

Development Plan for Urban Wetlands of Krong Kratié 2024 – 2035

Annexes

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Annex Introduction

Development framework

Vision	Modernizing and greening the city to make it a more attractive place to live, visit and do business, contributing to the Krong's long-term sustainable development.						
Objectives	1. Urban modernization that is based on the sustainable management of the Krong's natural resources;		2. Effective infrastructure development by systematic integration of the lake area with its eco-system services		3. Socio-economic development that valorizes the lake area as a strategic asset for community and tourism development.		
Goals	1. Improving Livability	2. Mitigating Flood Vulnerability	3. Ensuring Community Livelihoods	4. Strengthening Climate Resilience	5. Preserving Ecosystem Services	6. Enhancing Governance	
Priority Strategies	1. Flood Management	2. Wastewater Management	3. Urban Expansion and Green Development	4. Green Space Development	5. Recreation and Tourism Development	6. Capacity Building	7. Participatory Planning
Implementation Strategies	Implementation Strategy 1: Flood Management		Implementation Strategy 2: Green Space and Recreational Area Development		Implementation Strategy 3: Wastewater Management		
Key Strategic Elements	<ol style="list-style-type: none"> Strategic Vision Creation Further improvement and development of drainage system Ensuring flood absorption capacity of the Lake Area and its water flows. Reduce risk of drainage system blockages that can exacerbate flooding through effective solid waste management practices Capacity Development Programs: 		<ol style="list-style-type: none"> Strategic Vision Creation Awareness Campaign for Green Private Spaces and Business Premises' Tree Planting Identify and Develop Five Key Green Spaces in Krong Kratié Development of Green Recreational and Tourist Infrastructure along Waterfront, White Channel, and New Expansion Areas Concepts of Integrating Green Spaces into New Expansion Areas 		<ol style="list-style-type: none"> Strategic Vision Creation Develop Sanitation Plans for Urban Areas and Lake Area Centralized Wastewater Treatment Promote Decentralized Wastewater Solutions Integrate Fertilizer Management into Wastewater Strategy 		

Table 1. Development Framework

Location of Krong Kratié



Figure 1. Location of Krong Kratié and Kratié Province (Source: Own work, 2020)

Peak areas inundated between 2015 and 2022



Figure 3. Peak areas innundated between 2015 and 2022

(Source: Own Work based on Global Administrative Areas (GADM), 2012; & Copernicus Sentinel-1 Data [2015 - 2022])

Annex Chapter 1: Parts 1 and 2

SWOT analysis methodology

The methodology for conducting the SWOT analysis consisted of synthesizing the results of four activities with the input from local stakeholders and then validated by the same stakeholders by October 2024.

- **2019 to 2023:** Research and development of the Baseline Assessment with significant input from a variety of government stakeholders and partners.
- **October 2023:** Vision building and development goal planning workshop to identify specific localized challenges.
- **March 2024:** Transect Walk and workshop to identify solutions per sangkats.
- **March 2024 to October 2024:** Drafting of the Development Plan for Urban Wetlands for Krong Kratié 2024 to 2035.
- **October 2024:** Presentation and Introduction of the Development Plan for Urban Wetlands for Krong Kratié 2024 to 2035's SWOT Analysis for stakeholder feedback and validation.

Annex Part 1: Analysis of the existing and emerging water challenges in the context of urban development and climate change in Krong Kratié

Overview of distribution of population and densities in different sangkats

Sangkat	Village	Population (2020)	Area (km ²)	Density (population/km ²)
Koh Trong		1860	14,97	124,25
	Kbal Koh	970	10,53	92,12
	Chong Koh	890	4,44	200,45
Kra Kor		4189	14,81	282,85
	Kra Kor	3066	6,32	485,13
	Toul Monorum	1123	8,49	132,27
Kratié		6475	4,34	1491,94
	Daun Chraom	1528	0,44	3472,73
	Kratié	1540	0,51	3019,61
	Phsar Veng	666	0,82	812,20
	Trapang Pring	1709	0,5	3418,00
	Wat	1032	2,07	498,55
O'Russey		13111	32,47	403,79
	Kantreung	1074	2,65	405,28
	Kapo	2901	15,64	185,49
	O'Russey Ti Mouy	2565	1,11	2310,81
	O'Russey Ti Pi	2831	4,82	587,34
	Srae Sdao	3740	8,25	453,33
Roka Kandal		6208	24,83	250,02
	Ti Mouy	2976	16,53	180,04
	Ti Pi	3232	8,3	389,40
Total	Krong Kratie	31843	91,42	348,32

Table 2. Distribution of Population and Densities in Different Sangkats

(Source: National Institute of Statistics (NIS), 2020)

