and Wat Kratié area to the riverside promenade and provides an example of how green public spaces can present a welcoming and pleasant experience for visitors and tourists arriving in the city.

This intervention reinforces the role of green space as a connector between functional infrastructure and cultural heritage, demonstrating Kratié's commitment to an inclusive and climate-resilient urban core.

Visual Concepts

Before

Top View



Cross-section

Water-sensitive Elements

Flood Management

The first priority for flood management is infiltration trenches, which require minimal technical intervention. Community support is expected as the initiative addresses flooding by directing water to the main drainage system. Identifying responsible parties may be complex due to the small area and budget. Municipal funds could be allocated for this project.

The second priority is permeable paving, focusing on sidewalks. Implementation is straightforward, ensuring appropriate materials for effective infiltration. Improved aesthetics will garner community support. Maintenance responsibilities can be shared with local authorities.

Wastewater Management

The wastewater option is to connect to the grey drainage system (grey infrastructure). There is no demand for wastewater management in this area due to the absence of households along the specific streets. The existing systems will primarily manage rainwater. It is crucial to prevent solid waste from blocking channels or drains, as this area is not a pollution hotspot but is vulnerable to flooding.

Key Intervention 5: Southern Lake Road (Site 3)

Site Proposal and Master Plan

Design Concept

The Southern Lake Road will be upgraded as a shared, green-access corridor that balances ecological needs and community use. The concept includes:

- Roadside tree planting with native species to provide shade and ecological continuity;
- Simple drainage improvements such as swales and side channels to direct runoff away from homes;
- Clear walking paths and bicycle lanes using cost-efficient surface materials;
- Consultation with local households to co-design small interventions such as sitting areas, water points, and trash management.

Implementation will be driven by the **municipal government with support from the sangkat authorities, local communities, and relevant planning departments.**

Next steps include:

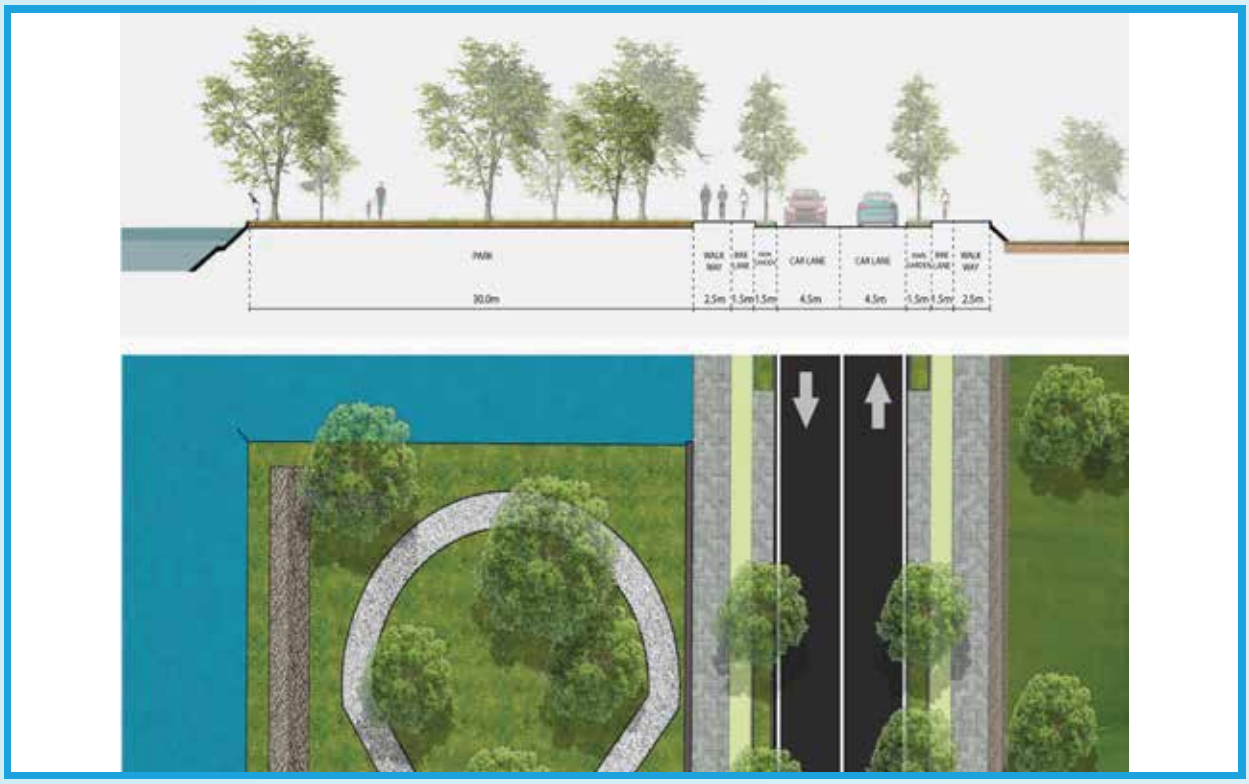
- Mapping vulnerable sections prone to flooding and encroachment;
- Establishing a landscape and mobility plan that aligns with existing informal uses;
- Coordinating funding through government and NGO partnerships for inclusive infrastructure.

This intervention highlights how peri-urban infrastructure can strengthen resilience while enhancing quality of life for all residents in expanding parts of the city.

Visual Concepts

Before

Top View



Cross-section

Water-sensitive Elements

Flood Management

The first priority for flood management is permeable paving. Local capacity suggests successful implementation is feasible. However, access issues may arise for the elderly and children if this terrain is uneven. The local authority can manage maintenance using their budget, though higher-level support is needed. Community contributions may be required for support.

The second priority is a dry detention pond, which is feasible at the local level. Residents are likely to engage and participate in the project as it may support farming and fishing activities. The local authority can also achieve this. Funding may be sourced from the local authority's budget.

Wastewater Management

DEWATS (Decentralized Wastewater Treatment System) is the preferred wastewater solution. Existing infrastructure allows for straightforward improvements. Residents will be generally supportive if the system aids local development and reduces health risks associated with flooding of existing blackwater collection units.

If the Sangkat is officially assigned to maintain the infrastructure, they will have the capacity to regularly perform this task. For the budget, there may be a contribution from the Sangkat; for example, if the total cost is $10,000, the Sangkat may be in a position to contribute a few hundred dollars as the population density is quite low compared to sangkats Kratié and O'Russey.

4. Way Forward

This chapter outlines the recommendations for the next phase of green space planning in Kratié.

A. Recommendations for Green Space Planning Activities

- To guide green space development effectively, it is essential to establish in the Implementation Phase of the project, a strategic working group or steering committee comprising local government departments, sangkat councils, communities, and the private sector.
- Collaborating with local stakeholders at the community level to finalize a Standard Operating Procedure (SOP) for public consultations will enable local communities to engage meaningfully with proposed green space projects.
- Developing action plans for each green space site should involve local stakeholders to ensure that developments meet both current and future needs.
- Continuing capacity building for local stakeholders fosters a sense of ownership over the green spaces.
- Promoting green initiatives among the public and private sector will raise awareness of the value of greenery in enhancing livability across the city and indicate what residents and businesses can do to support the initiatives.

B. Recommendations for Strategy Development and Water-Sensitive Urban Planning for Green Spaces and Recreational Areas in Kratié

- Discussing and addressing real community challenges in terms of managing and promoting green space initiatives, such as weak law enforcement and resource limitations, demands practical and actionable plans.
- Planning for the "low-hanging fruit" where possible offers quick, visible outcomes to cultivate stakeholder support and ensure sustained engagement.
- Enhancing the natural water bodies should continue to be prioritized and integrating them into a green space network with multifunctional designs that address ecological and social benefits.
- Planning for long-term sustainability should ensure that projects remain viable and adaptable to future changes.

C. Recommendations for Pilot Projects as Starting Points for a Comprehensive Water-Sensitive Transformation

- The pilot projects should act to build capacity and develop practical regulations, aligning urban development with community needs.
- These projects must consider visibility, feasibility, community engagement potential, and effectiveness in solving water management issues as criteria for their final selection and implementation.
- A comprehensive approach involving stakeholder participation and secure funding is crucial for successful implementation and sustainability.

D. Recommendations for Further Development of Standard Operating Procedures (SOPs) for Water-Sensitive Urban Transformation

- At the appropriate time, conduct a pilot of the SOP for public consultation at one of the Green Space sites in coordination and with the active involvement of city stakeholders.
- Developing SOP for raising awareness of the importance of green space on private properties and business premises to reduce the burden on existing drainage networks and reduce local temperatures and heat stress while supporting well-being.
- The framework for planning and executing water-sensitive urban projects must clarify stakeholder roles and responsibilities.
- Collaboration across sectors such as urban planning and water management fostering the integration of sustainable practices must continue.
- As part of operation and maintenance procedures, implementing a robust monitoring and evaluation framework supports continuous improvement and alignment with existing policies.
- Training programs and regular communication among government agencies support effective coordination.
- Plan for the incorporation of ongoing maintenance schedules and the engagement of both the community and the private sector throughout the project lifecycle.
- Ensuring dedicated funding and legal support will encourage the widespread adoption of water-sensitive practices.

5. Lessons Learned and Conclusions

This chapter presents the primary lessons learned and the conclusions of this specific process in Kratié as of 2025.

Key Learning and Takeaways

1. Importance of Green Spaces in Urban Development

Green spaces play a crucial role in Krong Kratié's sustainable urban development, offering numerous environmental, social, economic, and health benefits. As the town experiences gradual growth and faces challenges related to climate change, urban infrastructure, and water management, effective green space planning becomes essential for enhancing residents' quality of life. Integrating green growth principles is also aligned with Cambodia's vision outlined in the Pentagon Strategy Phase 1.

2. Assessment of Current Green Spaces

The existing green spaces in Krong Kratié serve multiple functions by facilitating social interactions, encouraging physical activity, and supporting small-scale economic initiatives. However, many of these spaces are underutilized due to a lack of amenities, insufficient shade, and inadequate infrastructure, which hinders their potential as community assets. Additionally, the absence of vegetation and shade in several areas contributes to uncomfortable environments, especially along market streets and roadsides, exacerbating the urban heat island effect.

3. Challenges

Accessibility poses a significant challenge, particularly in areas with unpaved roads during the rainy season, which limits access to spaces near Lake Romleach. Poor pedestrian pathways can make these areas less inviting and safe. Moreover, rubbish accumulation and ineffective waste management degrade the aesthetics and usability of the green spaces. It is essential to realistically incorporate operation and maintenance costs into feasibility studies and budgeting.

4. Feasibility of Implementing Green Spaces

The feasibility of developing new green spaces is influenced by factors such as available space, budget constraints, and necessary infrastructure, particularly in relation to long-term operational and maintenance needs. Collaborating with local authorities and development partners is vital for successful project implementation, securing funding, and ensuring sustainable operation and maintenance.

5. Improving Usability Focusing on Increasing Trees and Shade

Adding shade-providing trees, greenery, and walkways can create more inviting and comfortable public areas that encourage relaxation, socialization, and exercise. Developing safe, connected bicycle paths and pedestrian walkways, especially around Lake Romleach, will enhance accessibility, promote recreational activities, and attract tourism. Installing essential amenities such as benches, exercise equipment, rubbish bins, public toilets, and street lighting will improve usability, cleanliness, and safety. Strategic waste management practices are necessary to maintain cleanliness and elevate the overall appeal of green spaces.

6. Future Processes

A detailed proposal plan is required for each site, addressing budget allocation, infrastructure needs, operational requirements, and alignment with long-term city development goals. Key considerations include determining ownership and identifying the institutional entities involved, such as local councils and land tenure authorities. A strong emphasis on operation and maintenance is crucial, including clear mandates, responsibilities, and budgets. Engaging the community in the planning process is important to ensure that green spaces meet local needs and foster economic benefits. Collaboration with development organizations, local authorities, and the community will be essential for securing ongoing support and funding.

Conclusions

The **Green Space Assessment and Planning Workshops from 2024 to 2025,** building on insights from the Baseline Assessment, highlighted the current state of Krong Kratié's green spaces and the community's needs, identifying areas for improvement. A central focus was recognizing the importance of all water bodies in the town, encompassing the lakes and channels, and understanding their interconnected functions, including water flows, seasonal changes, and variations in accessibility to green spaces.

This is of paramount importance for residents impacted by regular seasonal and extreme rainfall showing that any development must address water-related challenges when developing public green spaces. This includes promoting greater green space on private properties as part of awareness raising activities.

By enhancing both public and private areas and integrating them with existing green spaces, Krong Kratié can maximize their ecological, social, and economic value for both residents and visitors. There is potential for simple, adaptable solutions to address seasonal changes, such as flooding, while catering to the desires of current users, residents and prospective tourists.
Importantly, the ongoing operation and maintenance of all spaces must be prioritized to ensure their longevity and effectiveness. To achieve this, project budgets must remain realistic and aligned with local capacities.

Through strategic planning, infrastructure enhancement, community engagement, and a strong commitment to operation and maintenance, Krong Kratié can develop multifunctional green spaces that promote urban well-being, stimulate economic growth, and bolster the town's resilience to environmental challenges. The outcomes of this process will inform future green space development in alignment with Krong Kratié's broader urban development goals and the Development Plan for Urban Wetlands as part of the PolyUrbanWater's Implementation Phase through 2026.

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The PolyUrban Waters Project

PolyUrbanWaters is a research and project network funded by the German Federal Ministry of Research, Technology and Space (BMFTR) (formerly the Federal Ministry of Education and Research (BMBF)) 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 Southeast Asia towards resilient, inclusive and livable urban areas, thus contributing to the fulfilment 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 Southeast Asia", 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, Department of Public Works and Transport

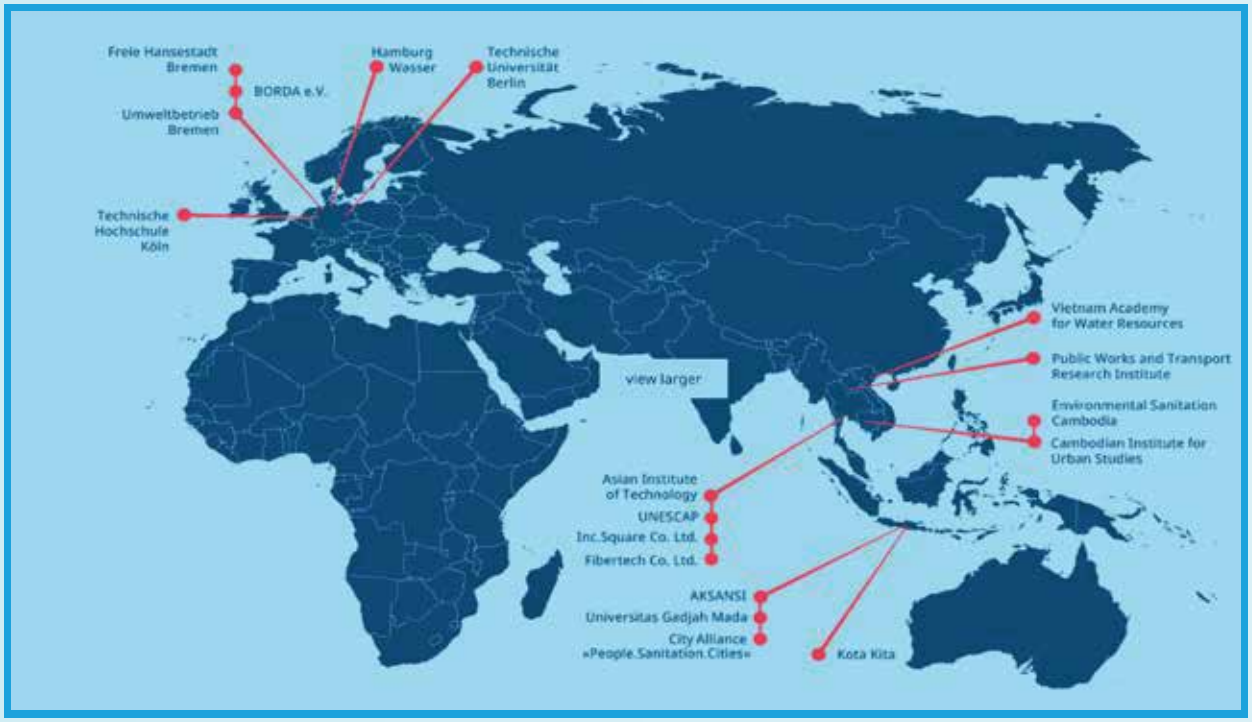


Figure 16 The PolyUrbanWaters- Network (PUW Own Work, 2023)

Annexes

Annex 1 Krong Kratié Profile

Introduction

Located in northeastern Cambodia, Kratié Province has experienced a consistent population increase over the years. It is accessible from Phnom Penh and Stung Treng via National Highway No. 7, passing through Snoul and Chhlong Districts, and by the Mekong River. The river flows through Krong Kratié and four other provincial districts, extending 140 km within the province. Covering an area of 12,250 km², Kratié borders Mondolkiri to the east, Kompong Thom to the west, Kampong Cham and Vietnam to the south, and Stung Treng to the north. The province comprises 258 villages across 42 communes and five sangkats within one krong . Krong Kratié, on the eastern side of the Mekong River, serves as the provincial administrative center, and covers 88.6 km², playing a crucial role in regional governance. The provincial population grew by 1.5% annually from 2008 to 2019, reaching 429,908 in 2020.

Figure 17 Location of 'Krong' Kratié, Cambodia (Source: Own Work)

[2] Krong is the latin translation for the Khmer word for town or a city that is not the capital city.

Natural Characteristics and Urban Green Space

Krong Kratié's landscape is characterized by a wide river valley with minor elevation changes, significantly influenced by the Prek Te river catchment to the south. The region itself is 19m above sea level.

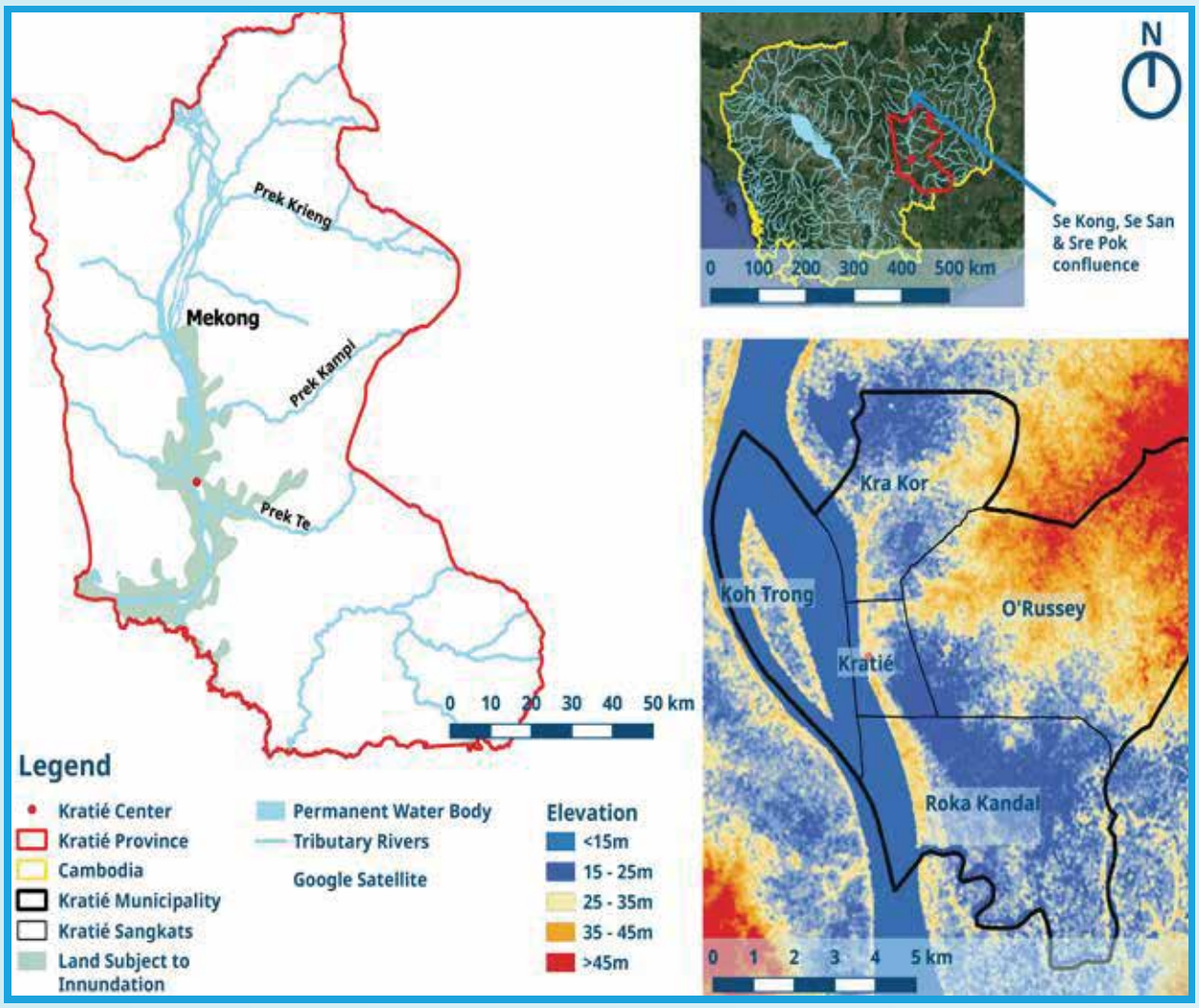


Figure 18 Location of Krong Kratié within different watersheds and its elevation profile (Source: Own Work based on Global Administrative Areas (GADM), 2012; Digital Chart of the World (DCW), n.d.; CNES Airbus, n.d.; Maxar Technologies, 2023; NASA Shuttle)

The urban environment historically incorporated green and natural spaces, but urbanization has led to a decrease in these areas. The urban core lacks parks and green spaces, with greenery mainly found in semi-public courtyards. In contrast, peri-urban sangkats have more green areas, but the core urban region shows patchy green space provision. Most existing green areas are small and isolated, lacking connectivity. Recreational spaces include the Mekong River promenade and green spaces around Beoung Romleach, but a cohesive green system is missing.

Figure 19 Aerial view of Kratié Village with the Mekong Promenade (left), green courtyards and Boeung Romleach (right). (Source: Smith, 2014)

Figure 20 The lake area as natural system of flood control - Aerial photo of Boeung Romleach (Source: Smith, 2014)

Time Series (2013 – 2021): Decline of Green in the Urban Core

The following images provide an example of how the green spaces within Krong Kratié have reduced overtime as urban densification has occurred. (See Figure 21 & Figure 22) The green space map (See Figure 23) provides an overview of the existing and planned green spaces (public and private) within the city as of 2023.

Figure 21 Greened court yards and block areas with trees in urban core of Sangkat Kratié in 2013 (Source: Google Earth Pro 7.3.4.8573. (n.d.). [Google Map of Kratié urban core in 2013 and 2021]. Retrieved July 17, 2023, from http://www.earth.google.com)

Figure 22 Partially diminished green court yards and trees in urban core of Sangkat Kratié in 2021 (Source: Google Earth Pro 7.3.4.8573. (n.d.). [Google Map of Kratié urban core in 2013 and 2021]. Retrieved July 17, 2023, from http://www.earth.google.com)

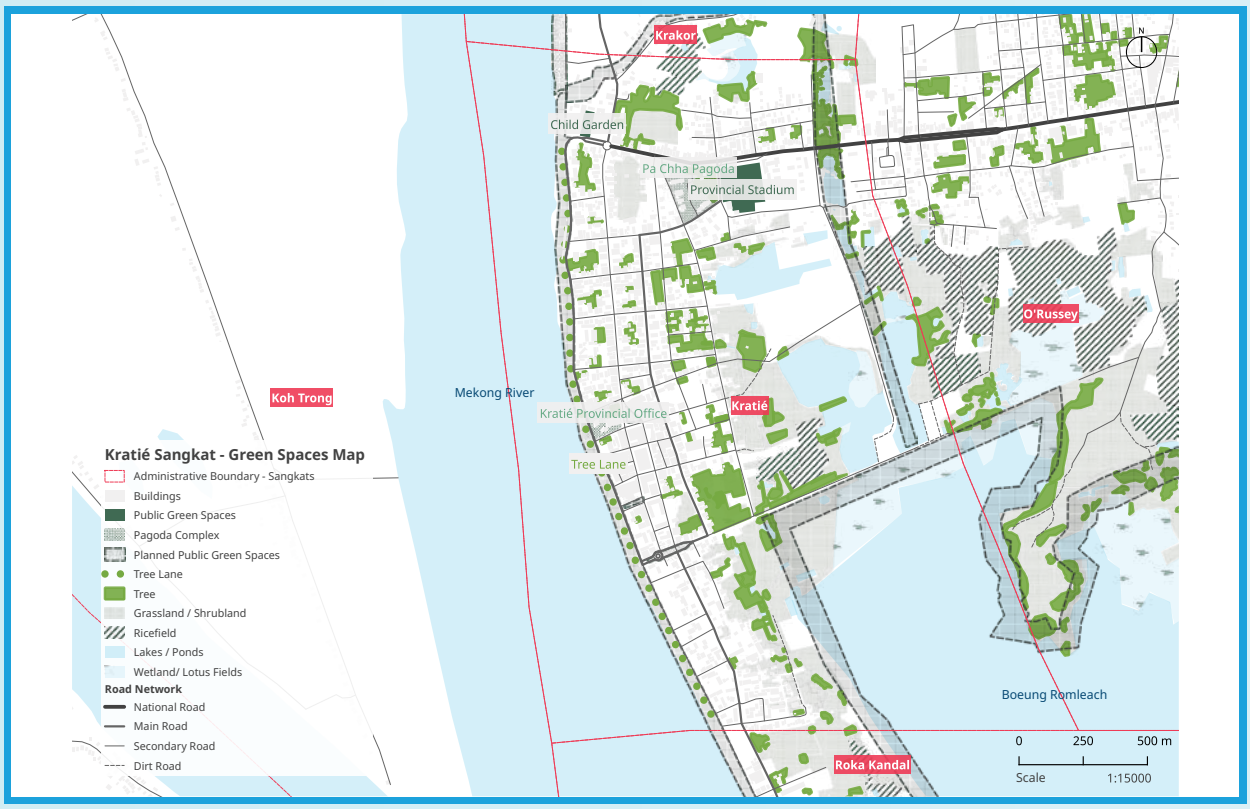


Figure 23 Map of identified and planned green public spaces around Sangkat Kratié (Source: Own Work)

Socio-Economic Development

Agriculture remains crucial, with the province acting as a marketplace for local produce. The Mekong River provides a significant source of income through fisheries, requiring sustainable practices for preservation. Kratié Province is a tourist destination thanks to the Irrawaddy dolphins, with ecotourism being promoted by the local government with private hospitality services offered. Infrastructure development aligns with the Greater Mekong Subregion program, aiming to enhance livability through improved systems and city beautification measures. Although there are untapped mineral resources, exploration must consider environmental and social impacts. Foreign Direct Investment in agriculture and manufacturing bolsters local economic development.