Mean annual temperature and precipitation 1981 to 2021

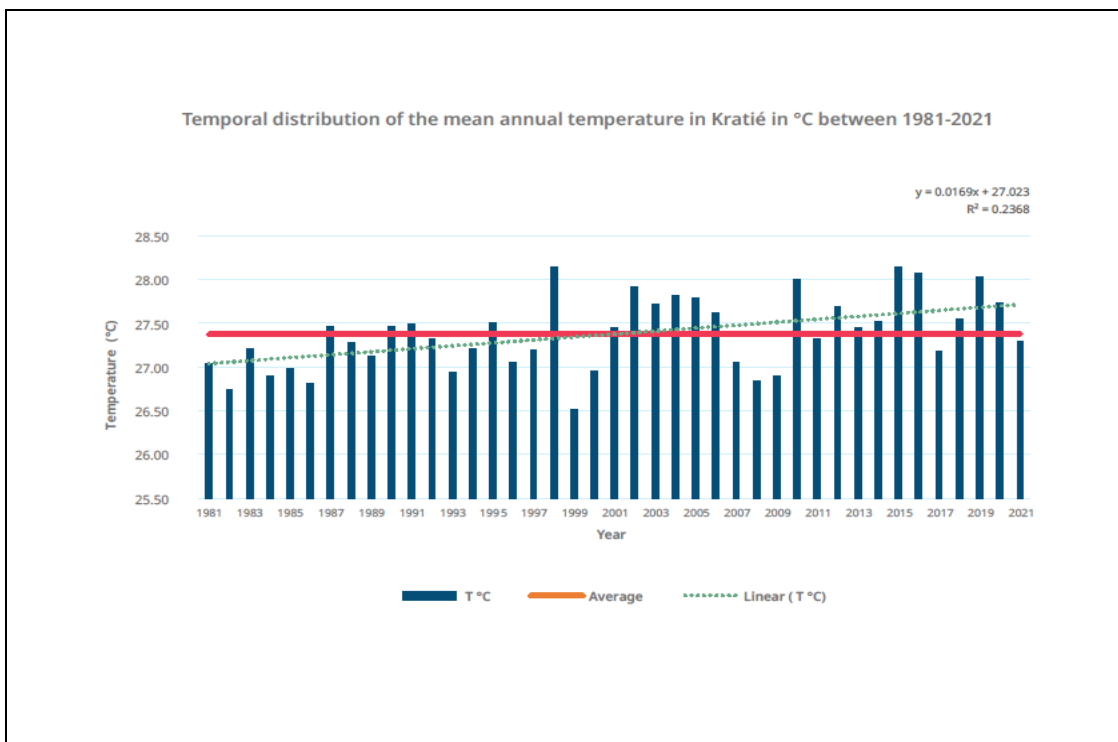


Figure 4. Temporal distribution of the mean annual temperature in Krong Kratié in °C between 1981-2021 (Source: Own Work based on Muñoz Sabater, 2019)

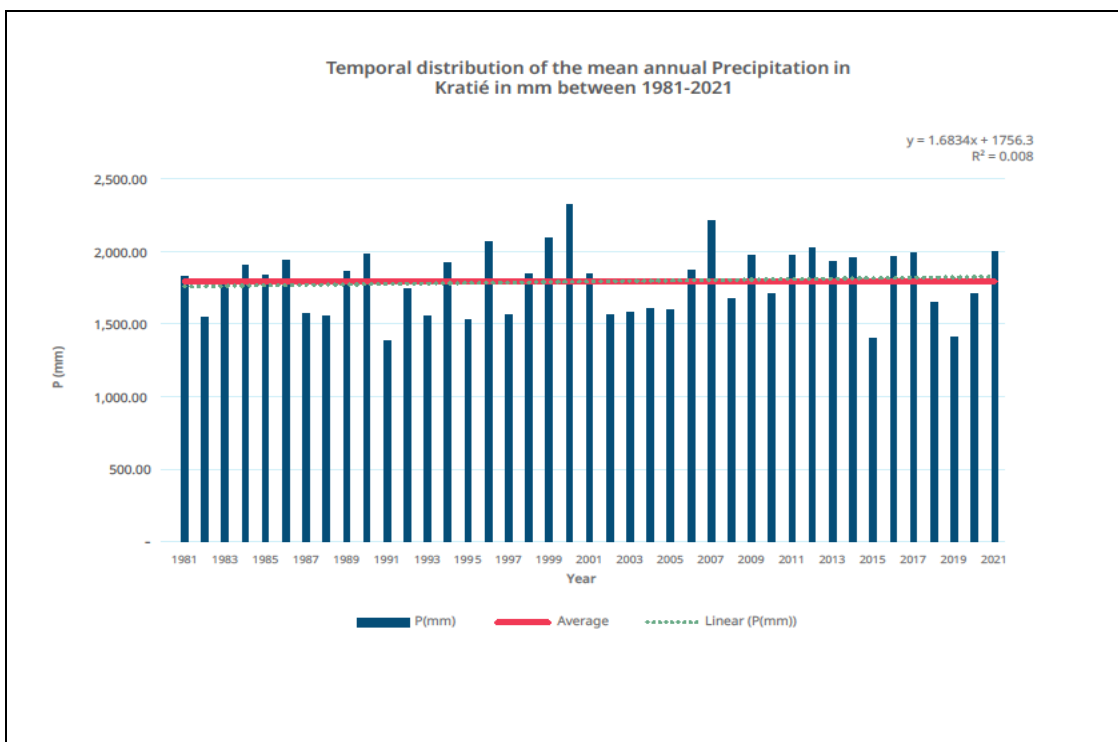


Figure 5. Temporal distribution of the mean annual precipitation in Krong Kratié in °C between 1981-2021 (Source: Own Work based on Funk et al., 2015)

Kratié's elongated form between Mekong River and seasonal lakes and wetlands

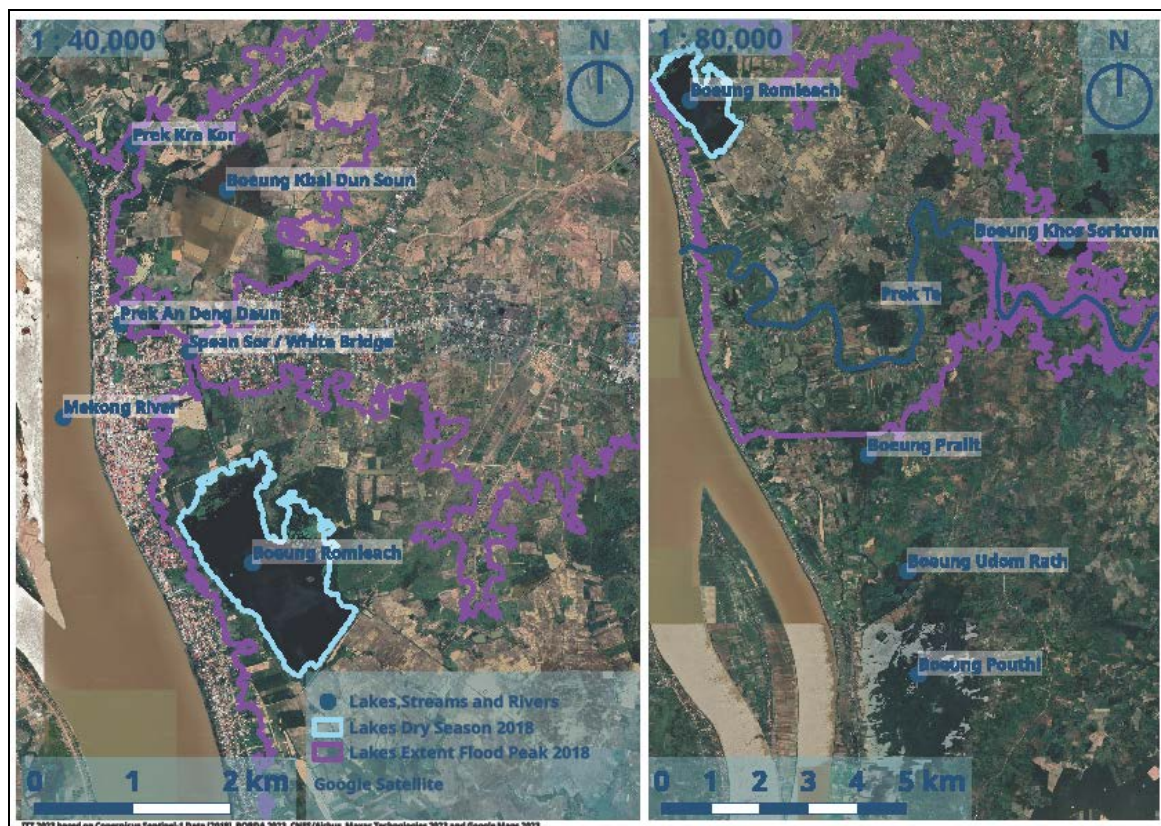


Figure 6. Boeungs (lakes and wetlands) in the vicinity of Krong Kratié (Source: Own Work based on Copernicus Sentinel-1 Data, 2018; CNES/Airbus; & Maxar Technologie)



Figure 7. The lake area as natural system of flood control - Aerial photo of Boeung Romleach

(Source: Smith, 2014)

Examples of sealing surfaces with concrete



Figure 8. Examples of concrete sealing at [Left] Krong Kratié Bus Station [Right] Krong Kratié Market (Source: Own Photo taken in 2023)



Figure 9: Examples of concrete surfaces completely covering grounds of roads and a property in central area (Source: Smith, 2014)

Annex Part 2: Analysis of the Relevance of and Development Challenges for Lake Area for the Sustainable Development of Krong Kratié

Development activities in and around the new development area



Figure 10. Development Activities in and around the New Development Area

(Source: Own Photo taken in 2023)