Tourism in Krong Kratié

Today, Kratié remains a relaxing destination with notable examples of colonial architecture, although some are gradually disappearing. Krong Kratié is widely recognized as the 'jumping-off' point for visiting the endangered Irrawaddy dolphins in Kampi, located 20 km north of the town up to the Laos border. Various cycling tours explore the surrounding area, and for many travelers, the town serves as a convenient stop en route to and from Lao PDR and the Thousand Islands.

The quay area within the town is an appealing spot for both visitors and locals, who utilize the riverside for exercise and socializing in the mornings and evenings. Only a limited number of boats operate on the Mekong River; aside from sand dredging, most traffic is between the quay and Koh Trong Island, a popular, laid-back destination for tourists seeking homestays, cycling, and a car-free experience. River cruises that operated in the Mekong during the 1950s and 1960s could potentially regain popularity among travelers eager to avoid road transport, particularly if a port is established in Kampong Cham (Simon-Barouh, 2004; ADB, 2017).

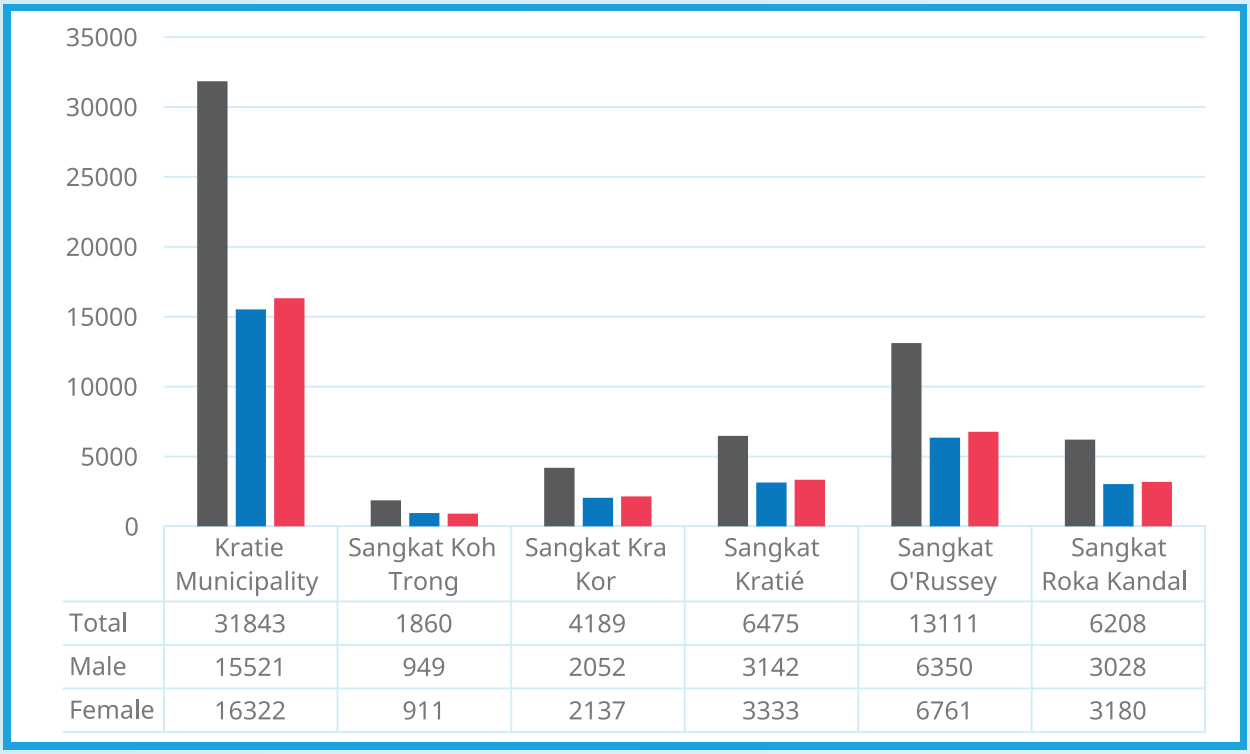
Currently, Krong Kratié is not a mass tourist destination, attracting primarily independent travelers, business professionals, and Cambodians visiting during specific festivals, such as Khmer New Year. While dolphin watching is a favored activity, the endangered status of these animals necessitates consideration of the attraction's sustainability, calling for the identification of diversification opportunities. For instance, enhancing the promotion of Boeung Romleach and Koh Trong could provide popular eco-tourism experiences. This will require urban planning and infrastructure development that improves both the visitor experience and the overall livability of Krong Kratié for its residents (ADB, 2017).

Population

At a Glance
Municipal Area (Krong Kratié):

Approx. 88.6 Km² (land area 72 Km²)
5 Sangkats (Kra Kor, Kratié, Roka Kandal, O'Russey, Koh Trong)
Villages: 16

Krong Kratié is administratively divided into five sangkats, encompassing 16 villages as of 2020. Koh Trong, on a Mekong River island, is the least developed and has inadequate infrastructure. The population reached 31,843 in 2020, with a notable percentage of families classified as poor, especially in Sangkat Koh Trong. Population growth remains steady, with the smallest increase noted in Koh Trong and the largest in Sangkat Kra Kor. As of 2020, Sangkat O'Russey had the largest population, followed by Sangkat Kratié, with Koh Trong being least populated.



	Kratie Municipality	Sangkat Koh Trong	Sangkat Kra Kor	Sangkat Kratié	Sangkat O'Russey	Sangkat Roka Kandal
Total	31843	1860	4189	6475	13111	6208
Male	15521	949	2052	3142	6350	3028
Female	16322	911	2137	3333	6761	3180

Figure 24 Total Population, Total Males, Total Females for Kratié 2020 (Source: Own Work based on CDB 2020)

Annex 2 Challenges and Opportunities for Krong Kratié

Land Use Development

Current urbanization processes are significantly transforming Krong Kratié, with four Sangkats, excluding Koh Trong, experiencing various forms of urban development. This includes housing densification and the covering of natural surfaces due to new construction and infrastructure expansions as part of urban renewal initiatives. The Land Use Master Plan for 2030 outlines a strategy for urban growth, proposing to allocate 1,612 hectares of the 6,166 hectares of agricultural land for urban purposes, thereby significantly expanding the urban area from its current constructed area. (Compare Figure 25 & Figure 26)

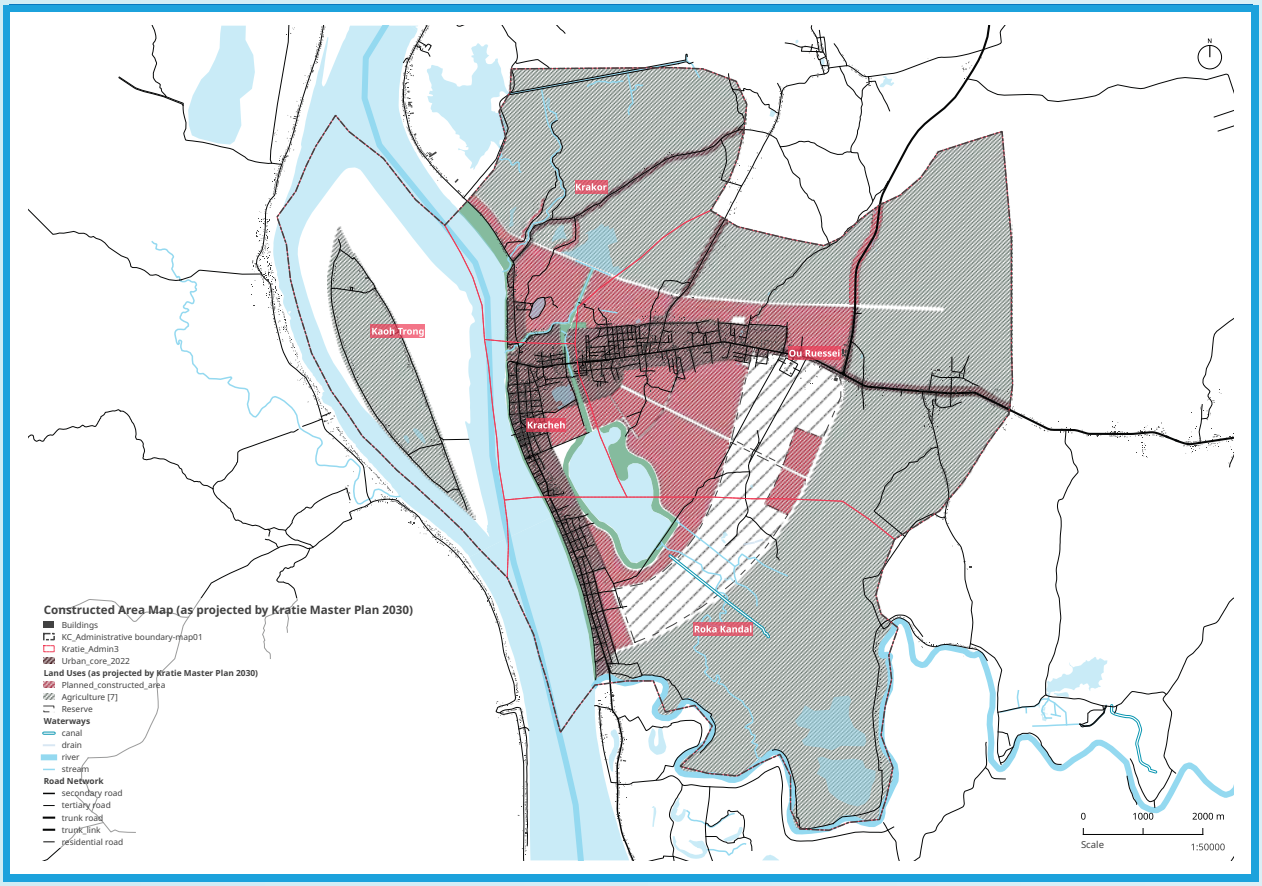


Figure 25 Constructed Area Map as projected in Krong Kratié Masterplan 2030 (Source: Own Work)

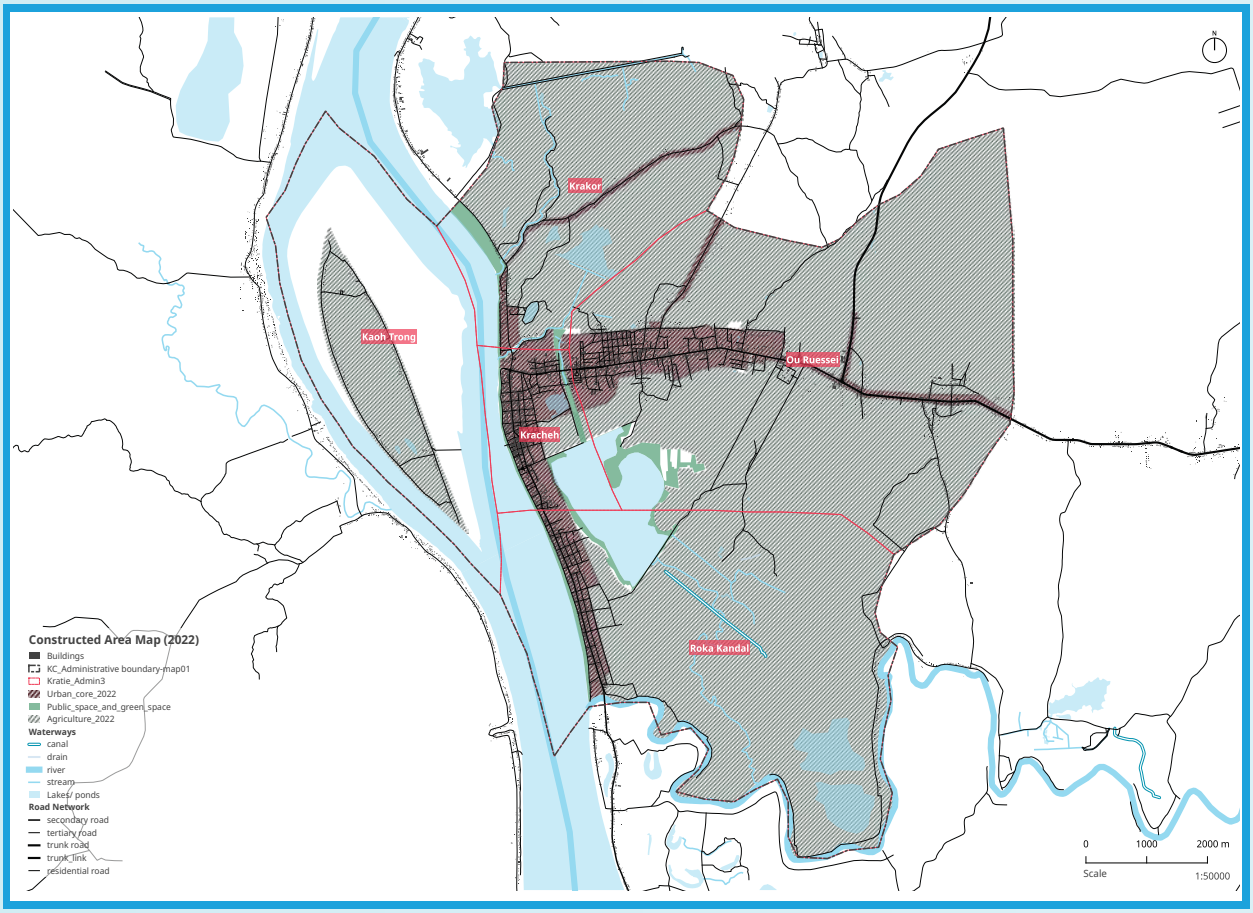


Figure 26 Current Constructed Area Map (Source: Own Work)

From a water-sensitive urban development perspective, several challenges need to be addressed. Key concerns include the provision of basic needs services, such as drainage, safe water, septage management, and solid waste management, to newly urbanized areas. Furthermore, in light of climate change and rising temperatures, it is essential to develop green infrastructure to maintain the livability of these neighborhoods. The urban flood management framework must also be comprehensive, as significant portions of the proposed urban areas intersect with frequently flooded regions around the lake area of Boeung Romleach. Addressing these flood risks is critical, given the lake area's importance in flood mitigation, regional climate regulation, and supporting local livelihoods. Effective planning for flood-resilient infrastructure, alongside a holistic approach to urban development, should consider both environmental and social impacts on residents and the wider community.

Settlement Development

Krong Kratié, as with other major cities in Cambodia, is constructed on elevated land, either naturally or artificially, adjacent to rivers and lakes with high water tables. The urbanization trend involves filling residential areas with soil to elevate buildings, which unfortunately leaves some locations susceptible to flooding. The urban layout of Krong Kratié is shaped in a T-form, extending 8 km north-south along the Mekong River and 8.5 km west toward National Highway No. 7, encompassing approximately 7,240 houses and over 900 businesses. (See Figure 27) This includes various amenities such as marketplaces, restaurants, hotels, health centers, and schools, illustrating a diverse urban landscape.

Figure 27 Main settlement areas of Krong Kratié showing general town layout with dense urban clusters characterized by a higher concentration of buildings adjacent to agricultural fields.
(Source: Google Earth Pro 7.3.4.8573 (06/2021))

Figure 28 Dense clustering of buildings in urban core area (Source: Own Photo taken in 2023)

The town's expansive riverfront influences its growth dynamics, encouraging development primarily in the north and south, facilitated by connections to the national road network. The central areas near the Mekong River showcase dense urban clusters with a higher concentration of buildings, while lakes and wetlands exhibit less construction activity, as these areas are often utilized for wastewater management and have lower land costs. The historical core of Krong Kratié features a compact layout focused around a marketplace, incorporating residential, commercial, and administrative spaces within a grid-like street framework that enhances accessibility and creates a sense of enclosure. (See Figure 28, Figure 29 & Figure 30)

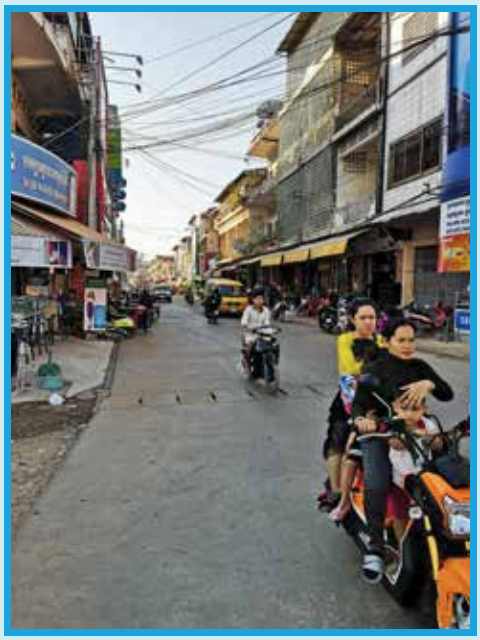


Figure 29 Sense of urban enclosure in central urban area (Source: Own Photo taken in 2022)

Figure 30 Central urban area shop houses (Source: Own Work taken in 2022)

Modern architectural practices have led to the extensive use of concrete and masonry in Krong Kratié, following the influence of "New Khmer Architecture" after independence. (See Figure 31, Figure 32 & Figure 33)

Figure 31 Example of concrete sealing at Krong Kratié Bus Station
(Source: Own Photo taken in 2023)

Figure 32 Example of concrete sealing at Krong Kratié Market
(Source: Own Photo taken in 2023)

Figure 33 Examples of concrete surfaces completely covering grounds of roads and a property in central area (Source: Smith, 2014)

The analysis of a typical block reveals that built-up areas dominate, comprising 82% of the space, leaving only 18% for vegetation. (See Figure 34)

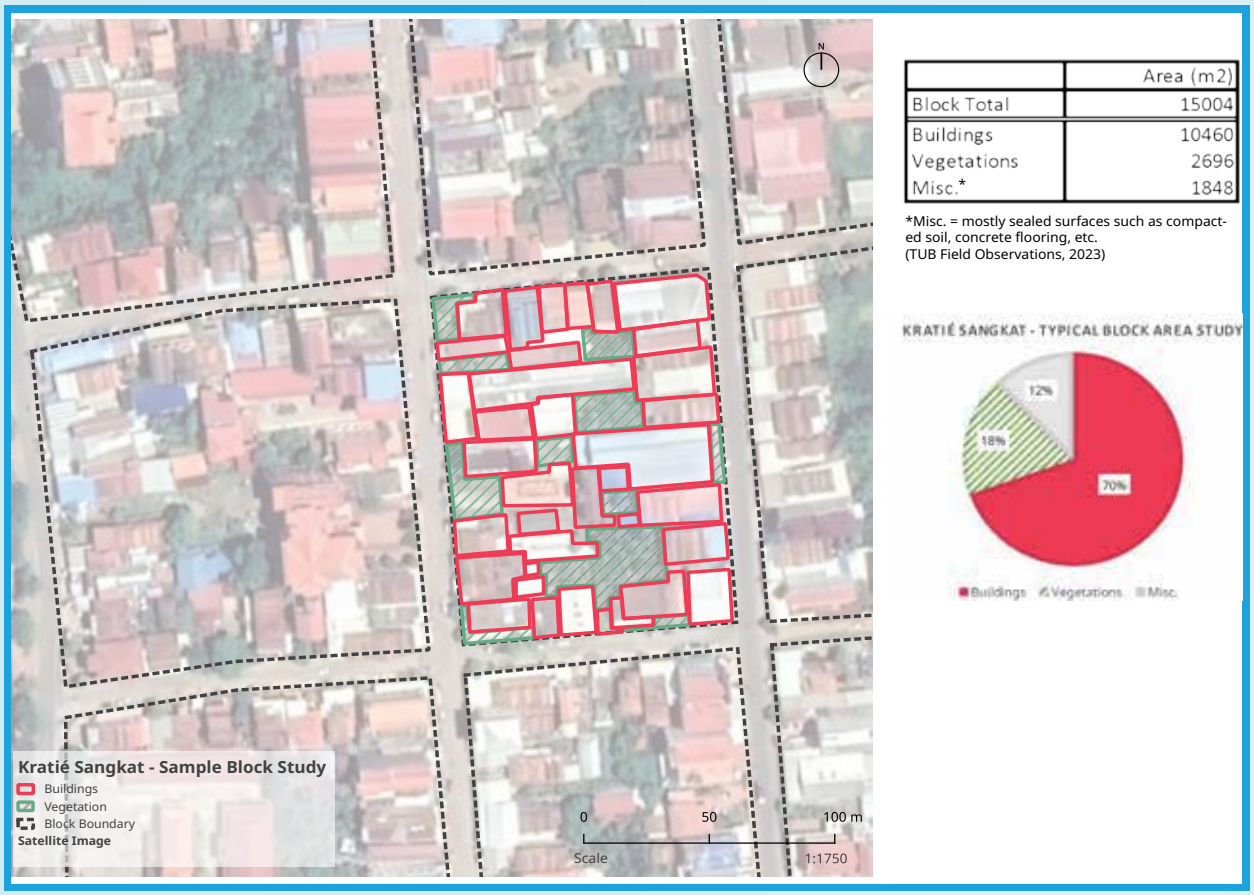


Figure 34 Composition and proportions of elements in the Kratié Sangkat Sample Block Study (Source: Own Work, 2023)

This trend reflects a significant transition to impermeable materials, contributing to urban heat, increased surface runoff, and reduced groundwater recharge, which presents both opportunities and challenges for sustainable development. Urbanization in Krong Kratié is manifesting through various transformations, including the emergence of new developments in central residential zones, continued densification, expansion into greenfield and low-density areas, and the gradual development along main roads along and towards National Highway No. 7, aiding connectivity and growth. (See Figure 35 to Figure 41)

Figure 35 Indication of development and infilling between 2013 and 2021 (Source: Left: Google Earth Pro 7.3.4.8573 (12/2013). Krong Kratié, Cambodia, Coordinates 12°29'20.85"N 106° 1'21.68"E Elev 1.26km; Right: Google Earth Pro 7.3.4.8573 (06/2021). Krong Kratié, Cambodia, Coordinates 12°29'20.85"N 106° 1'21.68"E Elev 1.26km)

Figure 36 New urban development (Source: Own Photos taken in 2022)

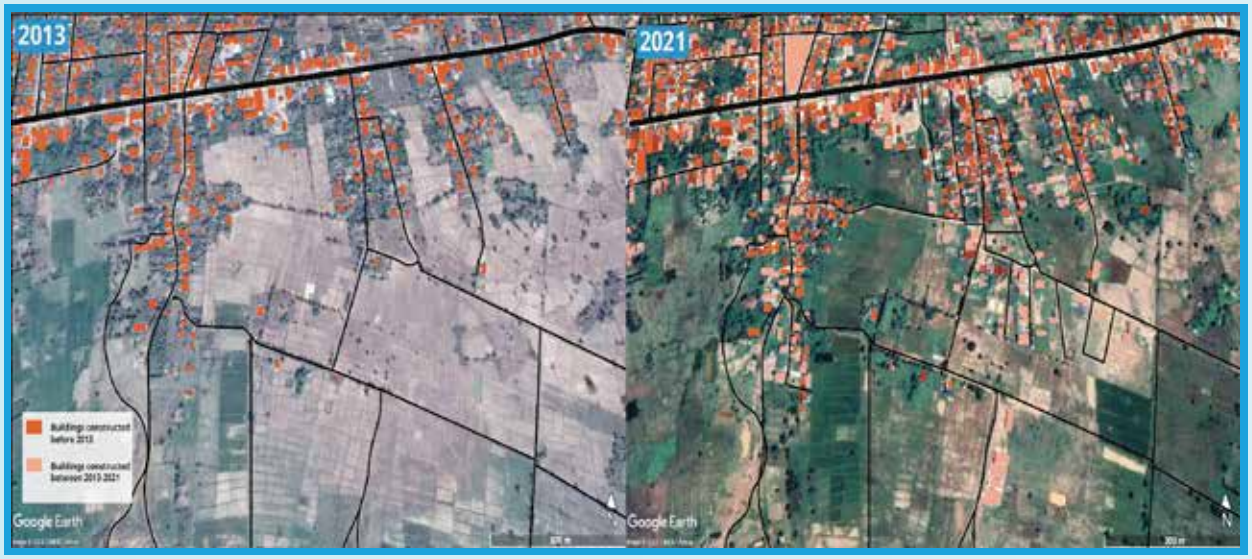


Figure 37 Development along the main roads Note: The two aerial photos depict the development that occurred between 2013 and 2021 (Source: Left Photo, Own Compilation based on Google Earth Pro 7.3.4.8573. (n.d.). [Google Map of Kratié urban block]. Retrieved July 17, 2023, from http://www.earth.google.com and Right Photo, Own Drone Captured Image taken in 2022)

Figure 38 Indication of development of plots on eastern fringe or urban area between core and lake between 2013 and 2021 (Source: Top: Google Earth Pro 7.3.4.8573 (12/2013). Krong Kratié, Cambodia. Coordinates 12°29'18.11"N 106° 1'11.60"E Elev 582m; Bottom:Google Earth Pro 7.3. 4.8573 (06/2021) Krong Kratié, Cambodia. Coordinates 12°29'18.11"N 106° 1'11.60"E Elev 582m)

Figure 39 Example of extension towards the lake area (Source: Own Photo taken in 2022)

Figure 40 Newly built urban villa in new peri-urban development (Source: Own Photo taken in 2023)

Figure 41 Example of extension towards the lake area (Source: Own Photo taken in 2022)

Krong Kratié faces increasing flood vulnerability due to factors such as the Mekong River's flow regime, its geographical and topographical setting, inadequate drainage infrastructure, soil compaction from ongoing construction, and the potential infilling of lakes. (See Figure 42)

Figure 42 Flood event and its impact in 2019 on Bus Station area and Promenade
(Source: Own Photos taken in 2019)

Severe flood events in the region have had significant impacts on lives, infrastructure, and agriculture. A PolyUrbanWaters survey indicated that nearly half of the households experienced flooding lasting over a month, with poor drainage exacerbating conditions for mosquito-borne diseases such as dengue fever. (See Figure 43 & Figure 44)

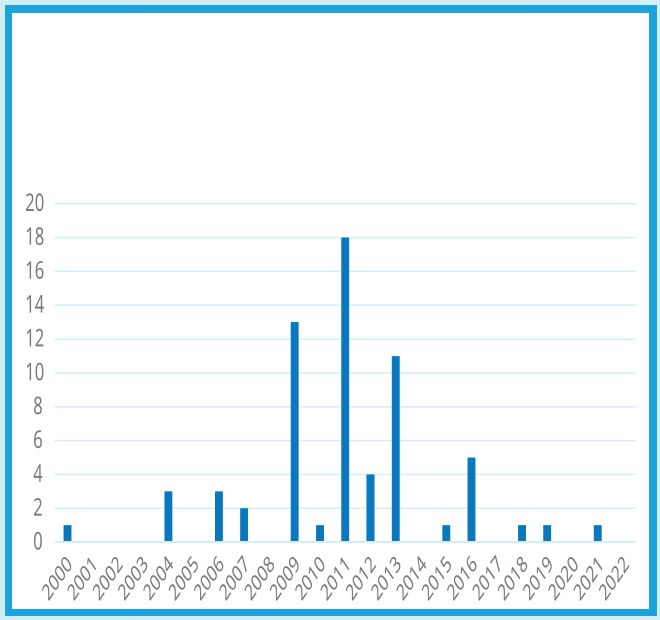


Figure 43 Number of Recorded Disasters Per Year in Krong Kratié
(Source: CamDi, 2022)

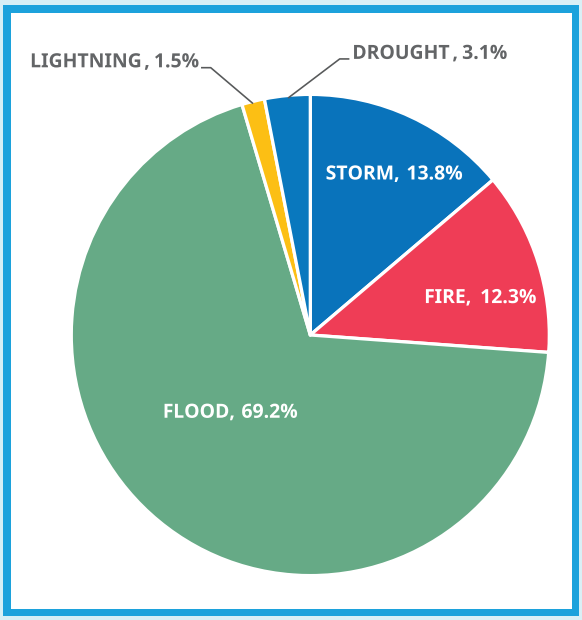


Figure 44 Incidence of Disasters in Krong Kratié from 2000 to 2022 in Percentages
(Source: CamDi, 2022).