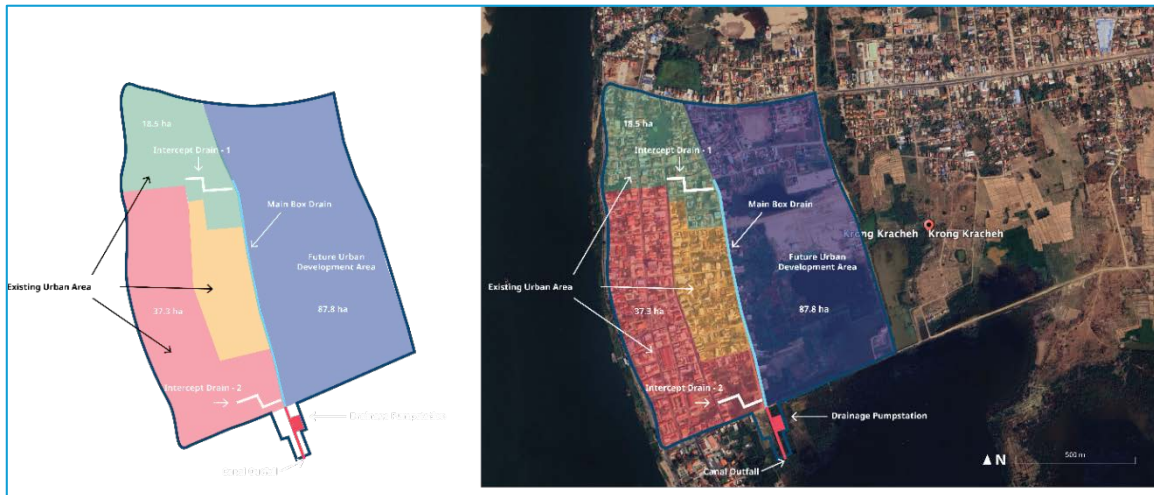


Figure 11. ADB Site Map and Google Map for Subproject Drainage and Pumping Station
(Source: cited in ADB. 2024)

Examples of lake area context outside of the new development area



Figure 12. Examples of Lake Area Context Outside of the New Development Area

(Source: Own Photo taken in 2023)

Annex Strategic Field 1: Flood management

Flood management relevant key information

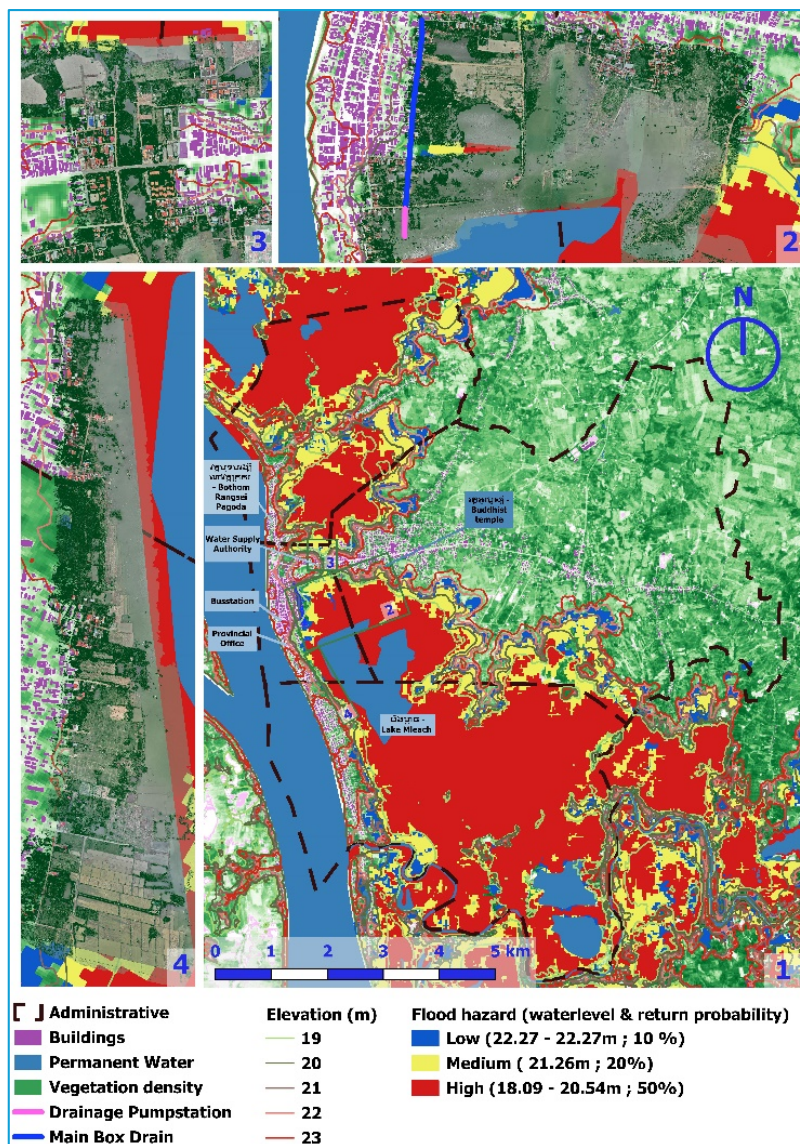


Figure 13. Flood hazard in Krong Kratié based on observed seasonal flood peaks 2015 – 2023

(Source: Own Work, 2024)

- Recorded flood peak events inundate areas up to ca. 21.5 meters above sea-level (masl) (Mekong water level of 22.5m).
- Buildings are largely located higher than 23masl, except for Kratié town center around the bus station, which is mostly 22 - 23masl.
- In case of extreme flood event with 23m or above, large sections of the town center would be flooded, and drainage systems become dysfunctional
- Exposure to flood hazards is significantly reduced for urban expansion above 23masl or more, primarily located east of Lake Romleach.

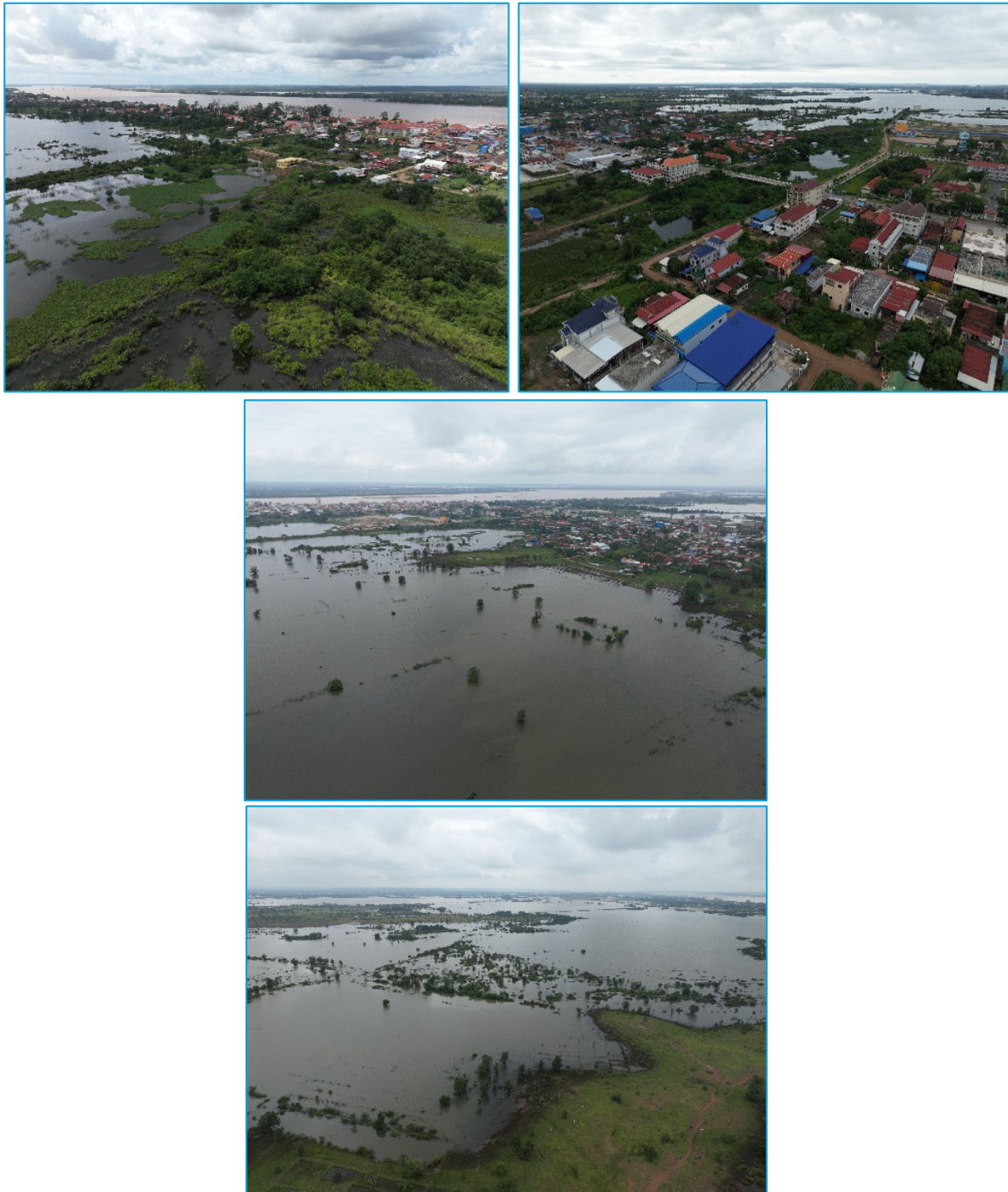


Figure 14. Drone images ADB Sub-Project Drainage site (Top Left), White Bridge channel (Top Right) North & East of Lake Romleach (Top and Bottom)

(Source: Own Work, 2023)

Examples of the development of green-blue infrastructure for flood management

Example of a bioswale between a walking path and a green area. In a neighbourhood, property owners can create a bioswale in existing roadside ditches (See below).