The city encounters three types of flooding: gradual flooding from the Mekong River, sudden monsoon floods caused by intense rainfall and poor drainage, and rare inundations resulting from Mekong River overflow. (See Table 1 & Figure 45)

Name	Water Level (m)	Probability (%)	Area Inundated (%)
Medium Hazard	21.6	33	44.69
Low Hazard	19.78	100	38.58

Table 1 Area inundated compared to total area applying flood frequency assessment (Source: Own Work based on MRC, 2023; NASA Shuttle Radar Topography Mission (SRTM), 2013; & Global Administrative Areas (GADM), 2012)

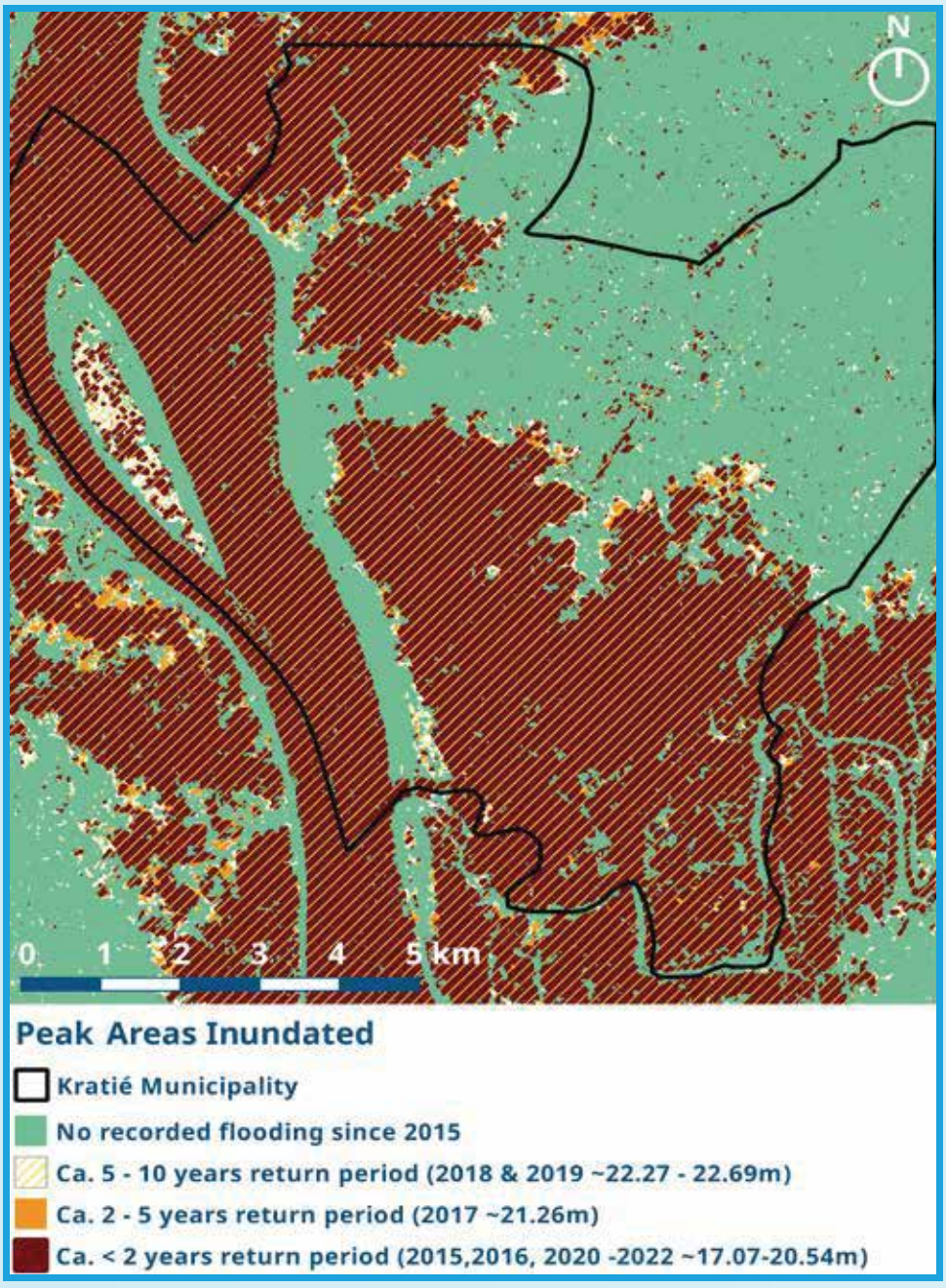


Figure 45 Peak areas inundated between 2015 and 2022 (Source: Own Work based on Global Administrative Areas (GADM), 2012; & Copernicus Sentinel-1 Data [2015 - 2022])

According to a 2018 study by the MRC, without interventions, flood damage could significantly rise due to ongoing development, sediment build-up, reduced floodplain storage, and climate change impacts, highlighting the need for data-driven infrastructure planning to improve flood management. (See Figure 46 & Figure 47)

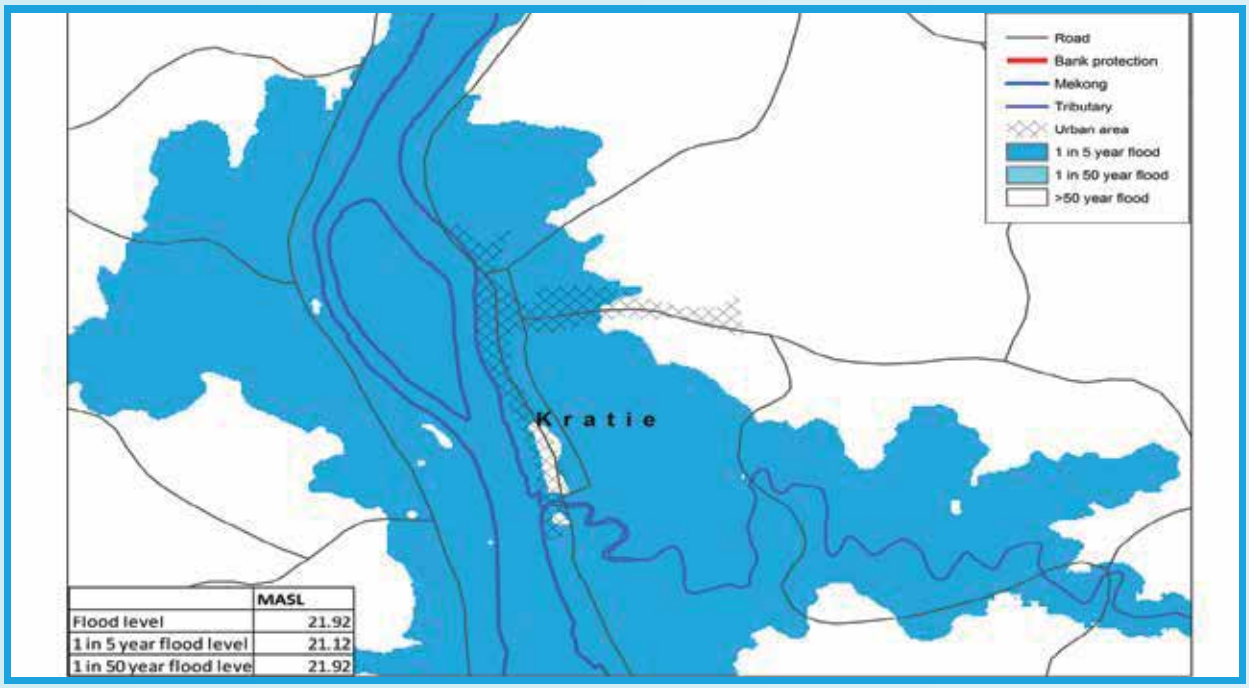


Figure 46 Krong Kratié: Predicted Potential Flood Events (Source: MRC Council Study, 2018, p.81)

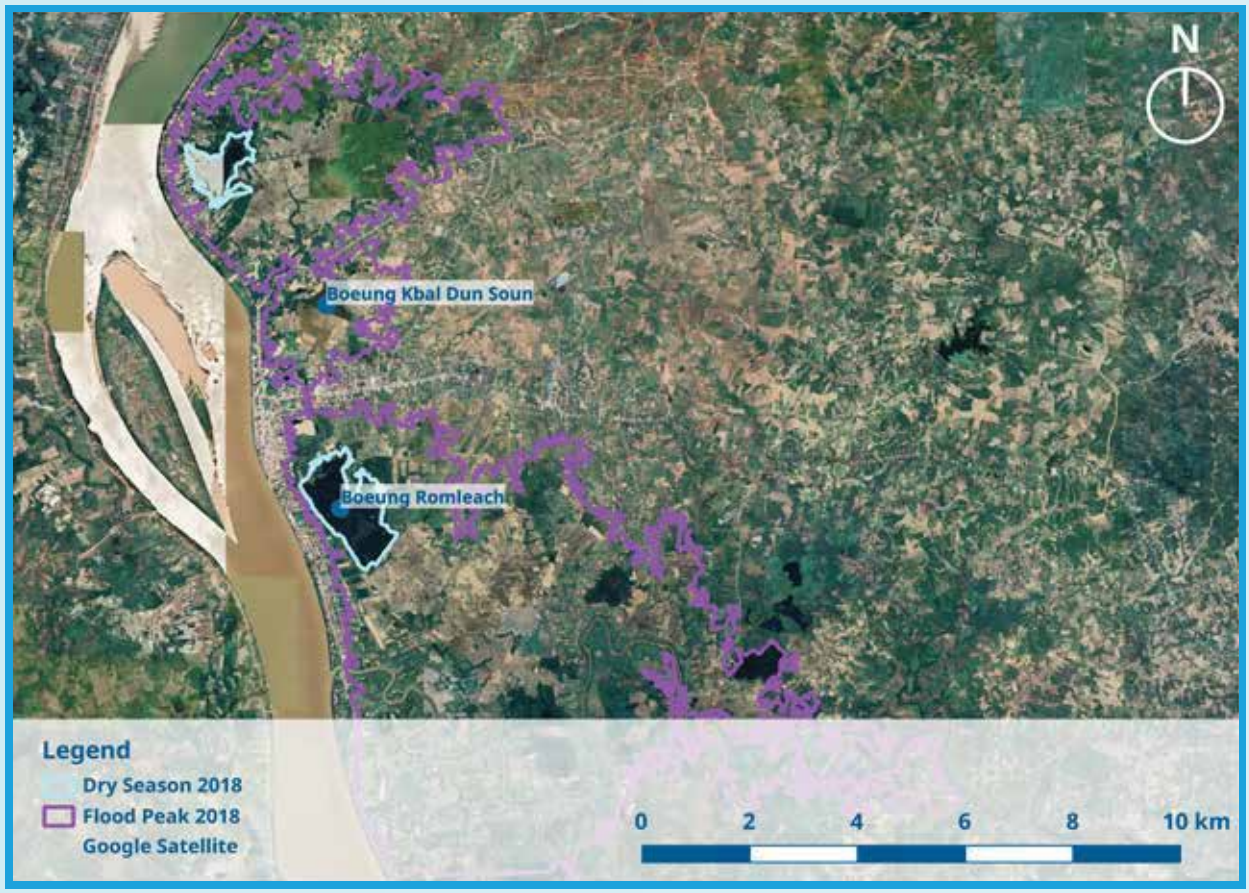
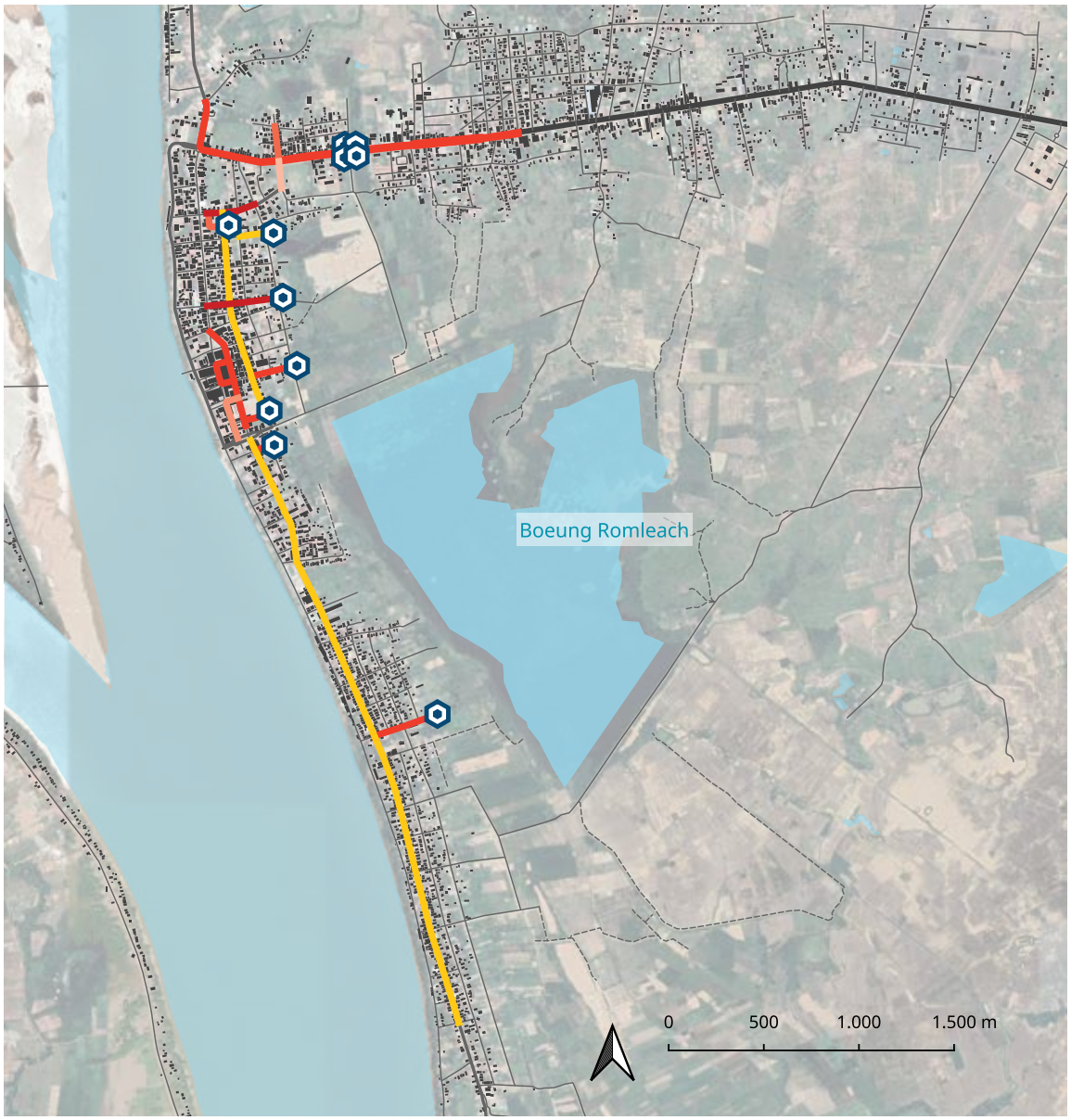


Figure 47 Urban water levels during the dry season and when flooding peaks in 2018 (Source: Own Work based on Copernicus Sentinel-1 Data [2018], CNES/Airbus, Maxar Technologies 2023 (Google Satellite)

The existing drainage infrastructure, dating back to the colonial era in some areas, faces various issues, notably aging infrastructure, limited coverage and connectivity, and urban hardening. Flooding adversely affects the town's road networks, causing closures and damage. (See Figure 48, Figure 49 & Figure 50)



Sewer Network and Discharge Gates

- Water Discharging Gate
- round sewers cross section 0,3
- round sewers cross section 0,4
- round sewers cross section 0,6
- round sewers cross section 0,8
- round sewers cross section 1
- U shape sewer cross section 0,5x0,5m
- Built area
- road
- main road
- national road
- Water body

Figure 48 Current drainage system in Krong Kratié (Source: Own Work based on RGC, 2022, p.115)

Figure 49 Gutter in central area (Source: Own Photo taken in 2019)

Figure 50 New roadside drainpipe in central residential area (Source: Own Photo taken in 2019)

To address these issues, enhancements under the GMS project, backed by the ADB, are being implemented, considering solutions that include combined and segregated sewer systems. The

dynamics of the floodplain, along with the roles of lakes and wetlands, are essential for managing water flow and minimizing flood risks. (Figure 51)

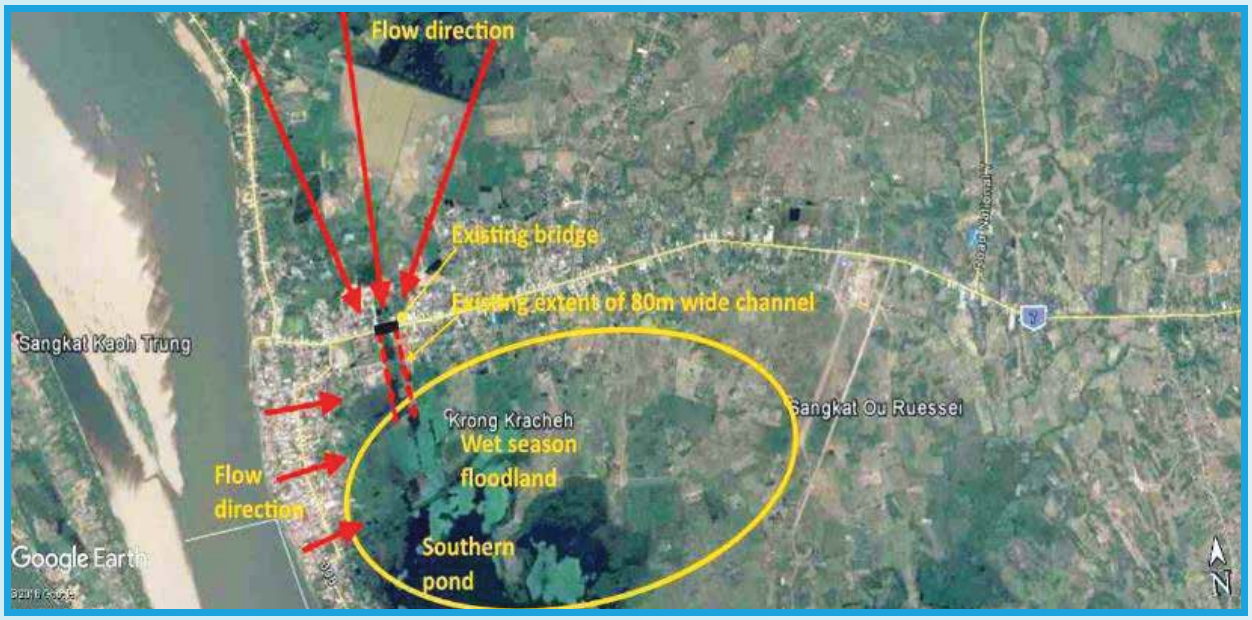


Figure 51 Current drainage flows for Krong Kratié (Source: Own Work based on ADB, 2018)

Comprehensive flood management strategies must transcend mere infrastructural improvements, emphasizing sustainable green infrastructure to mitigate flood impacts while respecting the environmental and social roles of waterways and wetlands. (Figure 52 & Figure 53) This holistic approach is necessary to ensure a balanced and effective flood response, addressing both immediate infrastructure needs and long-term environmental sustainability.

Figure 52 Elevated dirt road in central residential area (Source: Own Photo taken in 2022)

Figure 53 Potential accumulation of rainwater due to adjacent construction walls on property boundaries (Source: Own Photo taken in 2019)

Water Supply Management

Krong Kratié's water supply coverage has significantly improved, with 91% of the 7,701 families recorded in the 2020 Commune Database now having access to a safely managed water supply system that provides treated potable water (See Figure 54). This marks an increase from 84% in 2018.