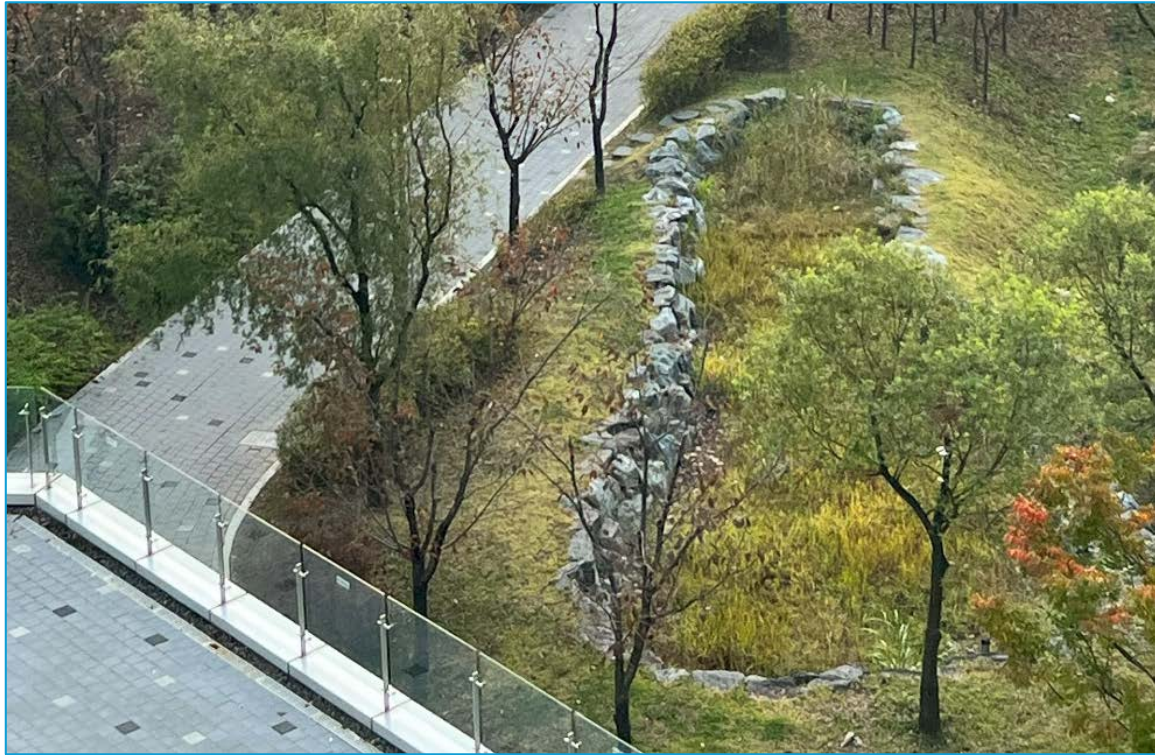


Figure 15. An example of a bioswale in between a walking path and green area
(Source: PUW, field visit in Seoul, South Korea, 2023)



Figure 16. An example of a ditch between main road and property wall in Krong Siem Reap that can be redesigned to act as a bioswale (Source: Own photo take in 2024)

Example of permeable concrete surfaces: permeable surfaces encourage stormwater to infiltrate rather than runoff



Figure 17: Example of permeable concrete surface used for parking on private property in Krong Siem Reap, Cambodia (Source: Own Photo taken in 2024)

Annex Strategic Field 2: Development of Green Spaces and Recreational Areas

Public space and green area zone definition

“Zones with predominantly green areas and facilities that primarily serve relaxation, recreation and/ or ceremonial functions and are open to the public.”

Public Space and Green Area Zones can contain following uses and activities: “Public parks such as municipal parks, commune/sangkat parks, neighborhood/village parks and children’s playgrounds regional parks, forest parks, botanical and zoological gardens. Roadside parks and boulevards; Sports fields and stadiums of all kinds, including their service facilities; Swimming pools and golf courses; Monuments (statues) and their surrounding public area; Picnic areas, rod-fishing areas, boating areas, small scale cafes and restaurants that are not disrupting the public green function, small scale facilities that serve the public green function, such as parking space, public toilets, boat station etc.” (MLMUPC, 2016).

According to the Royal Government Sub-decree on Urbanization of the Capital City, Towns and Urban Areas (2015, p. 26), Section 3 Public Space, Article 45, “Organization of public space in an area where construction can take place shall be set at 1 (one) hectare per 1000 people or at least 15% of the total land area in which the construction can take place.”

Kratié green space map

The Kratié Green Space Map 2023 below shows:

- Existing official public green spaces are limited to Child Garden and area surrounding Pa Cha Pagoda
- Officially planned, suitable public green spaces, include the Mekong River promenade, shore line areas around Beoung Meleach / Romleach, Spean Sor (White Bridge) channel. Specific sites for development into public green recreation infrastructure will be assessed on suitable criteria for environmental, social and urban planning and design.
- Within the built-up area, there are limited private green spaces located within private premises that should be preserved through appropriate controls and ordinances. A policy will be recommended to retain and maintain these existing green spaces. Additionally, new developments on private premises should designate a minimum agreed percentage of the area for green spaces.
- Overall, existing green areas are not interconnected to create a *network*



Figure 18. Map of identified and planned green spaces around Sangkat Kratié

(Source: TU Berlin 2023)

Examples for development of green recreational and tourist infrastructure along Waterfront, White Channel, and New Expansion Areas

1. **Tree-Lined Channels and Recreational Pathways:** tree-lined paths along water channels to improve landscape aesthetics and ecological value. Well-defined paths for walking, jogging, cycling etc.



Figure 19. Examples of a new tree-lined recreational corridor park in Siem Reap, for walking, jogging, cycling, etc.

(Source: PUW, 2023)



Figure 20. Tree-lined walking path/ park next to waterway in Vientiane, Laos

(Source: PUW 2022)

2. Waterfront Development: enhancement of existing waterfront areas with additional greenery and recreational pathways.

Hoi An, Vietnam



Figure 21. Example of Thu Bon River in Hoi an with new trees and waterfront paths

(Source: evivatour, 2022)



Figure 22. Example of a reinforced riverfront area with greenery in Hoi An, Vietnam

(Source: Shutterstock, 2022)

Annex Strategic Field 3: Wastewater Management

Current drainage system Krong Kratié

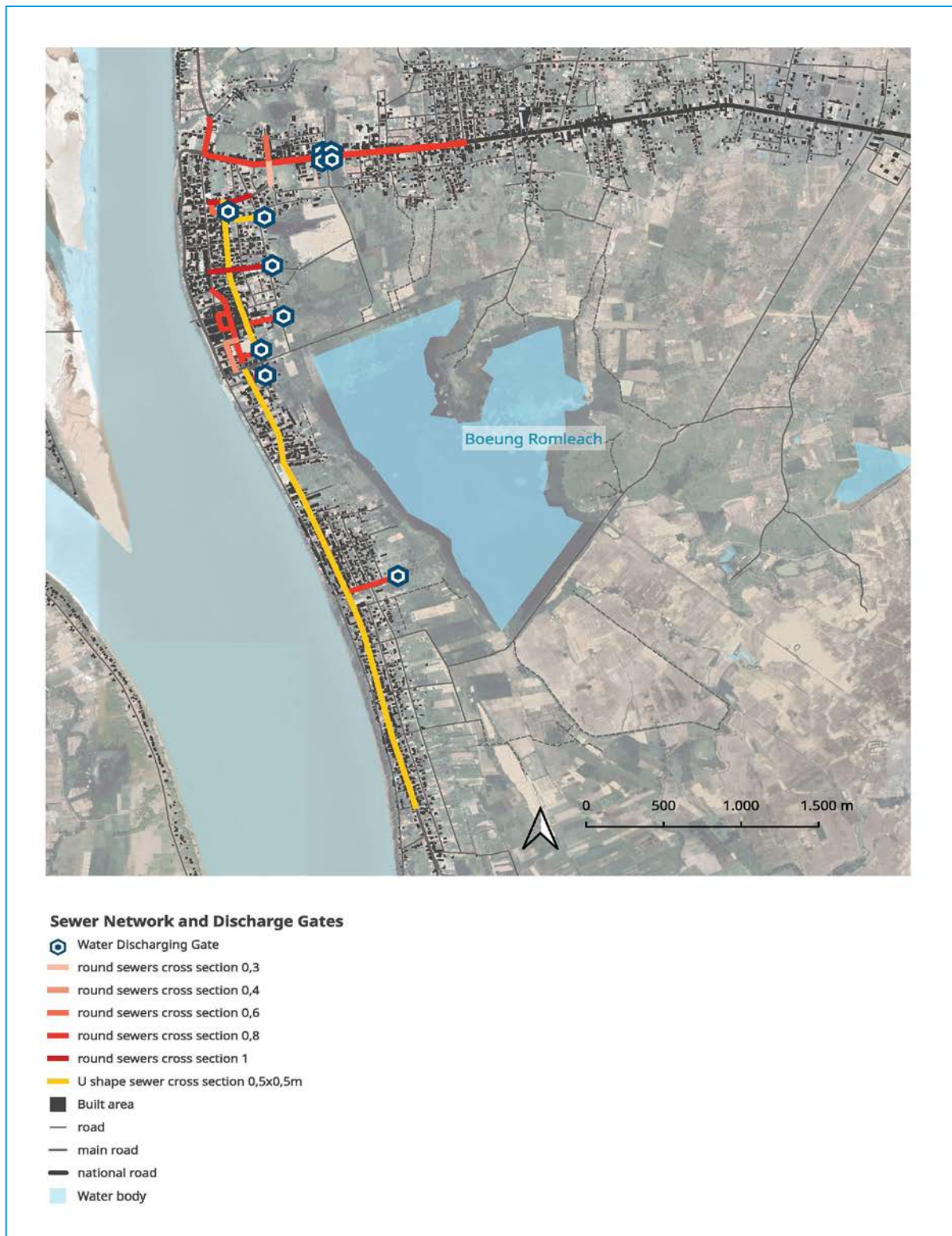


Figure 23. Current drainage system Krong Kratié (Source: Own Work based on RGC, 2022, p.115)

Current combined stormwater and wastewater drainage flow in and around Krong Kratié