Figure 54 Families Accessing Safely Managed, Basic or Unimproved Water Supply in Percentages (%) (Source: Own Work adapted from CDB, 2020)

The majority of this demand (90%) arises from the central downtown areas, where access to the water network is widespread, particularly among 6,021 households (approximately 80% of total households, equating to 24,948 individuals) in 2020. (See Figure 55)

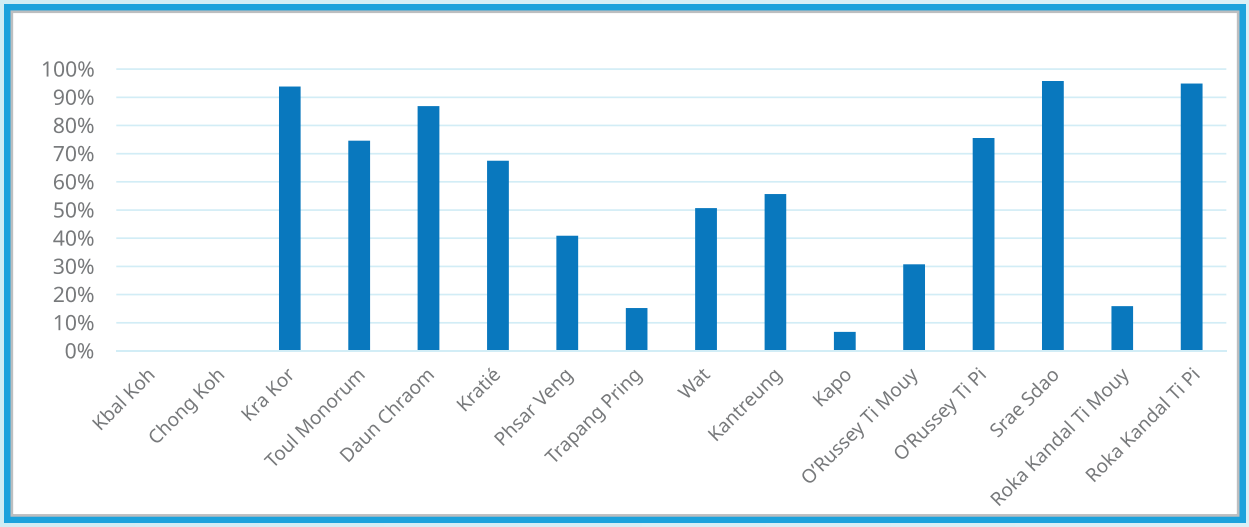


Figure 55 Families Accessing Safely Managed, Basic or Unimproved Water Supply in Percentages (%) (Source: Own Work adapted from CDB, 2020)

While half of Krong Kratié's 16 villages boast full access to improved water sources, around 666 families still lack such access, relying on unimproved sources like wells, notably in villages such as Tuol Monorum and Koh Trong. In Koh Trong, over 60% of households depend on pump or

drilled wells, while reliance on these informal sources is significantly lower in other regions. (See Figure 56)

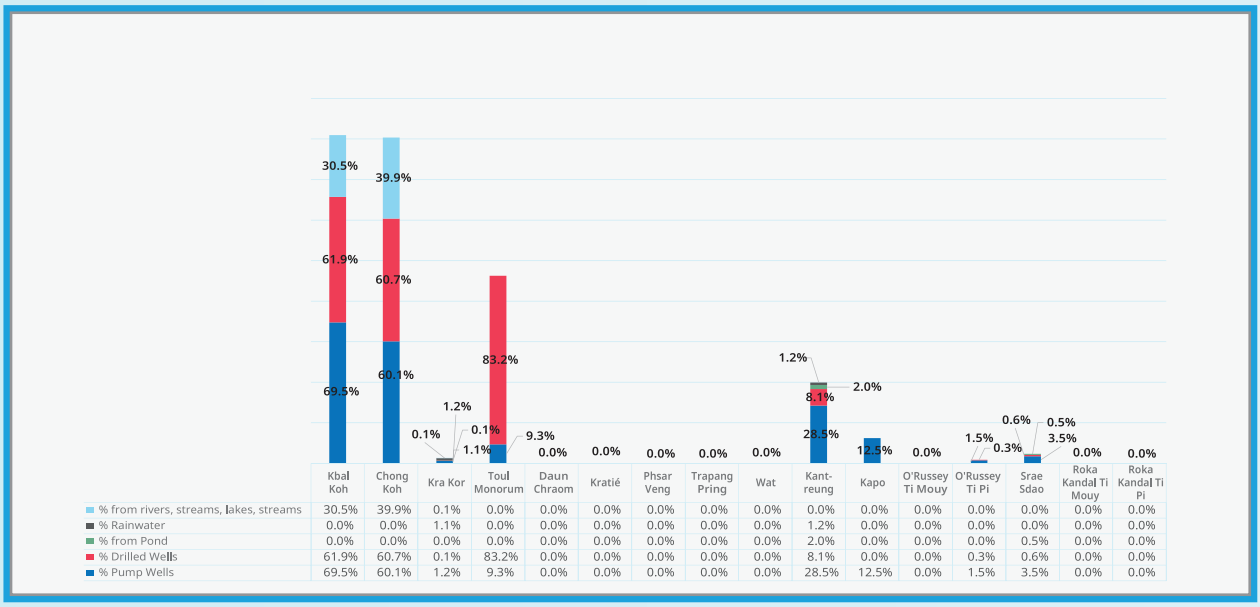


Figure 56 Households Using Other Water Sources than Water Supply in Percentages (%) (Source: Own Work adapted from CDB, 2020)

Despite widespread satisfaction with piped water services, many households continue to boil their water due to concerns about quality, indicating a lack of trust in the system. (See Figure 57) Additionally, numerous families purchase drinking water in 20-liter bottles, using piped water mainly for washing and bathing. A considerable portion of households in certain villages consumes water directly from the tap without any treatment; however, this is less than 20% in Trapang Pring, Kapo, and Ti Mouy. Approximately 50% of households in Koh Trong resort to boiling their drinking water due to a lack of access to the piped network, fostering health concerns regarding the consumption of untreated water from unimproved sources. Furthermore, those reliant on alternative water sources often face shortages during the dry season. Reports suggest that drilled 'tube' wells, although of adequate depth, are perceived as contaminated and are not utilized for drinking purposes.

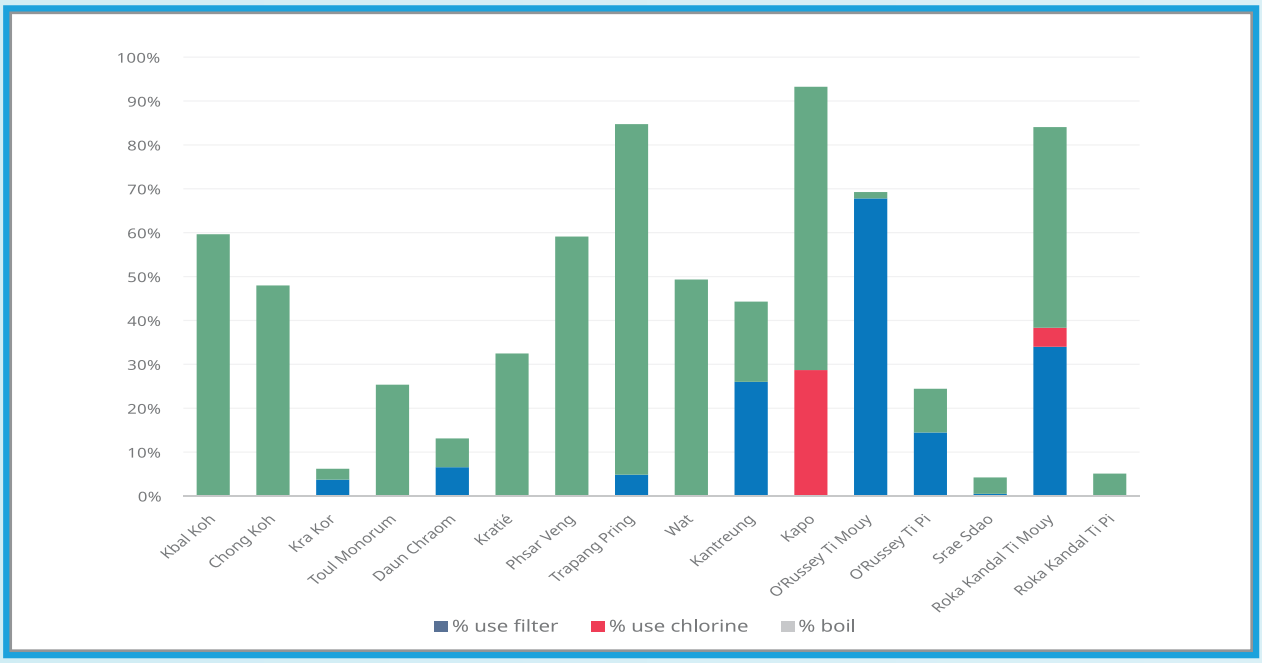


Figure 57 Households Treating Drinking Water Before Consumption in Percentages (Source: CDB, 2020)

More extensive upgrades to the water supply system are necessary to improve access and safety throughout the urban area. (See Figure 58)

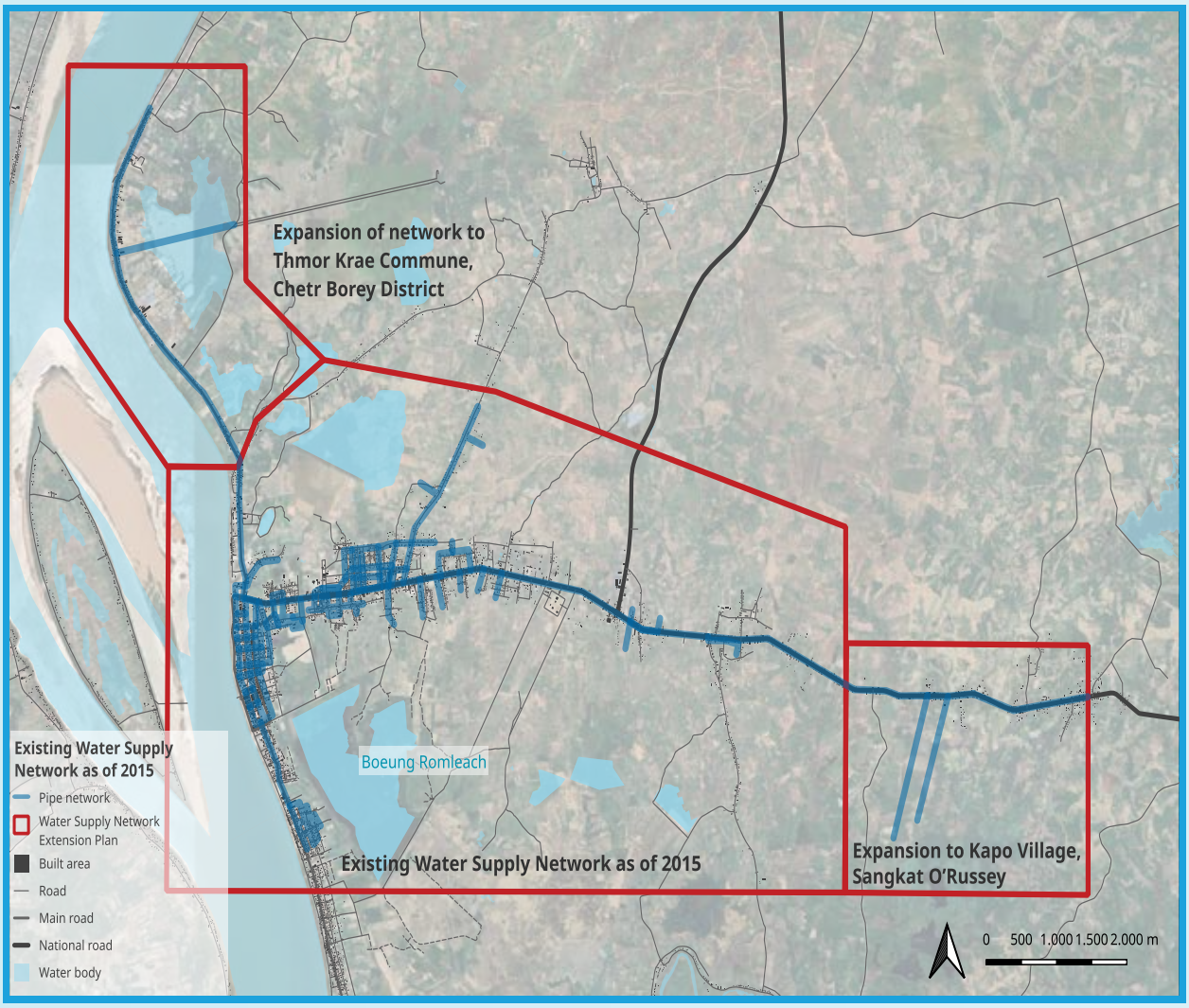


Figure 58 Water supply network for Krong Kratié as of 2015 (Source: RGC, 2022)

Households consume an average of 24.6 cubic meters per month, while hotels/guesthouses consume between 200 to 650 cubic meters per month. Restaurants consume between 47 to 375 cubic meters per month, and businesses consume 25 to 450 cubic meters per month. The cost ranges from 1700 to 1800 riel per month for each category. (See Table 2) For the larger of the city's two water operators, the connection covers 80% of households in Kra Kor, Kratié and O'Russey. The capacity of the operator is 700-800m³ per hour, producing 181,141 cubic meters of clean water as of September 2020, with 149,758 cubic meters distributed. Non-revenue water is between 16-18%. (See Table 3)

	Consumption			Cost	
Interviewed	From	To	Average	From	To
Households	23 m3 /month	84 m3 / month	24.6 m3 / month	1700 riel/ month	1800 riel/month
Hotels/guesthouses	200 m3 / month	650 m3 / month		1700 riel/ month	1800 riel/month
Assumption consumption is for 2020 based on Siem Reap.	145 liters / day / person (International) OR 150 l/d/p JICA Siem Reap				
Residential estimate	3617 m3 / day in 2020				
Restaurant	47 m3 / month	375m3 / month		1700 riel/ month	1800 riel/month
Businesses	25 m3 / month	450m3 / month		1700 riel/ month	1800 riel/month

Table 2 Piped Water Supply Consumption Rates and Costs per m3 (Source: RGC, 2022)

Water Supply Operator	Total HHs[3]	%	Coverage								
Connections	6021 HHs/ 24948	6021 HHs/ 24948	for Kra Kor (1 vill), Kratié (6 vills - most connections in these villages), O'Russey (2 vills)								
Capacity of the operator	700-800m³/ hour capacity	at	8 hours / day	as of September 2020	181141 clean water produced	149758 distributed	service fee USD 50	clean water is 1500 riel/ 1750 riel/ 1800 riel /m3	Source: Mekong River	piping 106 km	NRW is16 - 18%

Table 3 Piped Water Supply Operator Production Rate (Source: RGC, 2022)

[3] Households

Wastewater Management

Krong Kratié, as in many secondary and tertiary cities in Cambodia, faces the complex challenge of developing an efficient wastewater management system amid increasing population pressures, following the urban area's initial development. The challenges encountered are primarily of a regulatory, administrative, financial, and technical nature. Historically, the city utilized natural water bodies and wetlands for wastewater processing, but population growth and changes in land use have rendered these solutions less effective. The existing sewer system, which combines sewage and stormwater management, covers only about half of the municipality and discharges untreated waste into the nearby "Boeung," posing significant health and environmental risks. (See Figure 59 & Figure 60)

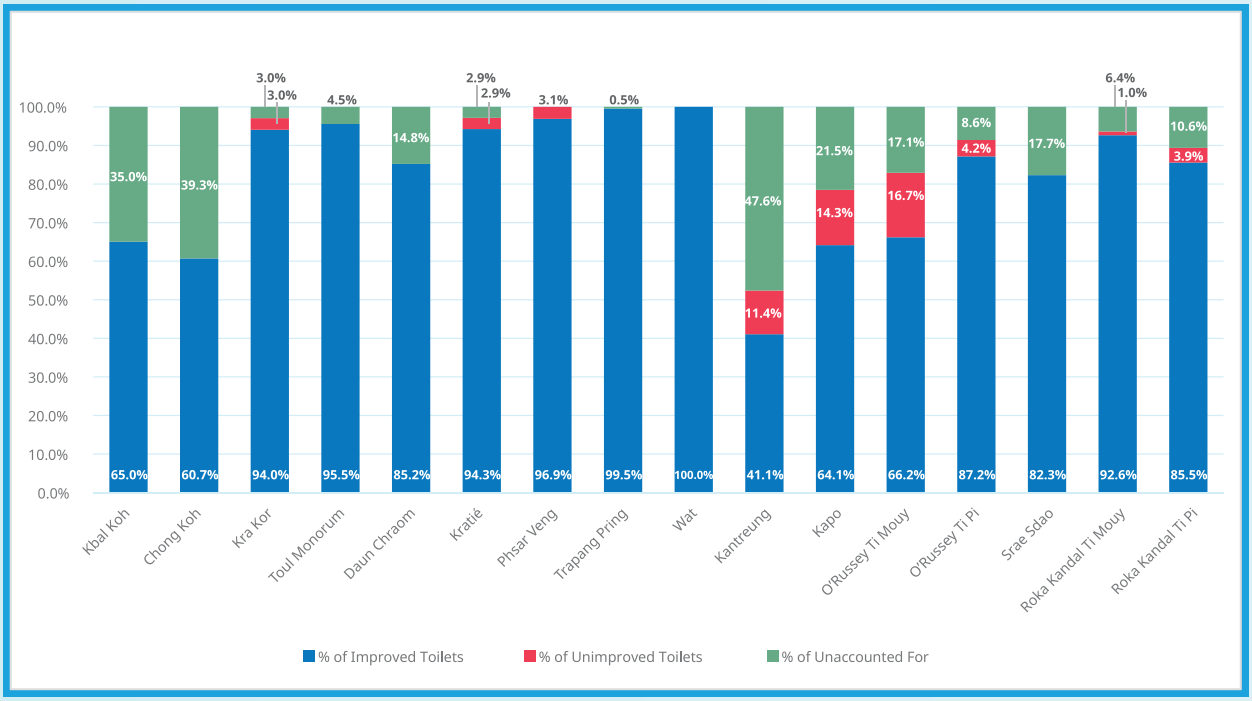


Figure 59 Reported Access to Sanitation in Percentages (%) (Source: CDB 2020)

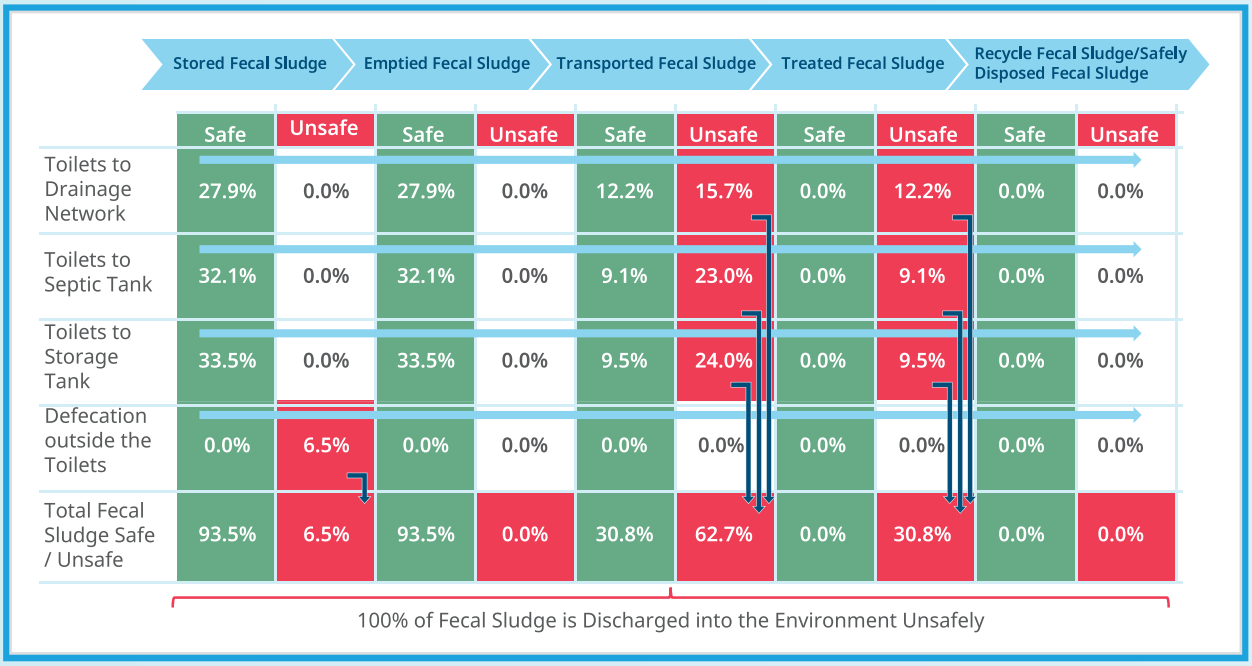


Figure 60 Sewage Flow Diagram (Source: RGC, 2022)

Pollution hotspots include the slaughterhouse and the referral hospital contributing to potential significant environmental pollution and public health risks. (See Figure 61 & Figure 62)

Figure 61 Krong Kratié Slaughterhouse (Source: Own Photos taken in 2022)

Figure 62: Krong Kratié Referral Hospital (Source: Own Photos taken in 2022)

Most households have resorted to constructing non-standard unsealed soak-pits, leading to reports of infrequent desludging and potential contamination of surrounding water bodies from leaking septic tanks. (See Figure 63)

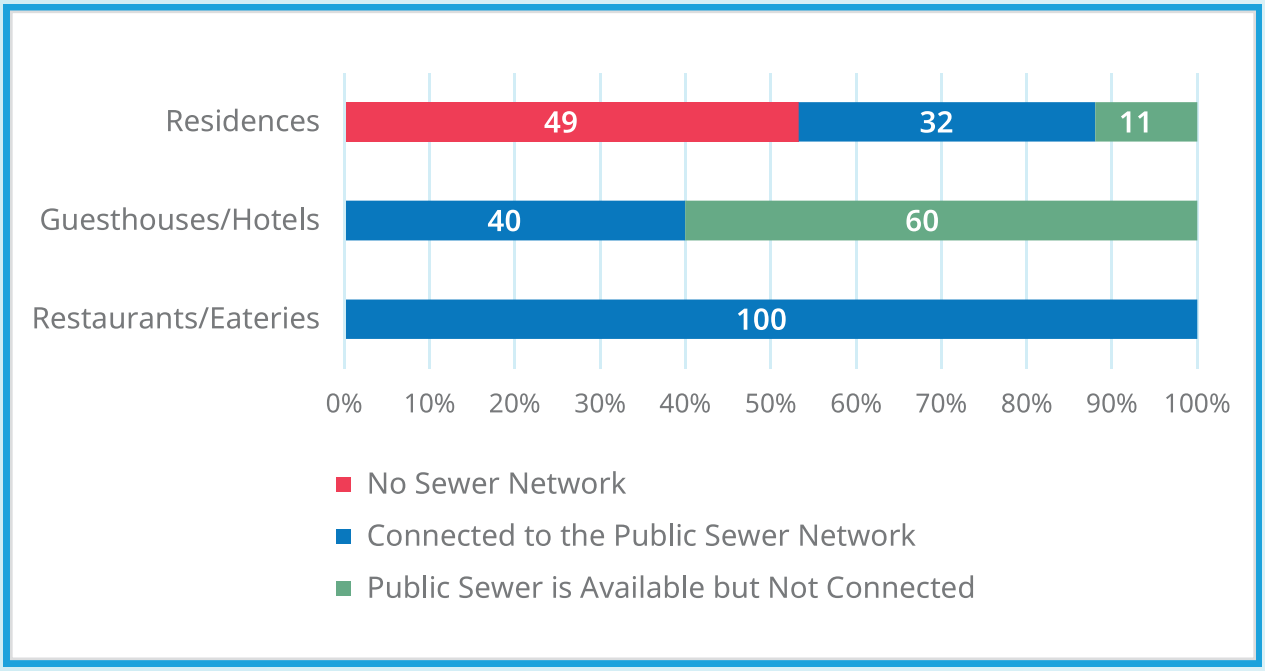


Figure 63 Types of Establishment Connected to Public Sewer Network in Percentages (Source: RGC, 2022)

There is a proposal for a centralized treatment plant funded by the Asian Development Bank, but this faces challenges in management, operation, and maintenance, alongside potential resistance from households unwilling to pay for sanitation services. (See Figure 64)

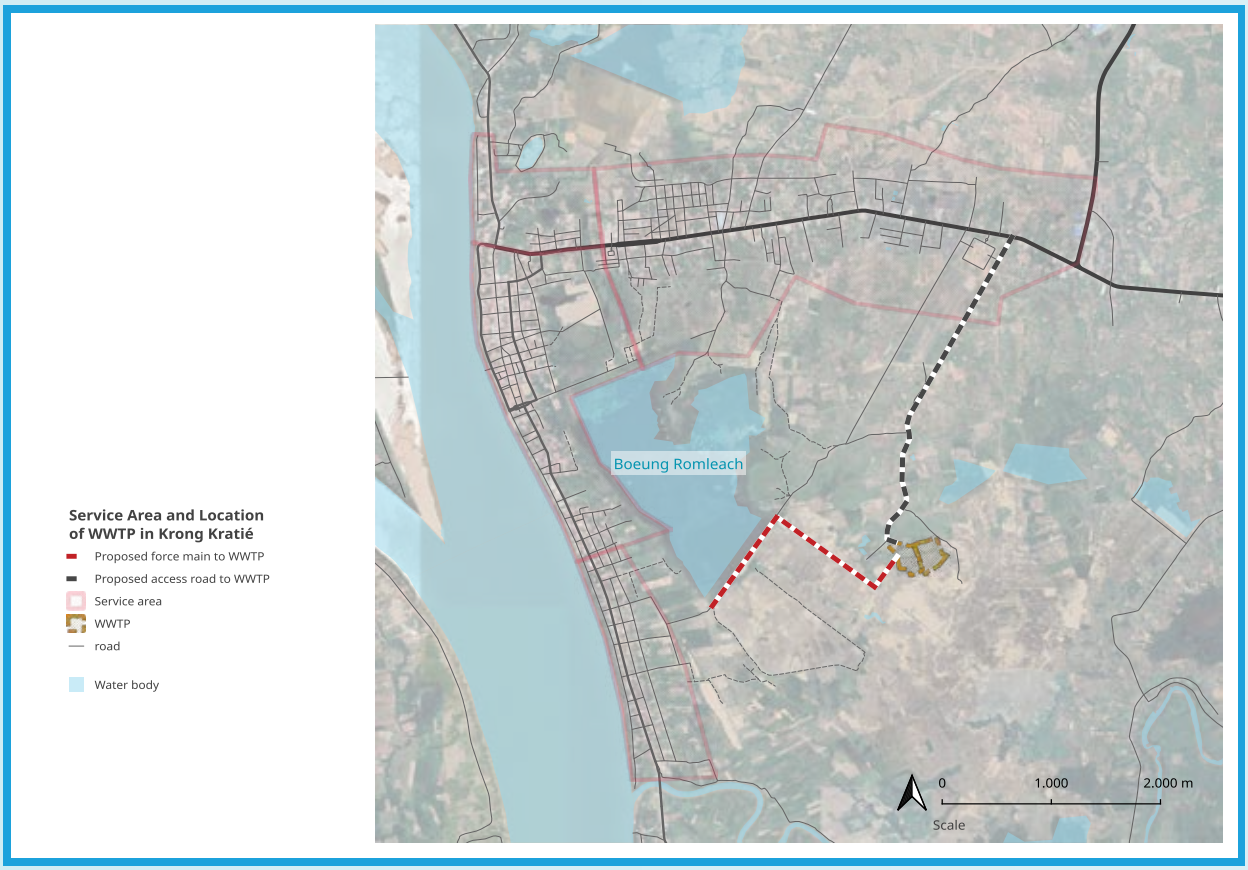


Figure 64 Map Showing the Service Area and Location of the Proposed WWTP in Krong Kratié (Source: RGC, 2022)

Nevertheless, two desludging businesses operate in Krong Kratié, yet their frequency of work as well as their tendency to dump fecal sludge in open spaces indicates potential significant environmental pollution and public health risks. (See Figure 65, Table 4 & Figure 66)

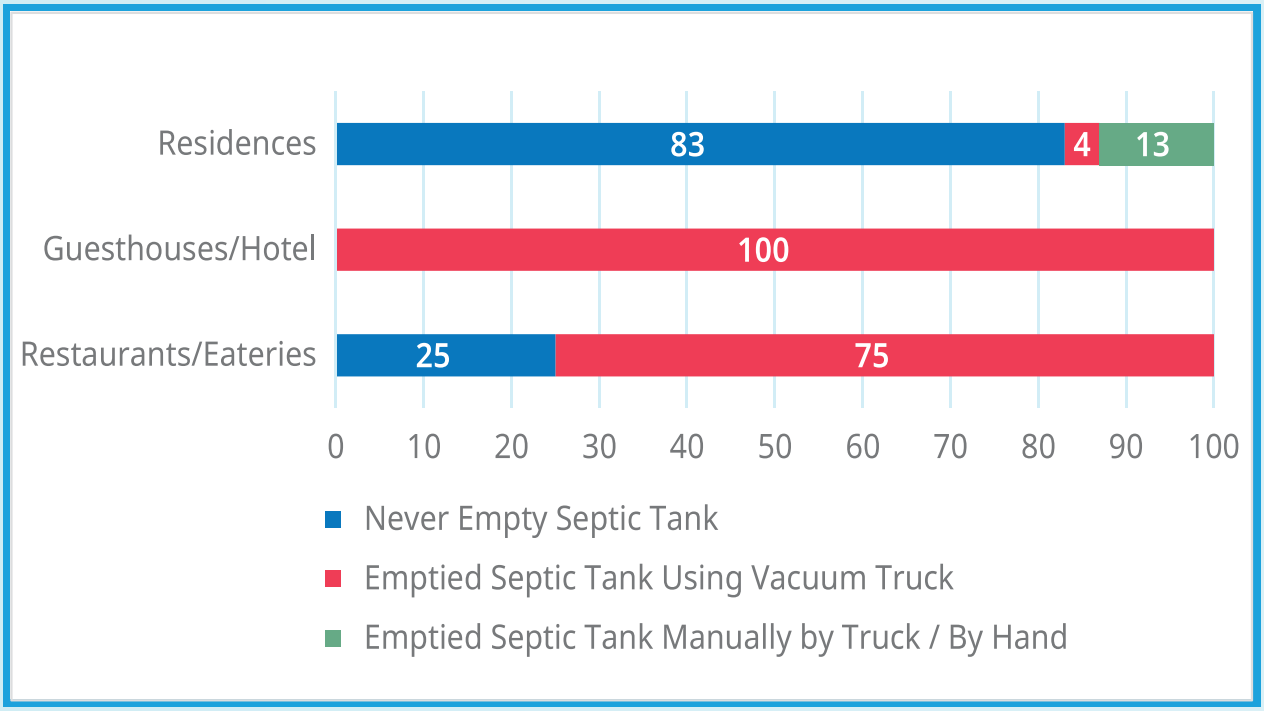


Figure 65 Septic Tank Emptying (Source: RGC, 2022)

Total faecal sludge discharge	Total faecal sludge discharge	Total faecal sludge discharge	m^3/year	m^3/year	%	%	m^3/year
			Residences	Tourists	Residences	Tourists	Total
Discharge quantity through the toilets			4950	75	98.5%	1.5%	5025
Discharge quantity from toilets to drainage network			1475	25	29.4%	0.5%	1500
Discharge quantity from toilets to septic tanks			1700	25	33.8%	0.5%	1725
Discharge quantity from toilets to pits/environment			1775	25	35.3%	0.5%	1800
Discharge quantity through outside defecation			350	0	100.0%	0.0%	350
Defecation outside the toilet (m3 /year			350	0	100.0%	0.0%	350
Total quantity of faecal sludge waste discharge			5,300	75	98.6%	1.4%	5375

Table 4 Estimates of Faecal Sludge Discharge (Source: RGC, 2022)

Figure 66 Krong Kratié's Central Bus Station Public Toilets (Source: Own Photo taken in 2022)

Moreover, current road developments often elevate the road level above ground-floor properties, discouraging connections to wastewater systems and potentially contributing to flooding of properties. (Compare Figure 67 with Figure 52)

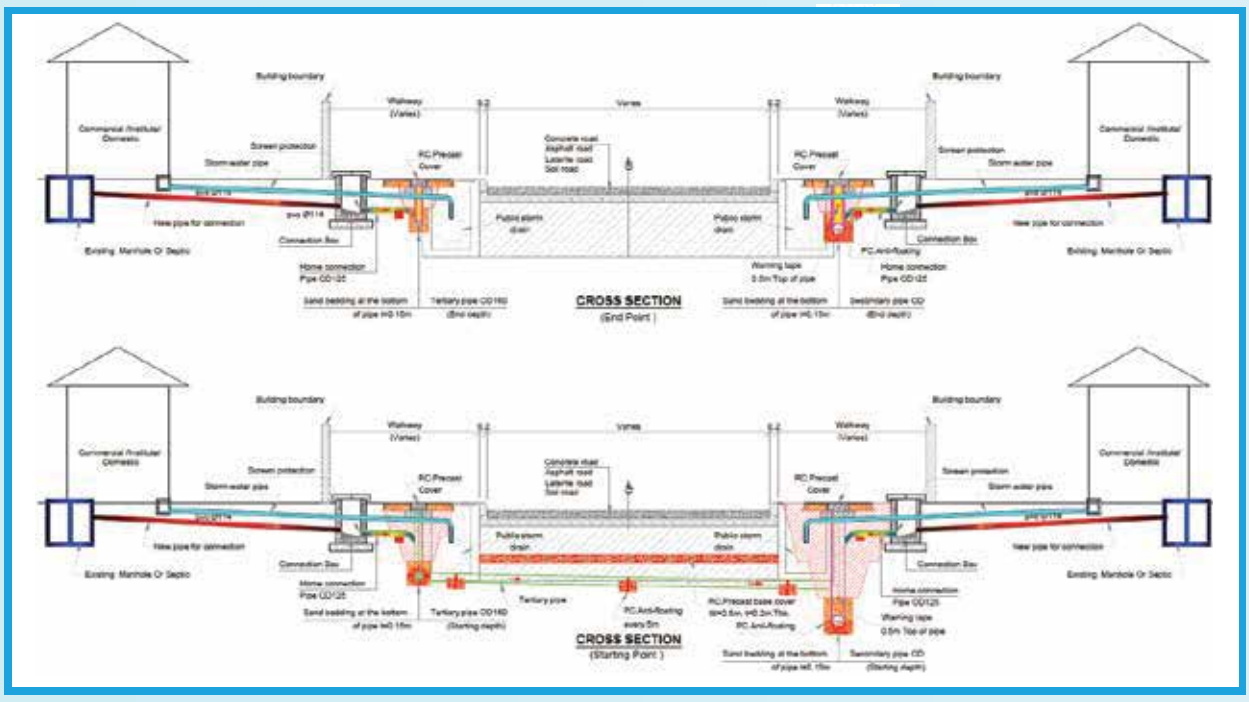


Figure 67 Indicative schematic of new road and associated infrastructure, Siem Reap Cambodia (Source: CDIA, 2019, p. 44) Reprinted with permission

Implementing a City Sanitation Plan could be instrumental in addressing these issues by considering Kratié's unique spatial characteristics, socio-economic conditions, and financial capacities while exploring a blend of centralized and decentralized solutions. Enhancing the capacity of public institutions to plan and enforce regulatory requirements is vital for creating a supportive environment for these initiatives.

Water Catchment

The Mekong River, approximately 4,800 km long and draining a catchment area of 795,000 km², serves as a critical resource for over 60 million people in its basin, influencing their daily lives and economic stability across the six countries it flows through. (See Figure 68)

Figure 68 Main reporting hydrological stations along the Mekong River (Source: MRC, 2021). Reprinted with permission

The river is divided into two main segments: the Upper Basin in Tibet and China, and the Lower Mekong Basin as it traverses Myanmar, Thailand, Laos, Cambodia, and Vietnam. Since the 1980s, the Basin has witnessed significant socioeconomic and ecological shifts driven by urbanization and population growth, resulting in transformed land use, particularly the conversion of forests and wetlands into agricultural and hydroelectric projects. (See Figure 69)

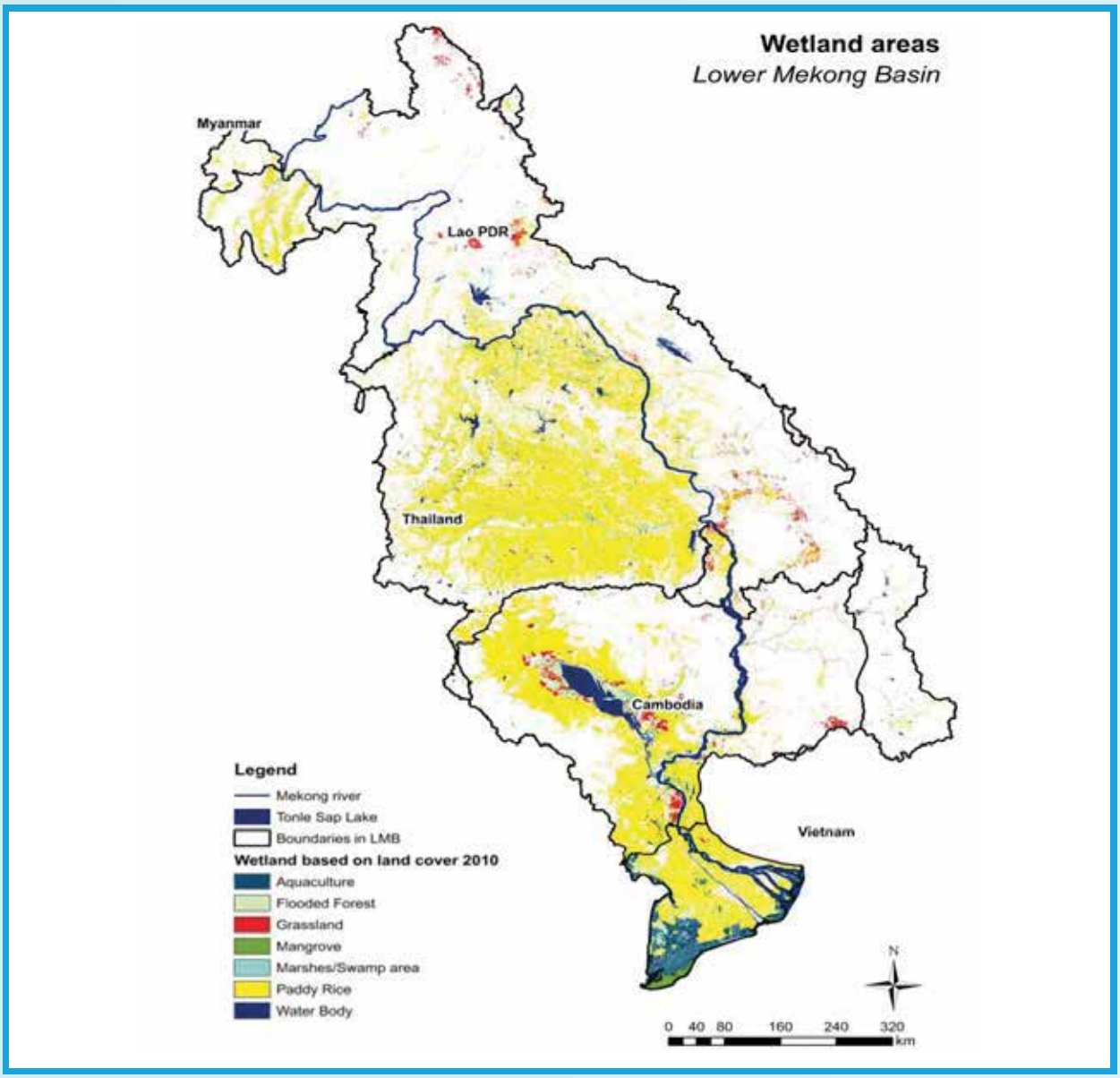


Figure 69 Wetland Areas of the LMB (Source: MRC, 2019, p.56). Reprinted with permission.

Despite these changes, the majority of the population remains in rural areas, relying on fishing and wetland resources for their livelihoods. Yet, the understanding and development of water resources in the Mekong Basin remain less comprehensive compared to other major river basins like the Danube, Nile, and Amazon, complicating the assessment of ongoing changes and climate impacts.

The hydrology of the Mekong River has historically been predictable, with an average annual discharge of approximately 475 km³, but is now undergoing significant alterations due to upstream dam constructions and changing land use patterns. This has led to increased flows during the dry season and reduced flows in the wet season, impacting sediment concentrations and the ecology of the river. (See Figure 70, Figure 71 & Figure 72)

Figure 70 Stream Flow at Kratié Mainstream Station *Note: MRC flow monitoring shows annual flood and dry season flows along with the yearly and monthly flows for recent years. The dotted white lines represent the annual average flows.* (Source: MRC, 2019, p.29) Reprinted with permission.

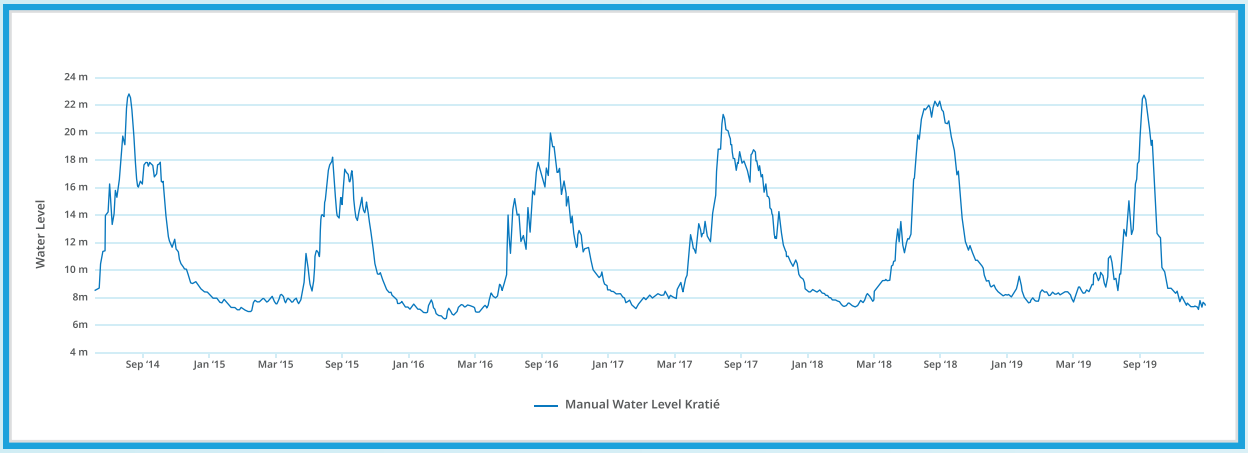


Figure 71 Water level in metres at Krong Kratié from 2014-2019 (Source: MRC, 2023 accessed June 12)

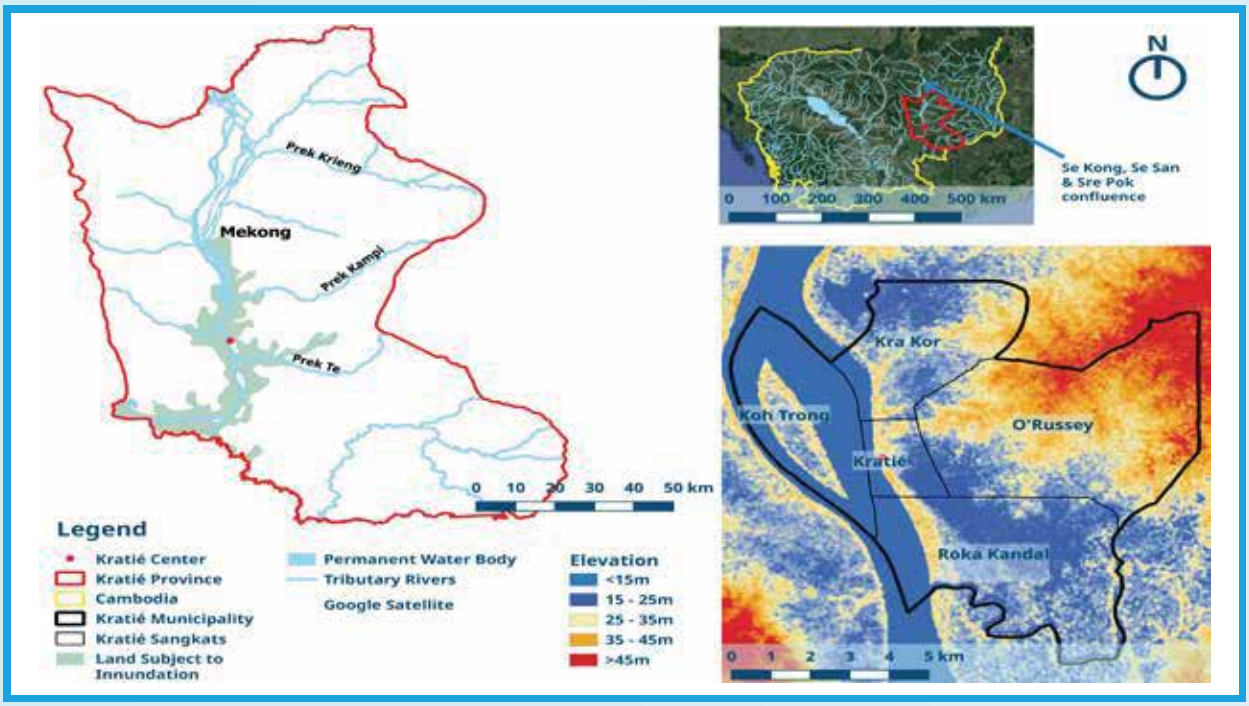


Figure 72 Location of Krong Kratié within different watersheds and its elevation profile (Source: Own Work based on Global Administrative Areas (GADM), 2012; Digital Chart of the World (DCW), n.d.; CNES Airbus, n.d.; Maxar Technologies, 2023; NASA Shuttle Radar Topography Mission (SRTM), 2013; & Shuttle Radar Topography Mission (SRTM) Global, n.d.)

The Mekong Basin is recognized for its rich biodiversity, which includes 1,148 fish species and numerous other flora and fauna, contributing vital resources for local communities. However, human activities and climate change threaten these ecosystems, with wetland loss posing risks to biodiversity and food security. Flooding plays an essential role in the Basin's ecology, providing

benefits such as habitat diversity and sediment fertilization for agriculture. Traditional management strategies enable communities to adapt; however, increased vulnerabilities arise from inadequate infrastructure, land development, and climate change effects. (See Figure 73 & Figure 74) The ongoing need for effective management is critical to preserve the Basin's ecological integrity and support its populations.

Figure 73 Living with floods - Detached stilt house in residential area of Krong Kratié (Source: Own Photo, 2019)

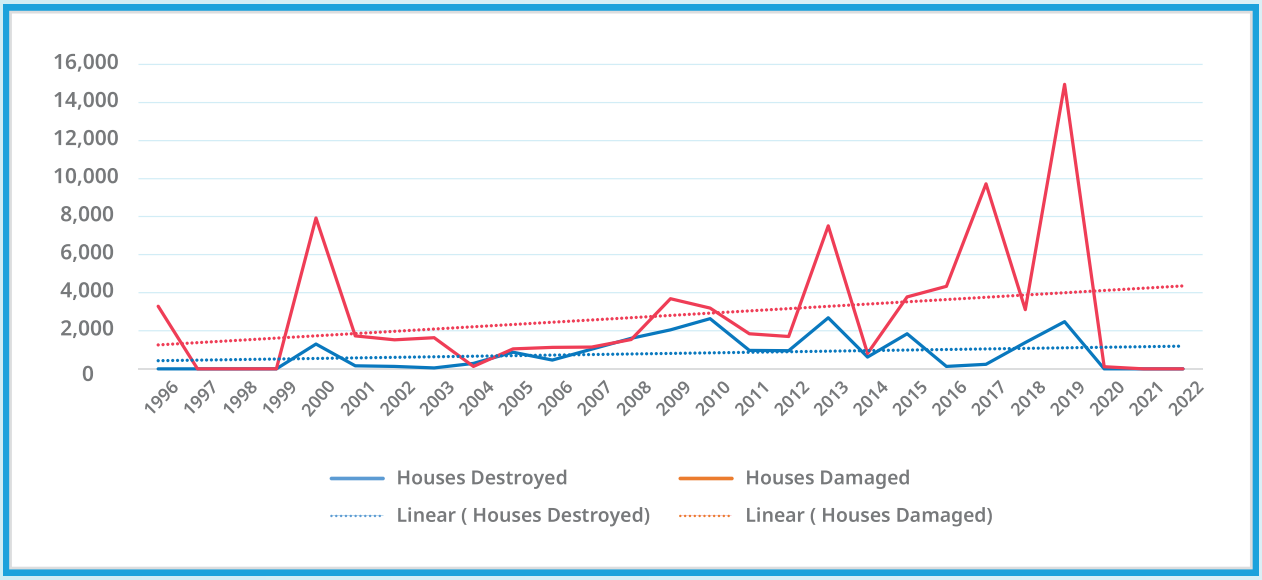


Figure 74 Houses destroyed and houses damaged by flooding between 1996 and 2022 in Cambodia (Source: Own Work based on CamDi, 2023)

The Lake Area of Krong Kratié is undergoing a transformative perception, shifting from an underdeveloped space to a strategic asset that enhances urban livability and resilience. Essential ecosystem services provided by these water bodies, including water purification, flood control, and climate regulation, support sustainable urban development. (See Figure 75 & Figure 76)

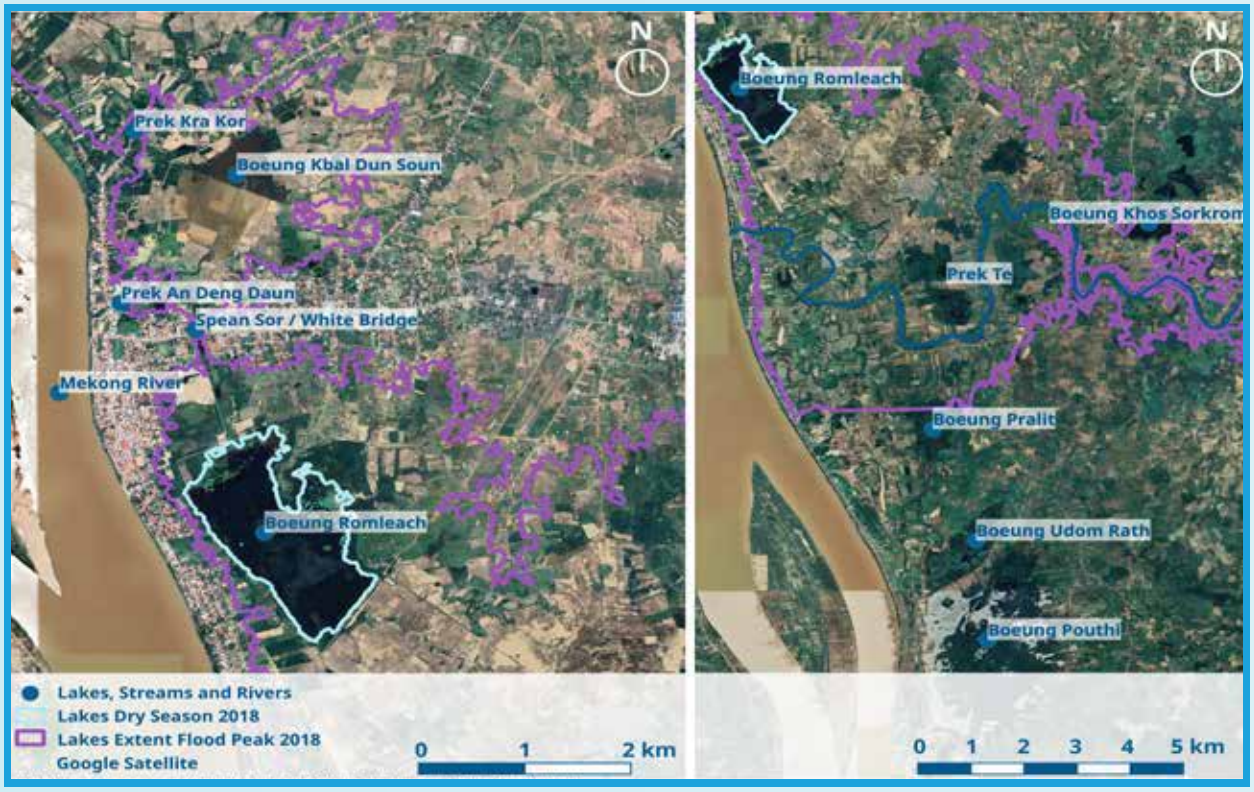


Figure 75 Boeungs (Lakes and Wetlands) in the vicinity of Krong Kratié (Source: Own Work based on Copernicus Sentinel-1 Data, 2018; CNES/Airbus; & Maxar Technology)

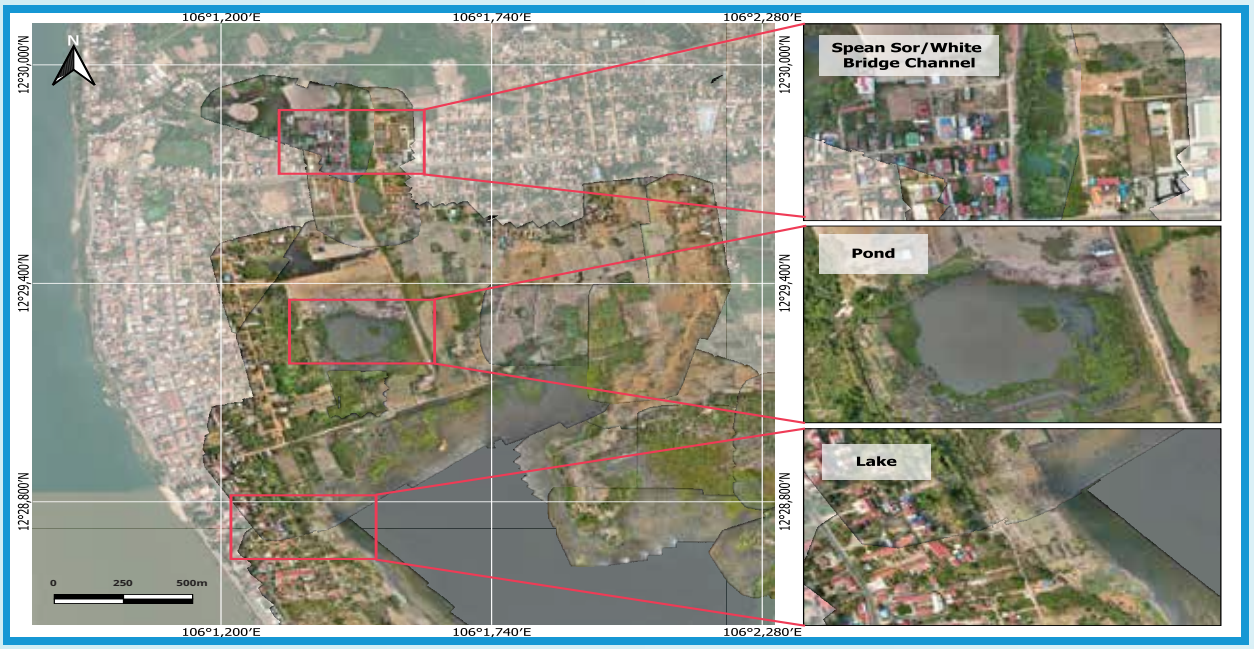


Figure 76 Northern part of Boueng Romleach with its blue-green network Note: High Resolution imagery in the suggested boundary (Source: Drone image mosaics obtained and processed by the Authors in 2023. Own Work).