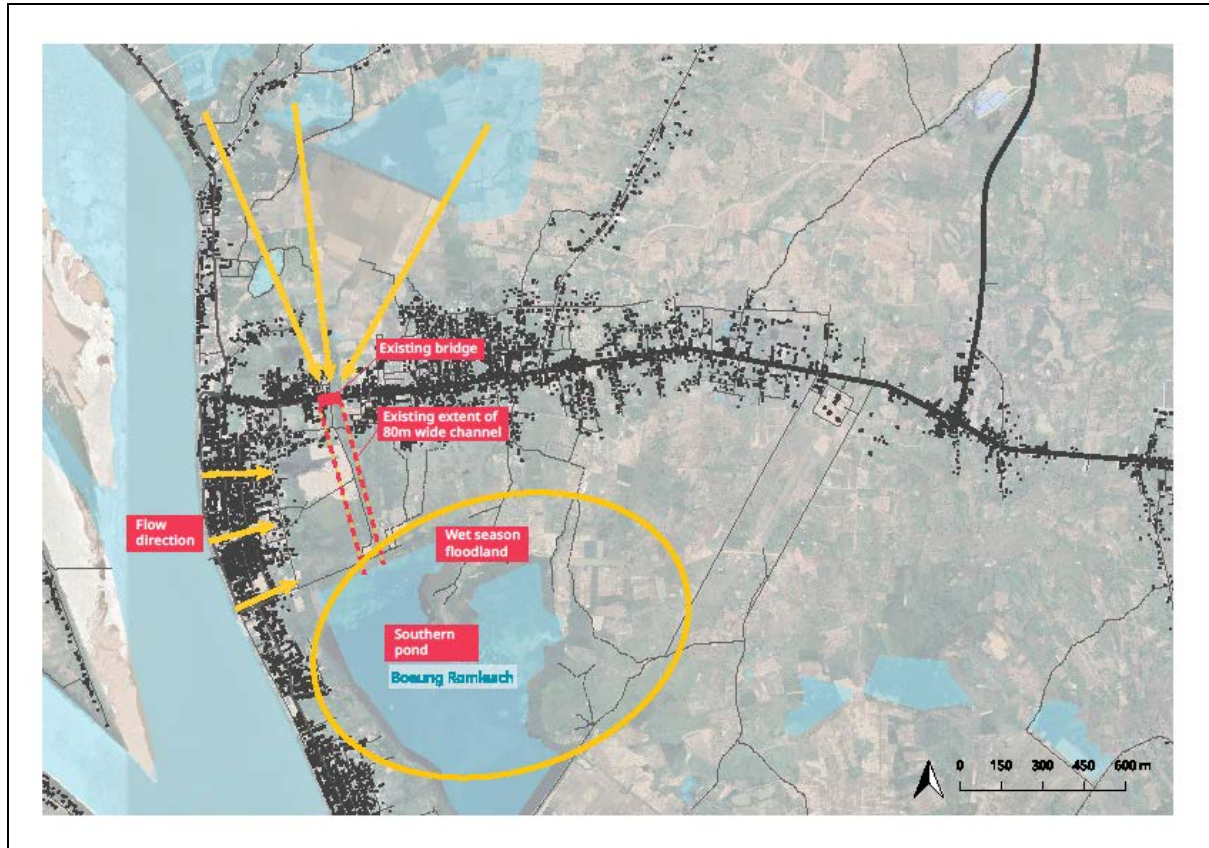


Figure 24. Current Combined Stormwater and Wastewater Drainage Flow In and Around Krong Kratié
(Source: Own Work based on ADB, 2018, p.42)

Examples of decentralized wastewater solutions

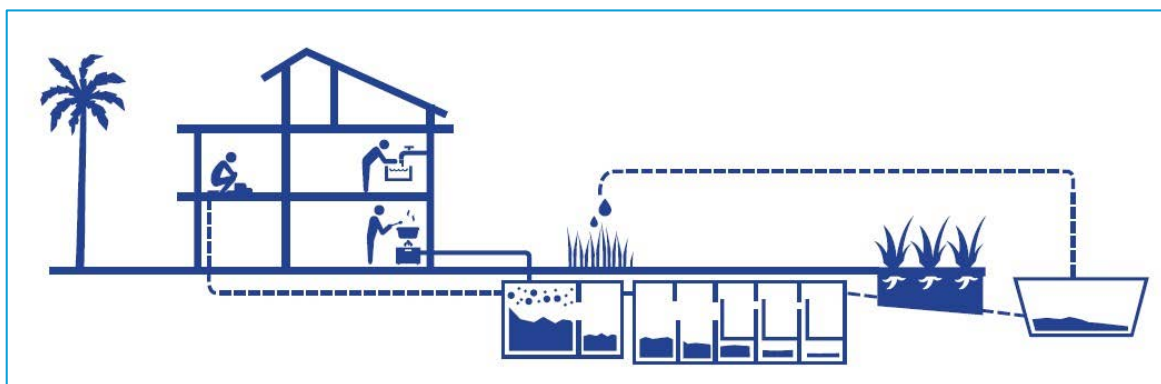


Figure 25. Examples of Decentralised Wastewater Solutions
(Source: BORDA 2017)

Example of chemical inputs used in rice farming in the lake area in Krong Kratié



Figure 26. Chemical Inputs Used in Agriculture in Krong Kratié

(Source: Own Photo taken in 2023)

References

Asian Development Bank. (February 2024). Environmental Management Plan. Stormwater Drainage Diversion and Drainage Pumping Station Subproject, Kratie City, Kratie Province. Cambodia: Fourth Greater Mekong Subregion Corridor Towns Development Project. Mandaluyong City, Philippines: Asian Development Bank.

Asian Development Bank. (January, 2018). Proposed Urban Infrastructure Subprojects for Development to Preliminary Engineering Design. Technical Annex. Cambodia: Fourth Greater Mekong Subregion Corridor Towns Development Project. Mandaluyong City, Philippines: Asian Development Bank.

Bremen Overseas Research and Development Association. (2017). DEWATS Implementation by BORDA. Bremen, Germany: Bremen Overseas Research and Development Association.

Ministry of Land Management, Urban Planning and Construction. (2016). District & Municipal Land Use Master Plan and Land Use Plan Handbook.

PolyUrbanWaters Project (2023). Towards a Sustainable and Water-Sensitive Krong Kratié, Cambodia. Baseline Assessment. Findings and Strategy Development. Phnom Penh, Cambodia: Bremen Overseas Research and Development Association.

Royal Government of Cambodia (RGC). (2022). Report on the Project to Improve the Drainage System and Mixed Water System in Kratié City, Kratié Province, Ministry of Public Works and Transportation, Phnom Penh.

Royal Government of Cambodia. (2015). Sub-decree on Urbanization of the Capital City, Towns and Urban Areas.

Ting, T. P. (2012). Urban Green Spaces and Liveability in Southeast Asia. In *Urbanization in Southeast Asia: Issues and Impacts* (pp. 262–276). chapter, ISEAS–Yusof Ishak Institute

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