Figure 77 Valuing the lake area for tourism development: Eco-lodges under construction

To integrate the Lake Area effectively into urban planning, guidelines must emphasize preserving natural water flow, mitigating wastewater inflows, regulating development in critical habitats, and developing recreational infrastructure that meets the expectations of residents and tourists alike. (See Figure 77)

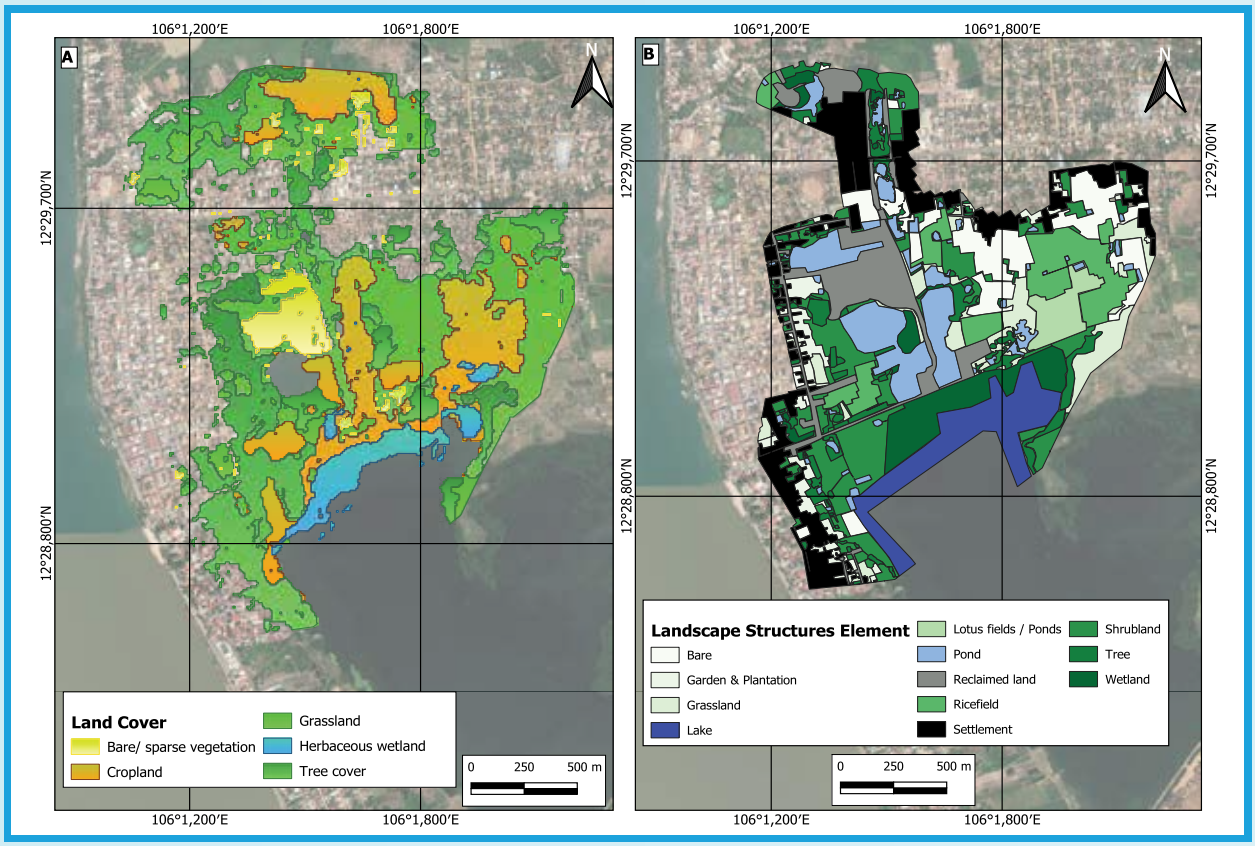


Figure 78 Land cover in Krong Kratié and the Prek-Te Watershed in 2021 (Source: Own Work based on Drone imagery (March 2023), Microsoft / Maxar Technologies 2023 (Bing Satellite)

The Lake Area also serves as a vital natural flood control mechanism, with its wetlands acting as a buffer against flooding and mitigating risks for surrounding communities. This natural sponge collects excess water during the wet season while releasing it slowly, thereby averting overwhelming inundation. Additionally, the area provides a cooling effect, essential for managing the urban heat island phenomenon exacerbated by climate change. (Figure 78 & Figure 79)

Figure 79 The lake area as natural system of flood control - Aerial photo of Boeung Romleach (Source: Smith, 2014)

With the local economy relying heavily on rice farming and fishing, maintaining water quality and biodiversity is crucial for both community livelihoods and the ecosystem. However, the region faces threats from pollution and unsustainable land use practices, necessitating proactive measures to preserve its ecological integrity and support the resilience of local communities. (See Figure 80, Figure 81 & Figure 82)

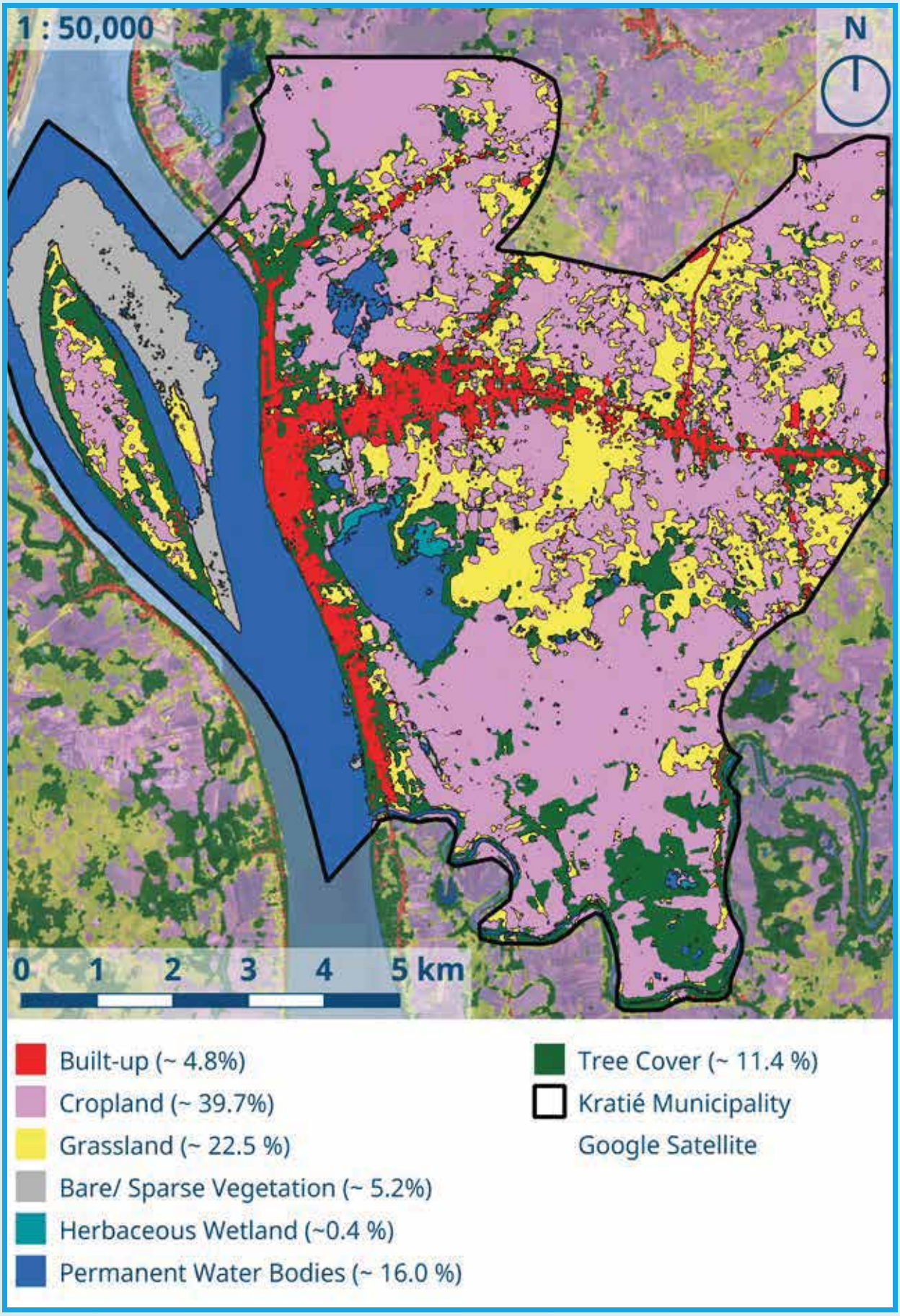


Figure 80 Large areas of Krong Kratié are used for crop production (Source: Own Work based on Zanaga et al., 2021)

Figure 81 Continuous input of sediments but the use of chemical fertilizer are significant rice farming inputs in the Lake Area (Own Photos taken in 2022)

Figure 82 Fishing activities in the lake in Kratié (Source: Own Photos taken in 2022)

Moreover, the rich biodiversity not only sustains local livelihoods through fishing and farming but also presents opportunities for eco-tourism. (See Figure 83)

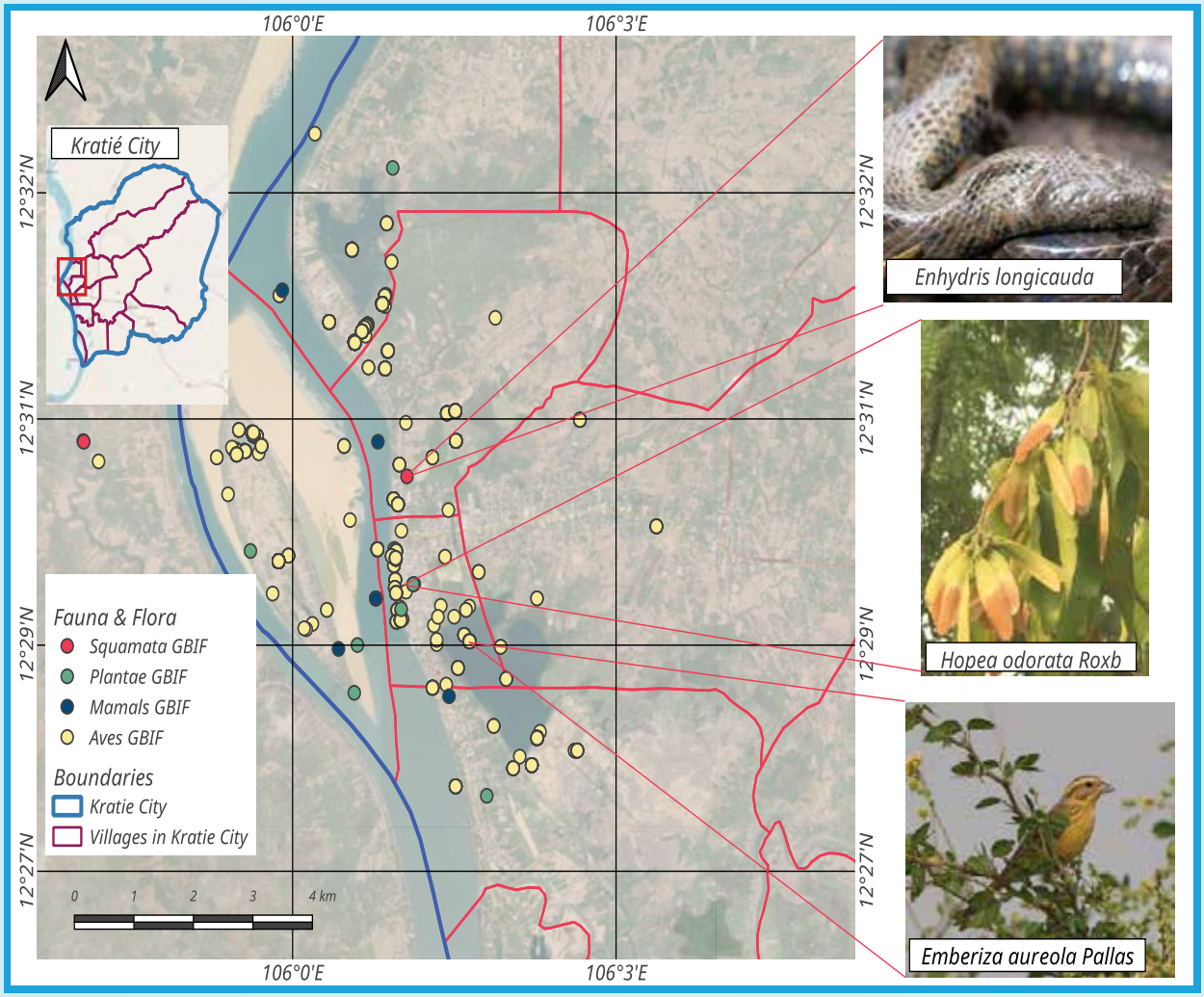


Figure 83 Examples of flora and fauna biodiversity in the lakes and wetlands of Kratié

Note: Presented here are three species with critical conservation statuses: a. Emberiza aureola Pallas, first identified in 1773-critically endangered, b. Enhydris longicauda Bourret-Vulnerable, first identified in 1934, c. Hopea odorata Roxb – Vulnerable. These species have been identified based on their respective coordinates of occurrence (Source: Own Work based on GBIF, 2023 and Microsoft / Maxar Technologies 2023 (Bing Satellite)

Solid Waste Management

Currently, approximately two-thirds of Krong Kratié is serviced by a solid waste management (SWM) system that collects waste for disposal at a dumpsite located about 5 km from the town. However, the existing SWM services are inadequate to manage the total waste generated, leaving significant areas unserved and requiring the population to manage their own waste, which often harms the environment. (See Figure 84) Although a new landfill site with improved management standards is proposed, challenges remain in waste collection, particularly in securing the collection fee, which raises concerns about the financial viability of the new facility.

Figure 84 Uncontrolled dumping of municipal solid waste near to a water body in Krong Kratié (Source: Own Photos taken in 2023)

Recycling practices in Krong Kratié are predominantly informal, with local families collecting and reselling valuable waste to intermediaries and recyclers, primarily in Phnom Penh. The lack of effective waste separation at the source and localized composting of organic waste risk quickly exhausting the landfill's capacity. To address these issues, systematic capacity building for local governments is essential in order to create an enabling environment that enhances the business prospects for waste collectors and strengthens the overall financial sustainability of the waste management system. Moreover, comprehensive awareness campaigns are necessary to educate communities about the importance of waste separation and management at the household level. Additionally, implementing preventive maintenance for drainage systems is crucial to mitigating urban flooding incidents, contributing positively to waste management outcomes. (See Figure 85)

Figure 85 Municipal solid waste blocking drainage systems in Krong Kratié (Source: Own Photos taken in 2022)

Annex 3 Development Plan for Urban Wetlands of Krong Kratié, 2024 to 2035

Vision, Objectives, Goals

The vision for Krong Kratié aims to modernize and environmentally enhance the city, making it a more appealing place for residents, visitors, and businesses. The emphasis is on contributing to sustainable development in the long term, by integrating modernization with environmental stewardship. This vision supports Krong Kratié in becoming a beacon of sustainable urban development and creating a harmonious environment that bolsters its appeal and functionality for various stakeholders.

Figure 86 Development Plan for Urban Wetlands of Krong Kratié 2024-2035

The 2024-2035 Development Plan for Urban Wetlands in Krong Kratié sets out objectives to transform the Lake Area and its connected zones into vital assets for sustainable development. The plan focuses on economic, social, and ecological modernization, ultimately providing a model for Cambodia's secondary and tertiary cities. By incorporating urban wetlands into infrastructure plans, the city aims to boost livability, protect livelihoods, and strengthen its resilience against extreme weather, aligning with climate change adaptation strategies.

To fulfill these objectives, the plan outlines six strategic goals. These include enhancing urban livability through better amenities and services, reducing flood risk with improved water management, and supporting community livelihoods for widespread economic and social benefits. Additionally, the plan prioritizes climate resilience through adaptive planning, preserving ecosystem services

of the lake area, and enhancing governance for sustainable development through participatory approaches. These goals collectively aim to elevate Krong Kratié's infrastructure and community well-being, ensuring an inclusive and resilient urban environment.

Priority strategies

The Development Plan for Urban Wetlands of Krong Kratié 2024-2035 employs seven priority strategies to realize its vision, objectives, and goals. These strategies include improving flood management through enhanced drainage and controlling impervious surfaces, adopting a mixed wastewater management approach for water quality protection, and guiding urban expansion with green development principles. The plan also emphasizes increasing urban greenery to boost biodiversity and leisure spaces, and integrating the lake into recreational and tourism frameworks for economic vitality. Additionally, it focuses on capacity building within governmental structures for effective plan execution and stresses participatory planning to ensure community, private sector, and civil society involvement in decision-making processes.

Implementation Strategy 1: Flood Management

To address flood management challenges in Krong Kratié, a strategic action plan emphasizes integrating the hydrological functionality of the Lake Area into the city's infrastructure development. The strategic vision involves efficient flood risk management through natural water systems, improved infrastructure, and strategic urban planning. This includes assessing flood vulnerabilities, integrating stormwater management policies utilizing both grey and blue-green infrastructures, and engaging stakeholders such as local governments and community leaders in formulating a strategic vision. Additionally, communication strategies through workshops and awareness programs are planned to support sustainable flood management efforts.

The plan outlines infrastructure enhancements, including upgrading and expanding drainage systems to improve water flow, restricting impervious surfaces by promoting permeable pavements and green roofs, and incorporating green infrastructure like bio-swales to increase water infiltration. There are efforts to preserve the flood absorption capacity of the Lake Area by designating conservation zones and enforcing urban development controls. Public participation is encouraged to balance community, investor, and hydrological needs within planning processes. Additionally, practices to reduce drainage blockages through solid waste management, including improving waste collection services and organizing community cleanup drives, are essential components of the plan.

Capacity development programs are crucial for effective implementation, involving interdepartmental collaboration between public works, environment, and water resource management sectors. Community engagement and private sector involvement are also prioritized to foster investment and participation in flood-resilient infrastructure. The plan outlines a timeline from 2024 to 2025 for initial upgrades of stormwater gates and drainage systems, with continuous development extending to 2035. This ongoing development will further enhance drainage infrastructures in existing and new areas and improve solid waste management systems and urban development guidelines.

Implementation Strategy 2: Green Space and Recreational Area Development

To effectively integrate the Lake Area into the green space development strategy for Krong Kratié, a detailed plan is established with a strategic vision that emphasizes a city harmoniously blended with nature, where green spaces enhance urban life, biodiversity, recreation, and sustainable development. This vision will be implemented through collaborative planning involving diverse stakeholders—including government, communities, and environmental experts—to create a comprehensive development plan and gather community feedback via public forums and media. The target for finalizing this vision is set for 2025.

Additionally, an awareness campaign for promoting green private spaces and business premises will be developed, which involves creating guidelines for maintaining green areas in private properties, educational programs to inform homeowners and businesses about the benefits of tree planting, and offering incentives like recognition awards. Financing for these initiatives will stem from landowners and private sector contributions, with guidelines to be elaborated by 2025 and awareness campaigns to be rolled out continuously through 2035.

The plan further includes identifying and developing five key green spaces in Krong Kratié, assessed for their environmental and social potential, and designed to serve multifunctional purposes with native plants. Infrastructure improvements will enhance waterfront areas and create recreational pathways around the Lake Area. New urban development will mandate the inclusion of green infrastructure, ensuring adherence to water-sensitive urban design principles. Timelines are set for identifying green spaces by 2025, developing them from 2027 to 2035, and further embedding these principles into existing and future land use plans.

Implementation Strategy 3: Wastewater Management

To enhance the technical, institutional, and service capacities for wastewater treatment in Krong Kratié, a strategic vision aims to prioritize sustainability, public health, and environmental protection by utilizing both centralized and decentralized wastewater management solutions. Implementation will involve engaging stakeholders such as government officials, community leaders, and technical experts through workshops to develop a shared vision, alongside public awareness campaigns to educate citizens on effective wastewater management and financing schemes. The timeline for establishing this strategic vision is set for 2024/2025.

The plan includes developing localized sanitation plans for urban areas, particularly focusing on integrating both centralized and decentralized systems in the Lake Area, with community participation to ensure that the plans address the specific needs of local residents. Funding for these initiatives will be sourced from organizations such as BORDA/BMZ, and the sanitation plans are scheduled for elaboration in 2024. Additionally, a centralized wastewater treatment system will be financed by the Asian Development Bank (ADB), with plans finalized by 2024/2025, and implementation occurring between 2025 and 2027. Capacity-building efforts for local governments will ensure the long-term sustainability of this system through 2035.

Furthermore, decentralized wastewater solutions will be promoted, targeting pollution hotspots and enhancing septic systems in residential and commercial areas, while forming an enabling environment for effective septage management. The timeline for identifying pollution hotspots begins in 2024/2025, with the implementation of decentralized solutions and capacity development planned through 2035. Additionally, integrating fertilizer management into the wastewater strategy includes training for farmers on optimal fertilizer application, enhancing agricultural extension services, and facilitating community meetings to share best practices. Continuous capacity development efforts will occur from 2024 to 2025.

Annex 4 Abbreviations and Acronyms

ADB	Asian Development Bank
AIT	Asian Institute of Technology
BMBF	Federal Ministry for Education and Research
BMFTR	Federal Ministry for Research, Technology and Space
BMZ	Federal Ministry for Economic Cooperation and Development-
BORDA	Bremen Overseas Research and Development Association
CBD	Commune Database
CIUS	Cambodian Institute of Urban Studies
DEWATS	Decentralised Wastewater Treatment System
ESC	Environmental Sanitation Cambodia
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMS	Greater Mekong Sub-region
LMB	Lower Mekong Basin
MRC	Mekong River Commission
NRW	Non-Revenue Water
PUW	PolyUrbanWaters
RGC	Royal Government of Cambodia
SDG	Sustainable Development Goals
SOP	Standard Operating Procedures
SWM	Solid Waste Management
WWTP	Wastewater Treatment Plant

Annex 5 Green Space Assessment Matrix

Green Space Assessment Matrix (Source: Hodgson, A. (September 2024). Green space planning: Assessment & site concepts review workshop, Krong Kratié, Cambodia. PolyUrbanWaters: Berlin)

Site Name	1. White Bridge/Channel	2. O'Russey Market Side Streets	3. Lake Mleach Southern Shore Road Roka Kandal	4. Lake Mleach Northern Shore Road O'Russey	5. Central Bus Stop / Pagoda
Short description of current space	Channel embankment area and access road	Access roads surrounding market	Dirt access road bordering south-west corner of Lake Mleach	Dirt access road bordering northern shore of Lake Mleach	East-west access roads in core area - connecting bus stop, Mekong River promenade, Pagoda and lake area to the east
1. Curret Usage	-Serves as an important access road for automobiles, bicycles, and pedestrians, connecting various parts of the area. -Frequently used by residents for exercising, such as walking or jogging, especially during cooler hours in the early morning and evening. -The grassy riverbank acts as a quiet, natural socializing spot in the late afternoon and	-Basic access road network that serves both the market, surrounding shops, and nearby residential areas. -Used by automobiles, bicycles, and pedestrians throughout the day for shopping, deliveries, and daily commuting. -Connects directly to the main road, serving as an essential link between the market	-Dirt access road used primarily by automobiles, bicycles, and pedestrians. connecting to various agricultural land uses and eastern side of the lake. -Used by residents for fishing and foraging around the lake. -Small mobile rest spot set up by single vendor with snacks/drinks/ chairs, sun umbrellas	-Dirt access road primarily used by automobiles, bicycles, and pedestrians. -Connects the northern shore of Lake Mleach to the core town areas in the west and north, including the Mekong River promenade and O'Russei's residential and commercial zones. -Mainly serves as a transit route with limited	-Functions as a crucial east-west access route connecting the bus stop, Mekong River promenade, Pagoda, and the lake area to the east. -Used extensively by automobiles, bicycles, and pedestrians, including local residents, market-goers, and tourists. -Central location makes it a hub of activity, but lacks infrastructure to support its varied use effectively.

	evening when temperatures drop. -Visitors often buy snacks and drinks from nearby shops and bring them to the site for informal picnics. -Locals use the channel banks for fishing and foraging for berries, contributing to its use as a multifunctional space.	and the rest of the town. -Partially used by street vendors and food stalls, (potential to contribute to congestion.) -Frequented by locals for and other town residents for shopping, particularly in the morning and late afternoon. -Provides access for loading and unloading goods for market shops and street vendors.	-People come to rest spot with children to bathe, relax, socialize, exercise after work. (ca. 100 per day all year round) -Few nearby amenities, making the road primarily a transit route rather than a destination.	infrastructure for safe bicycle or pedestrian movement.	
2. Environmental Observations	-The channel is lined with a large amount of vegetation, including grass and shrubs, contributing to the area's natural appeal. -The channel plays a vital role in managing water flow between the northern and southern lake areas, especially during flood seasons.	-General lack of vegetation and shade in the surrounding streets, resulting in a hot, harsh environment, especially during midday. -Roads are entirely paved with concrete, offering no permeable surfaces, which exacerbates water runoff and	-Constant cool breeze effect from lake and "fresh air" at lake shore. -Road is only partially usable during wet season due to inundation -Basic raised road, with dirt surface with minimal vegetation, leading to frequent dust in dry seasons	-Road bordered by natural landscapes but lacks vegetation and shade, resulting in a hot environment during the day. -Dirt surface creates dusty conditions in dry seasons and becomes muddy and difficult to	-Roads are paved but have no designated pedestrian sidewalks, leading to potential conflicts between different traffic modes. -Sparse vegetation and a lack of shade make the area hot and unwelcoming, especially during peak daytime hours

	-Some trees have been recently planted along the embankment, though there is still a lack of mature shade-providing trees. -The area is generally hot due to the lack of shade, although a fresh breeze often blows along the channel.	flooding during heavy rains. -Absence of pedestrian sidewalks causes potential conflicts between pedestrians, vehicles, and bicycles. -Streets are cluttered with rubbish due to the lack of proper waste disposal bins, impacting the area's cleanliness and overall aesthetic.	and mud in wet seasons, or completely inundated. -Lack of tree cover results in a hot environment with little to no shade. -Scenic potential not fully utilized due to poor road conditions and lack of amenities. -Little rubbish (collected by vendor)	navigate during the rainy season, -Not possible to use when fully inundated -Scenic potential not fully utilized due to poor road conditions and lack of amenities.	-Concrete surfaces limit water absorption, increasing the risk of flooding during heavy rainfalls.
3. Community Needs	-More trees are needed to provide shade and enhance the beauty of the area, making it a more inviting place for relaxation and exercise. -A dedicated walkway and exercise equipment would support recreational activities. -Installing seating areas along the embankment would	-Street trees and vegetation to provide shaded areas, creating a more pleasant and comfortable shopping experience. -Street lighting to enhance safety and visibility for market patrons, particularly in the early morning and evening hours. -Designated seating areas for market visitors and	-Increase significance of lake to be used and valued more by town and local community residents – good business opportunities for small scale sellers (food / drink vendors). -Introduction of vegetation, particularly trees, to provide shade and mitigate heat, particularly at	-Raised road surface for better drainage and improved accessibility, especially during rainy seasons. -Tree planting along the road for shade to make it more welcoming for locals and tourists.	-Street trees and greenery to create shaded areas and improve the overall attractiveness/ appeal of the area. -Installation of street lighting to ensure safety during the evening and night. -Development of pedestrian-friendly spaces, including sidewalks and seating areas.

	encourage social gatherings and provide rest spots for visitors. -Proper waste disposal solutions are required to keep the area clean. -Improved lighting along the road and embankment is needed to ensure pedestrian and driver safety at night. -Enhancing the area's aesthetic appeal could attract more tourists.	shoppers to rest and socialize. -Rubbish bins strategically placed to promote cleanliness and reduce littering. -Improved traffic management strategies, including pedestrian pathways or sidewalks, to separate different modes of traffic and ensure safer navigation. -A stormwater drainage system to handle water runoff and prevent street flooding, especially during the rainy season.	designated mobile rest spots. -Installation of simple make-shift seating to offer rest spots for those traveling around the lake. -Similar to other mobile rest spot locations found on new road on east side of lake		-Introduction of rubbish bins to promote a clean environment around the pagoda, bus stop and market.
4. Challenges and Concerns	-Portions of the access road can become muddy, especially after rain. -The absence of sufficient lighting makes the area less safe and less accessible during the evening and nighttime hours.	-The area becomes congested with mixed traffic, including pedestrians, cyclists, and vehicles, posing safety risks. -Hot, unshaded environment makes it less inviting for shoppers and potential tourists.	-Seasonal flooding means access is not possible part of the year. It also means any permanent infrastructure is not possible -Appropriate trees / vegetation needed that offers shade, attractive however does not destroy	-Dirt road conditions, including muddy patches during rainy seasons, make navigation difficult. -Absence of shade and amenities reduces the road's potential as a travel route and a tourism asset.	-Lack of greenery and shade makes it an uncomfortable area during the day, reducing its attractiveness for visitors and locals; this could also have a negative effect for tourism -The current traffic management system creates safety concerns, particularly for pedestrians.

	-The lack of rubbish bins leads to littering, which detracts from the natural beauty of the area. -Concentration of vegetation in channel affects water flow in the channel	-Rubbish accumulation and lack of proper waste management contribute to an unappealing market atmosphere.	road/ lead to erosion with roots. -Polluted water -Rubbish in water		
5. Suggestions for Improvement	-Plant tion to provide shade and enhance the area's aesthetic, making it more welcoming for socializing and exercising. -Use the channel for improved flood management by increasing the water flow rate, possibly through the construction of a flood wall. -Create designated walkways for exercising and install seating to support social and recreational activities.	-Introduce street trees and other vegetation to create shaded, cooler areas and enhance the market streets' visual appeal. -Implement designated pedestrian sidewalks to separate walking paths from vehicle lanes, improving safety and traffic flow. -Install street lighting to improve safety and extend market	-Planting of street trees and vegetation to create shaded areas for pedestrians. -Beautification efforts, such as “rest spots” with concertation on trees/ shaded areas for mobile/seasonal use with places for vendor street food carts, mobile seating, picnic, etc. -Clearly marked pathways with signage to encourage community use, tourism and social activities.	-Create a clearly marked bicycle path along the northern shore road to connect the core town areas, the Mekong River promenade, and O'Russei, promoting safe cycling for residents and tourists. -Implement a raised road surface if feasible, to prevent flooding and improve year-round accessibility. -Plant trees along the road to provide shade, enhance the	-Planting street trees to provide shade and enhance the area's aesthetic appeal and cooling effects, which promotes use of space for locals and tourists (e.g. arriving at bus stop) or visiting the pagoda and/or central market -Constructing sidewalks and pedestrian pathways to ensure safer, more organized movement around the area.

	-Add rubbish bins along the road and embankment to maintain cleanliness. -Install adequate lighting along the access road and embankment to improve safety and usability during nighttime. -Upgrade the road surface to prevent muddy patches and improve accessibility, regardless of weather conditions.	activities into the evening hours. -Provide rubbish bins and waste management solutions to keep the streets clean and attractive for locals and visitors. -Develop a stormwater drainage system to manage water runoff, reduce flooding, and ensure the streets remain accessible during rainy seasons. -Extend these improvements to surrounding streets for a more cohesive environment	-Designate as part of greater bicycle network around the lake/ linking to city for locals and tourism (mountain bicycles are becoming more popular as an exercise, recreational option – as seen in other parts of Cambodia, such as Siem Reap). -Lighting where possible on existing electricity poles	scenic value, and create a more appealing environment for cyclists and pedestrians. -Install street lighting to ensure safety for pedestrians and cyclists during nighttime, extending the road's usability. -Include rest areas along the path, with ample shade to encourage rest, sightseeing and socializing. -Place rubbish bins in strategic locations, and / or appropriate signage	-Implementing a stormwater drainage system (integrated with vegetated areas) to address water runoff and prevent flooding. -Other beautification measures, such as installing seating areas and rubbish bins, to encourage social interaction and tourism.

Annex 6 Group Assessment of Initial Basic Site Concepts

Group Assessment of Initial Basic Site Concepts (Source: Hodgson, A. (September 2024). Green space planning: Assessment & site concepts review workshop, Krong Kratié, Cambodia. PolyUrbanWaters: Berlin)

Sites/Areas	1. Environmental and Health Benefits	2. Usability and Community Benefit	3. Visual Improvement and Creating a Sense of Place	4. Feasibility of Implementation
White Channel/ Bridge	Priority - beautiful greenspaces; comfort zones; improving exercise options; emotional benefits for tourists. Enhance air quality and provide cooling	Increases community economies and tourism. Locals can generate income by selling products; creates a gathering space for exercise, relaxation, and socializing.	Enhances the beauty of the area. Becomes a place for recreation, clean air, and exercise. Connects to riverside beauty.	Implementation is ongoing, starting with tree planting. Needs a budget to continue. Requires integration into long-term city development plans and partnership mobilization.
O'Russey Market – Side Streets	Trees reduce heat, increase beauty, improve sanitation, and provide clean air. Help with stormwater management and reduce stress.	Boosts tourism and customer flow. Creates a walkable market environment, helps vendors sell more products. Facilitates socializing and increases property values.	Expands green areas into the neighborhood. Facilitates traffic, encourages nighttime activities. Includes toilets, trash bins, and solar lighting.	Sidewalk is narrow, which could impact private property. Requires strategic planning, budget, maintenance plan, and a tree-planting program.
Lake Romleach South Road (junction) Sangkat Roka Kandal	Benefits of adding green space include improved air quality, cooling effects, and recreational areas.	Can serve as a recreational area and social space. Potential to become a focal point for community gatherings.	Opportunity to create a welcoming space and improve the overall aesthetic of the area.	Feasibility depends on space availability and planning. Requires budget allocation and maintenance plan.
Lake Romleach North Road Sangkat O´Russey	Same as White Channel – focus on green spaces to improve air quality, provide exercise options, and offer emotional benefits.	Similar to White Channel - promotes exercise, relaxation, and social interaction. Increases economic opportunities for locals.	Contributes to beautifying the space, making it more welcoming and providing a sense of place.	Feasible with a similar approach to White Channel. Needs budget, strategic planning, and long-term maintenance support.

Bus Stop/ Side Streets	Improves air quality, provides a fresh and cool feeling. Reduces heat and flooding, while making the area attractive for locals and tourists.	Provides shaded areas for relaxation, socializing, and exercise. Attracts tourists, boosts local economy by improving the selling environment.	Includes benches, trash bins, mobile public toilets, small gardens, and a mobile library. Encourages local products selling, cultural events, and social interaction.	Feasibility is high; easy to implement with affordable costs and available land. Requires financial and human resources for maintenance and local authority involvement.

Annex 7 Green Space Factsheets

Factsheet Site 1: White Bridge Channel

Water-Sensitive Green Space Development: White Bridge Channel

Lead Agency: Department of Public Works and Transport

Ownership: The Department of Water Resources and Meteorology manages the water course, the embankments fall under the mandate of the Department of Public Works and Transport. Local sangkat authorities are responsible for regular maintenance.

Estimated Budget: $4,238,537.33m² (Stage 1)

Estimated Size: 2,726m² (Stage 1)

This green space near densely populated districts offers vital connectivity and potential recreational opportunities, combining exercise, socializing, and scenic water views. However, the area requires additional shade trees, recreational facilities, and infrastructure improvements to address challenges that include heat, litter, and accessibility, thereby enhancing safety, environmental management, and tourism potential.

Visual Concepts

Before

After

After

After

Water-sensitive Elements

Rainwater management

- **Open drainage** system utilizing the channel and fed by forms of infiltration, such as permeable paving in selected areas – funded in phases via local budgets.
- **The channel** can also be developed to store water in wet detention ponds for use during periods of low rainfall.

Wastewater Management

- **DEWATS (Decentralized Wastewater Treatment Systems)** where appropriate as a practical, regulation-compliant solution that potentially can generate revenue and is suitable for local community needs and funding sources.

Rationale for Improvement

Close to fairly densely populated sangkats providing exercise and relaxation combined with shade and seating with views over the water.

Environmental and Health Benefits: Enhances air quality, provides cooling effects, and creates attractive comfort zones for exercise and well-being.

Flood Mitigation: Manages stormwater to reduce the city's flood risk.

Economic and Tourism Growth: Supports local economies and tourism through income generating opportunities and social/recreational spaces.

Aesthetic and Recreational Value: Improves the area's beauty, fosters a sense of place, and provides accessible sites for recreation and relaxation.

Implementation Needs: Requires a designated budget, integration into urban development plans, and active partnerships for sustained progress.

Contact Information

Please contact the Municpality of Kratié for further information.

Donors and Partners

Factsheet Site 2: O’Russey Market Side Streets

Water-Sensitive Green Space Development: O'Russey Market Side Streets

Lead Agency: Department of Public Works and Transport

Ownership: Department of Public Works and Transport has the mandate for the side streets in terms of green space and drainage development. Solid waste is managed by the private company. Local sangkat authorities are responsible for regular maintenance. The market itself is privately managed.

Estimated Budget: $245,915.80

Estimated Size: 4,723m²

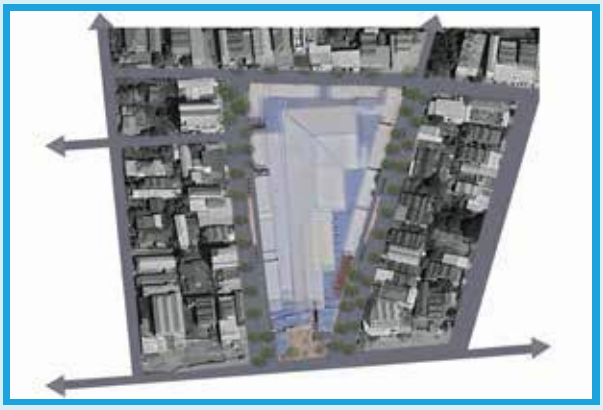
Process: Bring under management of the Project Steering Working Group and develop project proposal for funding from 2026 onwards.

O'Russey Market side streets currently serve as a vital but congested and environmentally challenging access point for the market and surrounding community. To improve the market's appeal and functionality, proposed enhancements include adding vegetation for shade, designated pedestrian walkways, improved lighting, waste management solutions, and a stormwater drainage system, which should be extended to the market's surrounding streets.

Visual Concepts

Before

After



After

After

Water-sensitive Elements

Rainwater management

- **Infiltration Trenches** are technically feasible with support from municipal/provincial teams. While generally beneficial, some community members may not be completely satisfied. This aligns with government priorities yet funding will be constrained by local budgets, requiring additional sources.

Wastewater Management

- **A DEWATS (Decentralized Wastewater Treatment Systems)** system is technically feasible with public works department capacity and if limited to market businesses. This will require conflict resolution for potential non-participation. Requires a maintenance mechanism for post construction. However, there is a current lack of funding at municipal and Sangkat levels.

Rationale for Improvement

Shaded streets around this popular market create a more relaxing market experience with sidewalks and seating.

Environmental and Health: Trees reduce heat, beautify the area, improve sanitation, and provide cleaner air.

Flood Mitigation: Aids in stormwater management and reduces environmental stress related to flooding.

Economic and Tourism: Boosts tourism and customer traffic, creates a more walkable environment, increases sales for vendors, facilitates social interaction, and enhances property values.

Aesthetic and Recreational: Expands green spaces, improves traffic flow, encourages night-time activities, and includes essential amenities like trash bins and solar lighting.

Implementation Considerations: Requires strategic planning, dedicated budget, a maintenance plan, and a tree-planting program, while addressing potential sidewalk width limitations and impacts on private property.

Contact Information

Please contact the Municpality of Kratié for further information.

Donors and Partners

Factsheet Site 3: Southern Lake Road

Water-Sensitive Green Space Development: Southern Lake Road

Lead Agency: Department of Public Works and Transport, Department of Land Management and Construction, Department of Water Resources and Meteorology

Ownership: Department of Public Works and Transport has the mandate for the lake-side areas and roads whereas Department of Water Resources and Meteorology is mandated with managing the lake itself. Department of Land Management and Construction and local sangkat officials are responsible for managing potential conflicts with residents impacted by the development.

Estimated Budget: $1,411,150.00

Estimated Size: TBC

Process: Bring under management of the Project Steering Working Group and develop project proposal for funding from 2026.

The Southern Lake green space site currently serves as a basic access road with some recreational use, but suffers from seasonal flooding, a lack of shade, and underutilized scenic potential. Improvements should focus on creating shaded "rest spots" with vegetation and mobile vendor areas, establishing clear pathways, integrating the site into a bicycle network, and providing lighting to enhance community use and tourism while considering environmental constraints like seasonal flooding and water pollution.

Visual Concepts

Before

After

After

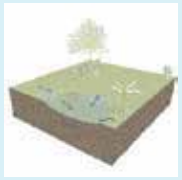
After

POLYURBAN WATERS

Water-sensitive Elements

Rainwater management

- **Permeable Paving** is technically feasible with local capacity; potential access issues for vulnerable populations, such as the physically disabled. The local authority can manage maintenance with potential higher-level support and community contributions for maintenance may be necessary.



- **Dry Detention Pond** is feasible at the local level. Strong community engagement and participation is expected. This intervention is achievable by the local authority. Funding for rainwater management is potentially available from the local budget.

Wastewater Management

- **DEWATS (Decentralized Wastewater Treatment Systems)** is the preferred solution. The existing infrastructure allows for straightforward improvements. Generally, a positive community reception is anticipated. Diligent oversight is expected if the Sangkat officially maintains the infrastructure. There is a potential financial contribution from the Sangkat.

Rationale for Improvement

This site is situated on the shores of the lake and surrounded by rice fields providing a beautiful location for relaxing, walking, cycling or picnicking with family and friends with parking and lots of shade.

Environmental and Health: Green spaces improve air quality, provide cooling effects, and create recreational areas.

Flood Mitigation: Flood management mechanisms can enhance year-round access and potentially offer water storage solutions.

Economic and Tourism: Opportunity to create a welcoming space and improve the overall aesthetic of the area, potentially boosting tourism.

Aesthetic and Recreational: Serves as a recreational area and social space, with the potential to become a focal point for community gatherings and tourist attraction due to the natural beauty of the area.

Implementation Considerations: Feasibility depends on space availability and planning, requiring budget allocation and a maintenance plan.

Contact Information

Please contact the Municpality of Kratié for further information.

Donors and Partners

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Factsheet Site 4: Wat Kratié Side Roads

Water-Sensitive Green Space Development: Wat Kratié Side Roads

Lead Agency: Department of Public Works and Transport

Ownership: Department of Public Works and Transport has the mandate for the side streets in terms of green space and drainage development. Sangkat officials will support regular maintenance. The Wat itself is managed by the Wat's own administration.

Estimated Budget: $99,366.80

Estimated Size: 7,988m²

Process: Bring under management of the Project Steering Working Group and develop project proposal for funding from 2026.

The Wat Kratié green space site is a busy thoroughfare lacking adequate infrastructure, suffering from a lack of shade, pedestrian safety issues, and flood risk. Improvements should focus on planting trees for shade, constructing more accessible sidewalks, implementing a stormwater drainage system, and other beautification measures, installing seating areas and rubbish bins, to enhance the area's appeal and safety for both locals and tourists.

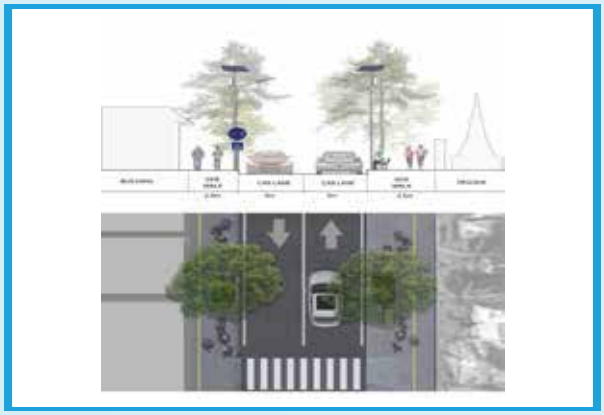
Visual Concepts

Before

After

After

After



POLYURBAN WATERS

Water-sensitive Elements

Rainwater management

- **Infiltration Trenches** require minimal technical intervention. Community support is expected due to flood mitigation. Identifying responsible parties for operation and maintenance needs to be clarified. Municipal funds could be allocated.

- **Permeable Paving** for sidewalks are a straightforward implementation with proper materials. Contribution to improved aesthetics will foster community support. Maintenance can be shared with local authorities. Funding may require drawing from various budgets.

Wastewater Management

- **Grey Infrastructure Drainage System** is the preferred option due to no demand for wastewater management. Existing systems will primarily manage rainwater. It is crucial to prevent solid waste from blocking channels or drains to avoid flooding.

Rationale for Improvement

Kratié's Wat will be more beautiful surrounded by shaded, tree-lined streets making this a more integral part of the riverside promenande green area linking it more effectively to areas popular with walkers.

Environmental and Health: Improves air quality, provides a fresh and cool feeling, and reduces heat.

Flood Mitigation: Flood management mechanisms contribute to reducing the risk of flooding in the area.

Economic and Tourism: Attracts tourists, boosts the local economy by improving the selling environment for local vendors.

Aesthetic and Recreational: Provides shaded areas for relaxation, socializing, and exercise; includes amenities like benches, trash bins, mobile public toilets, small gardens, and a mobile library; encourages local product sales, cultural events, and social interaction.

Implementation Considerations: Feasibility is high with affordable costs and available land; requires financial and human resources for maintenance and local authority involvement.

Contact Information

Please contact the Municpality of Kratié for further information.

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Factsheet Site 5: 30 Metre Street

Water-Sensitive Green Space Development: 30 Metre Street

Lead Agency: Department of Public Works and Transport

Ownership: Department of Public Works and Transport has the mandate in terms of green space and drainage development. Sangkat officials and local residents will support regular maintenance.

Estimated Budget: $1,520,919.40

Estimated Size: 12,982m²

Process: Bring under management of the Project Steering Working Group and develop project proposal for funding from 2026.

The 30m Street green space site, a densely populated residential area near a major highway, is hampered by a lack of pedestrian infrastructure, sparse vegetation, and flood risk. Proposed improvements include planting street trees for shade, constructing sidewalks, implementing a stormwater drainage system, and adding amenities like seating and rubbish bins to enhance safety, aesthetics, and community engagement.

Visual Concepts

Before

After

After

After

POLYURBAN WATERS

Water-sensitive Elements

Rainwater management

- **Stormwater Drainage with Infiltration** during the construction of a good quality road aimed at improving both the road and the city. Technical experts will need to be consulted. There is a potential for resident discontent due to possible negative impacts of construction. The local authority will oversee budget allocation. There is a significant budget available due to the area's population.

Wastewater Management

- **DEWATS (Decentralized Wastewater Treatment Systems)** is preferred as wastewater generation is expected due to households and a school in the area indicating the need for well-managed, improved toilets. There is no negative impact on residents anticipated as it will likely garner support.

Rationale for Improvement

This residential area will benefit from more shade, seating and specific lanes for cars and cyclists and separated sidewalks so that children and elderly can enjoy the cooler temperatures created by the trees.

Environmental and Health: Improves air quality, provides a fresh and cool feeling, reduces heat, and enhances a sense of well-being.

Flood Mitigation: Flood management mechanisms contribute to reducing the risk of flooding in the residential area.

Economic and Tourism: Provides opportunities for small-scale vendors, potentially attracting tourists and boosting the local economy.

Aesthetic and Recreational: Offers shaded areas for relaxation, socializing, and exercise includes amenities like benches, trash bins, public toilets, small gardens, and street lighting. Encourages cultural events and social interaction.

Implementation Considerations: Feasibility is medium, within the capacity of local government with affordable costs and available land; requires financial and human resources for maintenance and local authority involvement.

Contact Information

Please contact the Municpality of Kratié for further information.

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Annex 8 The PolyUrbanWaters Project in Krong Kratié

Background

The Royal Government of Cambodia's current National Strategic Development Plan reaffirms its dedication to the 2030 Agenda for Sustainable Development by incorporating approximately half of the SDG indicators as Cambodian-specific goals. By aligning performance metrics with budgetary outcomes, Cambodia demonstrates regional innovation.

The government's objective is to integrate Cambodia into the regional economic network through enhanced infrastructure and multi-sector urban development to address climate change challenges. Significant efforts are needed to strengthen subnational capacity for effective multi-sector initiatives, with a focus on ensuring water security and creating livable urban environments, particularly under SDG 6 “Clean Water and Sanitation,” SDG 11 “Sustainable Cities and Communities,” and SDG 13 “Climate Action.”

Funded by Germany’s BMFTR (formerly BMBF), the "PolyUrbanWaters" Project aims to improve urban water management in Southeast Asia's secondary and tertiary cities, enhancing their resilience and livability. Invited by Kratié's authorities, the project supports localizing SDGs and enhancing urban livability through sustainable water resource management. It prioritizes understanding the interaction between natural systems and urban areas to advance urban planning in Krong Kratié's and other water-rich areas in Cambodia.

A baseline study, developed in collaboration with Cambodian stakeholders and an international research team, responds to government interests in improving informed decision-making. It evaluates sustainable water management challenges and opportunities in Krong Kratié, establishing the foundation for strategy development and capacity building supported by "PolyUrbanWaters" until 2025. This study examines the urban environment and major water issues, providing specific action-oriented recommendations for Krong Kratié. Summaries of this baseline assessment are presented in Annexes 1 and 2 of this report.

Since 2021, "PolyUrbanWaters" has assisted Krong Kratié in implementing the integrated 2030 SDGs. Beyond infrastructure expansion, it advocates for effective, context-specific urban planning suited to the needs of Cambodia’s cities, identifying strategic action areas and practical implementation solutions.

From 2023, “PolyUrbanWaters” has built on the baseline assessment to conduct vision-building exercises in Krong Kratié, defining and planning to achieve pertinent water-sensitive development goals. These goals were developed in detail through participatory processes, with priority areas including flood management, wastewater management, and the development of green and recreational spaces as part of the Urban Wetlands Development Plan for Krong Kratié 2024-2035. The project will specifically focus on planning for green and recreational spaces, with this Research and Development Phase culminating in detailed planning for the Implementation Phase to 2027.

[4] Krong is the latin translation for the Khmer word for town or a city that is not the capital city.

Project Framework and Objectives

The PolyUrbanWaters project is a transdisciplinary initiative aimed at strengthening integrated urban planning through the lens of water management, environmental resilience, and livability. In Kratié, the project has operated in close cooperation with the municipal and provincial authorities, supported by Cambodian NGOs, planning institutions, and technical experts from Germany and the Southeast Asian region.

Core Objectives:

- Strengthen the capacity of local actors to plan and manage urban green infrastructure;
- Improve stormwater and wastewater management through decentralized, site-based solutions;
- Promote participatory urban governance and inclusive planning;
- Develop replicable models for climate-resilient secondary city development in Southeast Asia.

To facilitate informed decision-making and strategic development for the holistic management of urban waters in Krong Kratié, it is essential to consider the Krong's unique characteristics. Consequently, the baseline study was carried out to:

- Develop a qualitative and quantitative understanding of “water” within the dynamics of urban development by providing insights into current water resources, usage patterns, water-related vulnerabilities, and both existing and emerging challenges in Krong Kratié;
- Establish a comprehensive understanding of the water cycle within the natural context of Krong Kratié, in relation to urban development dynamics and urban spaces;
- Compile a robust information base to support informed decision-making;
- Identify strategic interventions as potential entry points for the future water-sensitive development of Krong Kratié referencing the eight elements below in Figure 87.

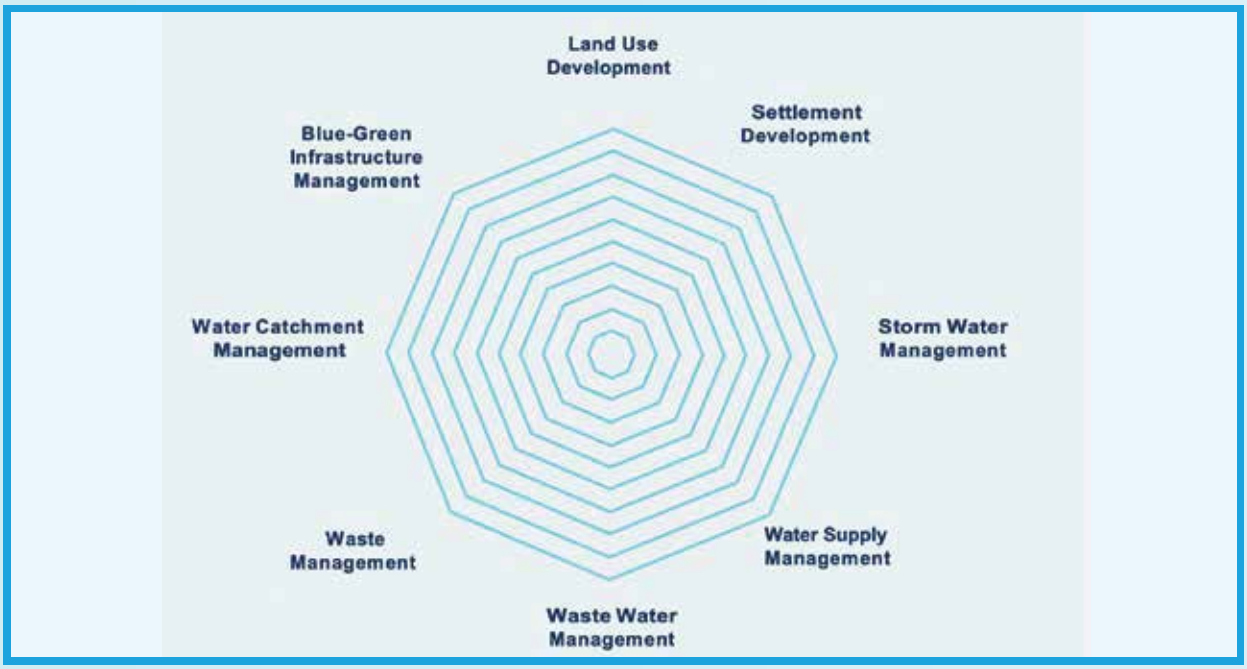

Figure 87 Strategic interventions as entry points refer to the PolyUrbanWaters approach (Source: Own Work, 2022)

Methodology

The methodological approach of the PolyUrbanWaters project in Krong Kratié was grounded in the internationally recognized DPSIR (Drivers–Pressures–State–Impact–Response) framework and complemented by spatial diagnostics, participatory planning tools, and iterative stakeholder engagement. (See Figure 88) This multi-layered approach enabled the project to generate an integrated urban development strategy rooted in both scientific evidence and community priorities.

Drivers of change in Kratié included rapid urban growth, climate variability, and socio-economic transformation, placing pressure on the city's limited infrastructure and ecological systems.

Pressures observed were unregulated construction in floodplains, inadequate drainage, degradation of wetlands, and reduction in urban vegetation. Ongoing urban densification has also contributed to the loss of remaining green spaces, weakening the city's capacity to regulate heat, absorb runoff, and provide public amenities.

The **State** of the urban environment was characterized by deteriorating wetland functions, reduced pervious surfaces, and a growing spatial mismatch between infrastructure services and expanding settlement areas. Spatial analysis using satellite data, land use mapping, and hydrological overlays identified multiple environmental stress zones.

Impacts from these pressures were severe and increasingly evident:

- **Flood vulnerability** has worsened due to blocked drainage channels, encroachment on natural waterways, and insufficient stormwater infrastructure.
- **Poor urban wetland management** has led to the disappearance of natural buffers, reduced water retention, and deterioration of water quality.
- **Urban heat island** effects are intensifying due to deforestation, sealed surfaces, and lack of shading.

In **Response,** the project promoted:

- **Green space development** as multifunctional infrastructure to manage runoff, improve air quality, and offer social and recreational benefits;
- **Improved flood management** through site-specific drainage improvements and preservation of ecological retention zones;
- **Effective** instruments for wastewater management including decentralized systems and sludge schemes;
- **Private green space initiatives** to support decentralized and inclusive adaptation;
- **Participatory planning** and co-design with communities.

The main output of this methodological process is the **Development Plan for Urban Wetlands of Krong Kratié (2024–2035),** which serves as a roadmap for resilient green space development.

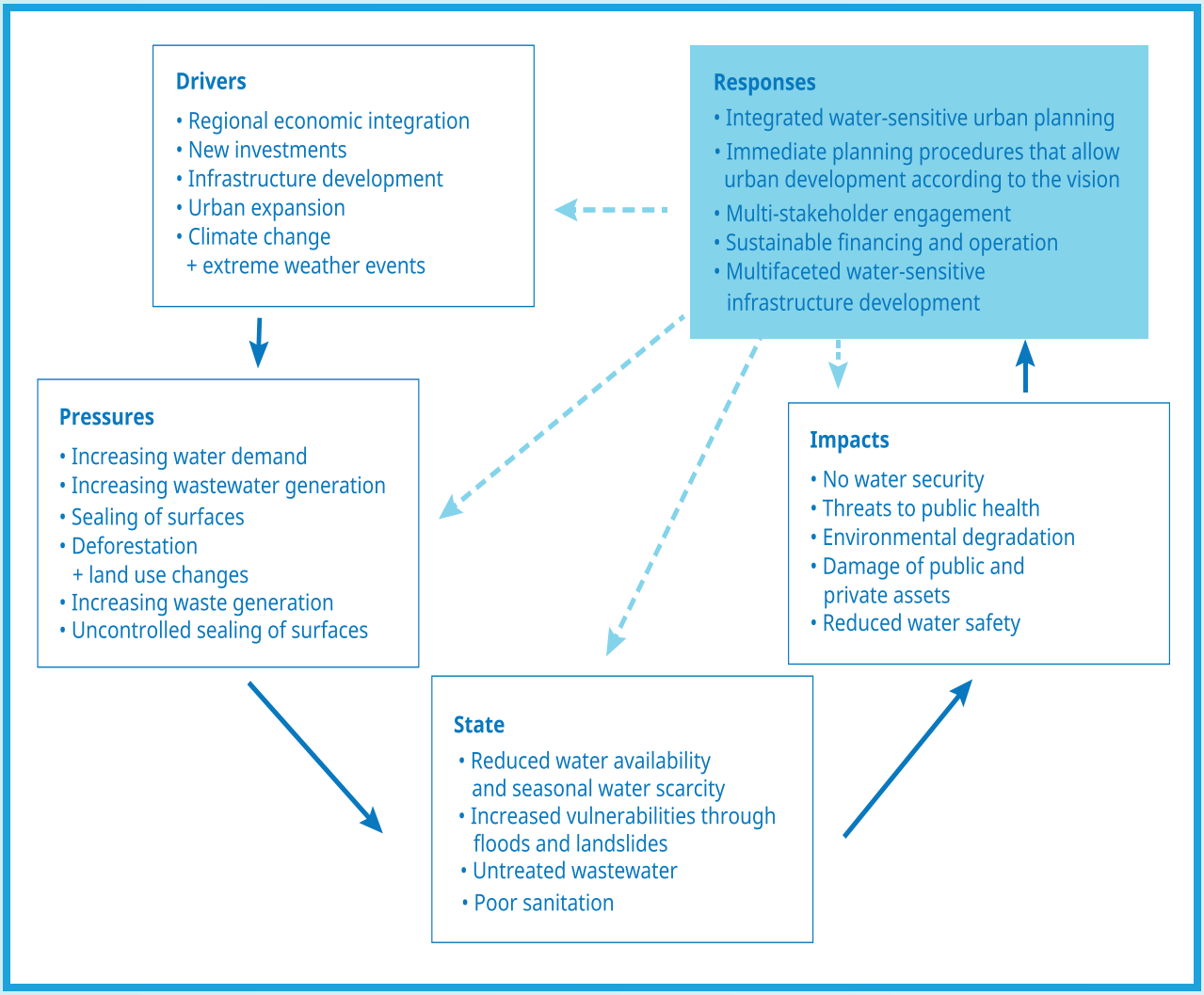

Figure 88 DPSIR-framework with selected parameters (Source: Own Work, 2021)

PolyUrbanWaters Project Stages Overall Process

The concrete localization of the polycentric management approach to urban waters has been guided by a co-production process consisting of three main steps. (See Figure 89)

1. Baseline assessment - what is the current status of water resources in the city? (Insights from local stakeholders)
2. Vision building - what might the city look like in 2030 and 2045? (Developing scenarios and visions together)
3. Transition pathways - how can we formulate concrete steps to achieve the vision? (Co-design approach)

The Baseline Study marked the initial phase of the PolyUrbanWaters research in Krong Kratié. Findings from this study informed the subsequent Vision Building stage, in which the project teams collaborate with local stakeholders to develop clear, realistic, and achievable visions and scenarios for the town. These ‘visions’ serve as guides for exploring the intersection of urban planning and water management, ultimately leading to the current stage: the design of actionable interventions or transition pathways in partnership with local stakeholders.

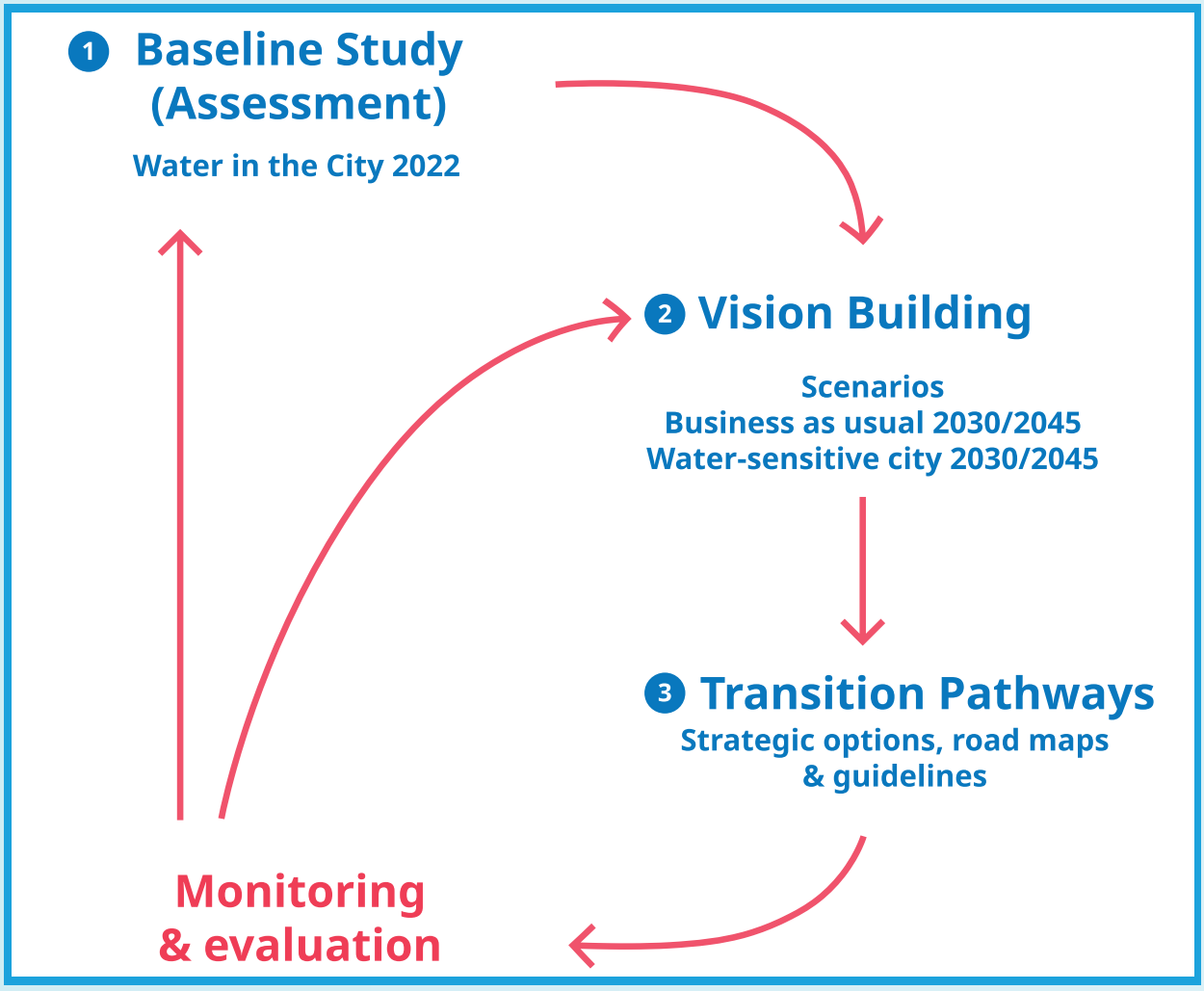

Figure 89 Main working process stages of PolyUrbanWaters project (Source: Own Work, 2019)

The “baseline study - scenario building - transition pathways” process has been underpinned by a robust science-policy dialogue and ongoing capacity development, while being analyzed from various perspectives, including:

- Urban water resources (supply, demand, quality);
- Social-ecological systems (e.g., Nature-based Solutions);
- Participatory methods;
- Governance models and SDG-oriented planning.

The initial field visits started in 2019 aimed to establish communication among project partners and draft a preliminary project design. While international research visits scheduled for 2020 and 2022 were hindered by COVID-19 travel restrictions, data collection transitioned to local efforts wherein BORDA Cambodia staff took on field research duties, maintaining constant virtual communication with the international team. Data was primarily gathered through stakeholder interviews with municipal and government officials, supplemented by field visits and support from government agencies and international partners. The international research team analyzed this data, ultimately leading to the initial draft of the Baseline Study, which was presented to Cambodian partners in February 2023.

Annex 9 Development Planning in Krong Kratié

The following section summarises the development goals and vision for Krong Kratié, formulated through workshops and meetings held from October 2023 to March 2024 culminating in the drafting of the Development Plan for Urban Wetlands for Krong Kratié 2024-2035. (See Annex 3 Development Plan for Urban Wetlands of Krong Kratié, 2024 to 2035)

In March 2024, a participatory workshop and field visit was organised in Krong Kratié with the primary stakeholders from key subnational departments (public works, land management, and planning) and the staff of the local sangkats as the official institution representing communities and residents. The objective was to assess three mainland sangkats bordering the lake for areas that could potentially be developed into Green Spaces and Recreational Areas: Sangkat Kratié, Sangkat O'Russey and Sangkat Roka Kandal.

Figure 90 Transect walk and workshop participants March 2024 (Source: Own Work, 2024)

The results of the field visit and subsequent workshop are summarised below.

Priority actions for Sangkat Kratié include establishing stormwater and wastewater connections to the lake to relieve localized flooding, upgrading and restoring existing drainage systems, and developing public amenities such as gardens, lighting, and seating along the White Bridge channel. The locations assessed include the area from the White Bridge south to the lake and the new development area east behind the existing urban area. (See Figure 91)

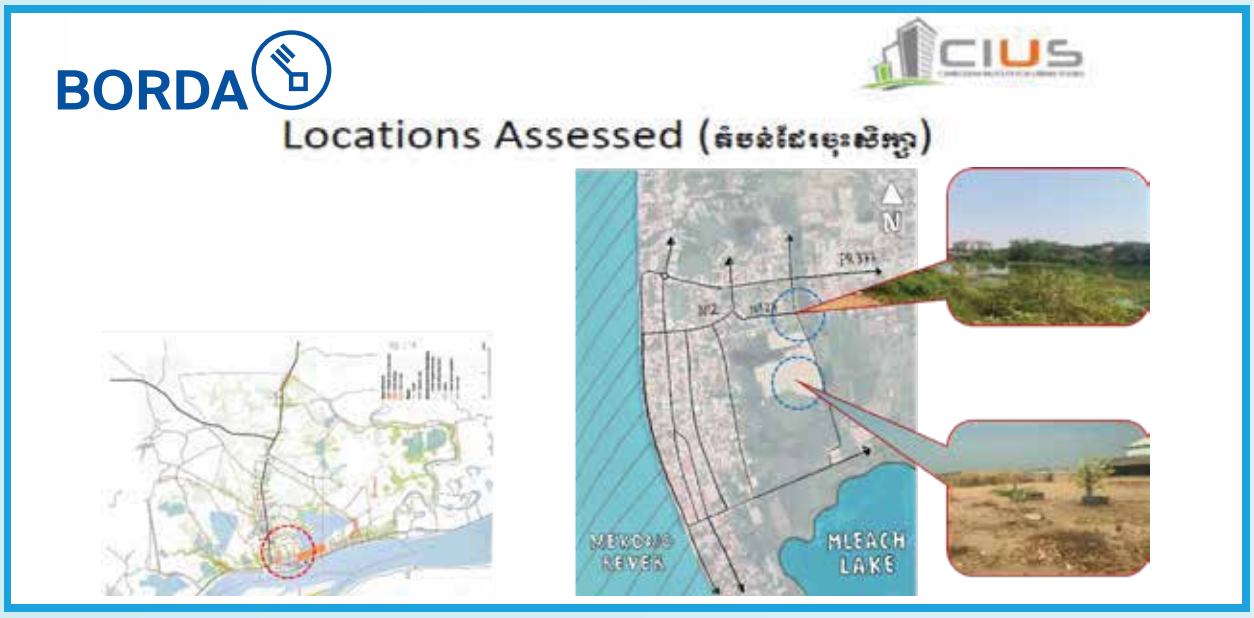

Figure 91 Locations assessed in Sangkat Kratié (Source: Workshop Output by CIUS, 2024)

Key initiatives in Sangkat Roka Kandal involve constructing a combined drainage system to prevent sewage flooding, addressing solutions for areas beyond the wastewater treatment plant's coverage, and enhancing existing drainage. Additional plans include creating a water reservoir, removing sediment to increase the lake's depth, and repairing roads while responding to residents' concerns regarding land use. The locations include the areas between the Mekong River and Boeung Romleach as well as south of the lake in the vicinity of the planned pumping station for the proposed wastewater treatment plant. (See Figure 92)

Figure 92 Locations assessed in Sangkat Roka Kandal (Source: Workshop Output by CIUS, 2024)

Locations assessed include the urban area in the vicinity of O'Russey Market and the new development area to the east of the lake within Boueng Romleach's flood expansion area. (See Figure 93) Priorities include implementing an effective drainage and sewage management system for Zone A, connecting households to infrastructure in Zone B, and maintaining water flow and road access in Zone C. There is also potential to develop recreational spaces to boost tourism by incorporating gardens and tree plantings.

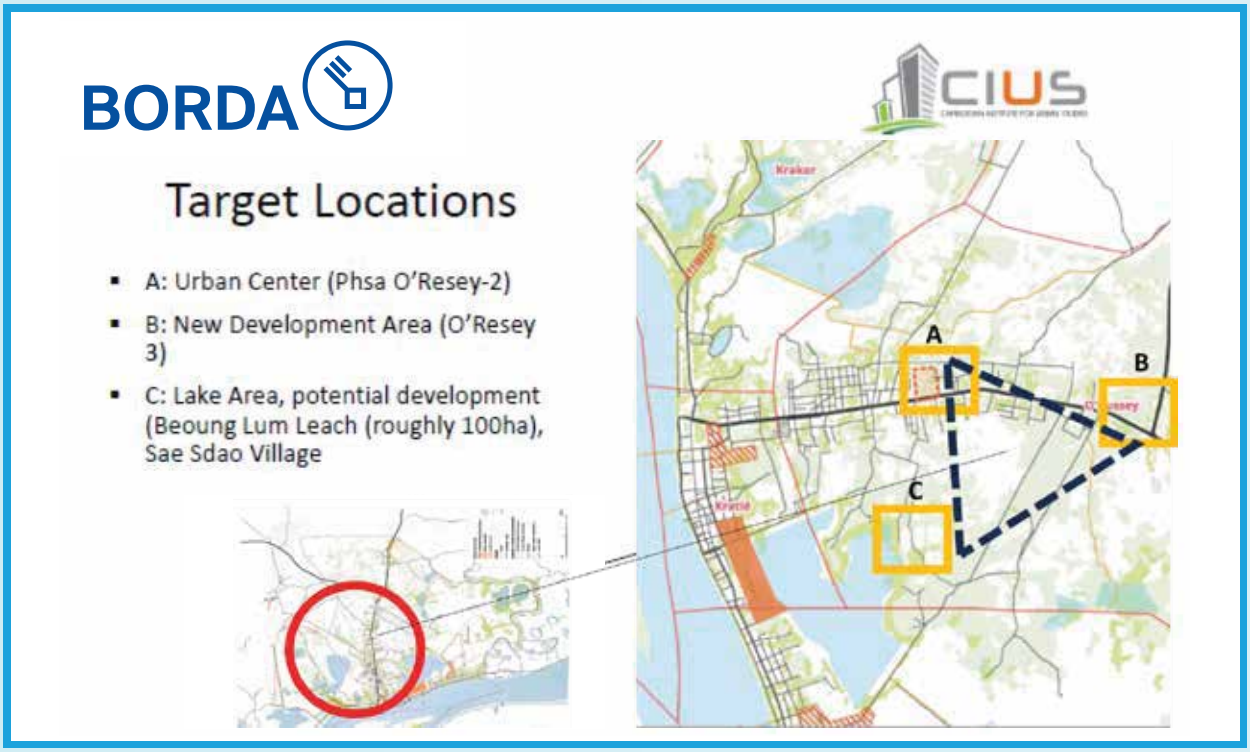

Figure 93 Locations assessed in Sangkat O'Russey (Source: Workshop Output by CIUS, 2024)

The results of the field visits and workshops indicate that development needs at the local level in Krong Kratié are primarily focused on enhancing water supply access and wastewater management, addressing climate change and related risks, and exploring potential tourism and ecological opportunities.

The Development Plan for Urban Wetlands of Krong Kratié 2024 to 2035

These vision building and transition pathways activities throughout 2024, confirmed the development strategies and priorities. With an increasing awareness of how crucial the lake area and other green areas within the city are to flood resilience, effective wastewater management and reductions in extreme temperatures, the Development Plan for Urban Wetlands of Krong Kratié was required to ensure that the key water-sensitive elements are addressed in future development planning and appropriately aligned: flood management, wastewater management and improvements in urban livability.

The Development Plan's vision for Krong Kratié is to progressively modernize and environmentally enhance the city, making it more attractive for residents, visitors, and businesses while contributing to long-term sustainable development. The goal is for Krong Kratié to become a model of sustainable urban development, harmonizing modernization with environmental water-sensitive management to bolster its appeal and functionality for business, residents and visitors. The Plan aims to recognise the Lake Area as a vital asset for sustainable development and bring it and other green areas into formal development planning focusing on economic, social, and ecological improvements. This plan seeks to boost livability, protect livelihoods, and strengthen resilience against extreme weather.

Seven priority strategies drive the Plan, including improving flood management, adopting improved wastewater management approaches, guiding urban expansion with green development principles, increasing urban greenery, integrating the lake into recreational and tourism frameworks, building capacity within governmental structures, and ensuring participatory planning. (For more details see Annex 3 Development Plan for Urban Wetlands of Krong Kratié, 2024 to 2035)

In September 2024, stakeholders were introduced to the final Development Plan, accompanied by a transect walk for green space planning. This workshop identified five potential development sites and discussed enhancing green space connectivity. A subsequent meeting in December 2024 facilitated a dialogue with subnational authorities about their interests and support needs for implementing the green space strategy, covering site identification, incremental development, landowner engagement, and community awareness efforts. Furthermore, in April 2025 green space designs for the identified sites were presented at a workshop during which initial stakeholder feedback was gathered by the project team, potential flood and wastewater management techniques were discussed and initial draft standard operating procedures for green space development in Krong Kratié were outlined with further localised contextualisation of these planned in the subsequent months.

Kratié, a growing secondary city in northeastern Cambodia, is experiencing frequent flooding, heat stress, shrinking green space and limited public amenities; this report, produced under the German funded FONA framework's PolyUrbanWaters project, charts a path to a more resilient, inclusive and livable city through multifunctional green infrastructure and water-sensitive design. Drawing on technical analysis, stakeholder engagement and participatory planning, the report identifies five priority interventions that demonstrate practical, scalable solutions to strengthen climate adaptation, enhance public green space accessibility and preserve the environment in response to the impacts of climate change.

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