# Towards a Sustainable and Water-Sensitive Kratié, Cambodia.

## Executive Summary of Baseline Assessment
## Findings and Recommendations

POLYURBAN WATERS

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**March 2023**

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# List of Abbreviations and Acronyms

| | |
|---|---|
| ADB | Asian Development Bank |
| BMBF | German Federal Ministry for Education and Research |
| BOD | Biochemical Oxygen Demand |
| BORDA | Bremen Oversears Research and Development Association |
| CDB | Comune Database |
| CIUS | Cambodian Institute of Urban Studies |
| COD | Chemical Oxygen Demand |
| CSDG | Cambodian SDGs |
| ESC | Environmental Sanitation Cambodia |
| FSM | Faecal Sludge Management |
| FONA | Research for Sustainability |
| GMS | Greater Mekong Sub-region |
| GMSCTDP | Fourth Greater Mekong Subregion Corridor Towns Development Project |
| ITT | Institute for Technology and Resources Management in the Tropics and Subtropics |
| IWRM | Integrated Water Resource Management |
| NSDP | National Strategic Development Plan |
| PUW | Polycentric Management of Urban Waters |
| RGC | Royal Government of Cambodia |
| SDG | 2030 Agenda for Sustainable Development |
| SNA | Sub-National Administration |
| SWM | Solid Waste Management |

| | |
|---|---|
| **TUB** | **Technical University Berlin** |
| **USD** | **United States Dollar** |
| **WWTP** | **Waste Water Treatment Plant** |

# Terminology and Definitions

**Adaptive capacity:** The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities (IPCC, 2012).

**Baseline/reference:** The baseline (or reference) is the state against which change is measured. It might be a 'current baseline,' in which case it represents observable, present-day conditions. It might also be a 'future baseline,' which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines (IPCC, 2012).

**Biochemical Oxygen Demand (BOD):** describes how much oxygen is required for the oxidisation of matter, which can be oxidised biologically with the help of bacteria (Ulrich et al., 2009).

**Blue Infrastructure:** European Commission stated that blue infrastructure is understood as a strategically planned and intensively managed system of natural, semi-natural and man-made water-based features such as coastal areas, rivers, lakes, wetlands but also designed elements such as artificial channels, ponds, water reservoirs, retention basins and tanks as well as urban waste water networks.

**Catchment:** An area that collects and drains precipitation (IPCC, 2012).

**Chemical Oxygen Demand (COD):** is the most common parameter for measuring organic pollution. It describes how much oxygen is required to oxidise all organic and inorganic matter found in water (Ulrich et al., 2009).

**Climate change:** A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2012).

**Climate:** in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. In various chapters in this report different averaging periods, such as a period of 20 years, are also used. (IPCC, 2012).

**Disaster management:** Social processes for designing, implementing, and evaluating strategies, policies, and measures that promote and improve disaster preparedness, response, and recovery practices at different organizational and societal levels (IPCC, 2012).

**Disaster risk:** The likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical

events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2012).

**Drought:** A period of abnormally dry weather long enough to cause a serious hydrological imbalance (IPCC, 2012).

**Evapotranspiration:** This refers to evaporation (E) from soil, plant surfaces and water bodies and the transpiration (T) through plant canopies. The term is useful in regards agriculture where the actual evapotranspiration relates to the Crop Water Requirements.

**Exposure:** The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas ([UNDRR] United Nations Office for Disaster Risk Reduction, 2020).

**Flood:** The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods (IPCC, 2012).

**Green Infrastructure:** Strategically planned and intensively managed systems of natural, semi-natural and man-made land-based features such as terrestrial protected areas, field margins in intensive agricultural land, ecoducts and tunnels for animals, parks and green roofs in cities (Lucius et .al, 2011).

**Grey Infrastructure:** This term is often used to oppose what is called "Green-blue (or natural) infrastructure", it refers to any hard structure or traditional engineering solutions (UNEP, 2019).

**Greywater:** is the total volume of water generated from washing food, clothes and dishware, as well as from bathing, but not from toilets. It may contain traces of Excreta (e.g., from washing diapers) and, therefore, also pathogens. Greywater accounts for approximately 65% of the wastewater produced in households with flush toilets (IWA, 2016).

**Hazard:** A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation ([UNDRR] United Nations Office for Disaster Risk Reduction, 2020).

**Hydrological/water cycle:** The cycle in which water evaporates from the oceans and the land surface, is carried over the Earth in atmospheric circulation as water vapour, condenses to form clouds, precipitates again as rain or snow, is intercepted by trees and vegetation, provides runoff on the land surface, infiltrates into soils, recharges groundwater, and/or discharges into streams and flows out into the oceans, and ultimately evaporates again from the oceans or land surface. The various systems involved in the hydrological cycle are usually referred to as hydrological systems (IPCC, 2012).

**Indicator:** A single variable or parameter that quantifies the state of a system (Walz, 2000)

**Index:** Combination of single indicators in a dimensionless number (Mitchell et al., 1995)

**Integrated Water Resource Management:** Is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP, 2011).

**Land use and land use change:** Land use refers to the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation). Land use change refers to a change in the use or management of land by humans, which may lead to a change in land cover (IPCC, 2012).

**Nature-based solutions (NbS):** have been defined as “actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” (IUCN, 2016). NBS are not intended to replace grey infrastructure and technical solutions but rather to integrate with them in order to form resilient combinations that adapt to complex systems and changing environments (Haase, 2015), (Bai, 2018) recommends applying a “kaleidoscope” approach when working with NBS. An approach that connects to the principles of urban ecology and acknowledges existing settings (governance, social systems & infrastructure) while initiating truly creative interconnections that go beyond a grey, blue or green focus.

**Polycentric management of urban waters (PUW):** The concept of PUW considers the challenges for urban areas and settlements to include "water" as a cross-cutting issue requiring cross-sectoral solutions. PUW brings together security of supply of water-related services (water supply, waste water and waste management, flood management, etc.), resilience to the impacts of climate change, and the creation of liveable and inclusive urban spaces in an integrated approach to sustainable water resource management (IWRM) and participatory urban development planning. The solutions are developed and implemented according to the specific natural and socio-economic characteristics of the respective urban areas, the regulatory frameworks, and the financial and institutional capacities of the towns and local stakeholders.

**Progressive Implementation:** This principle follows the Agenda 21 of the United Nations Conference on Environment & Development Rio de Janerio, 1992. Infrastructure development should be guided in accordance with local capacities and the local context in order to ensure sustainable maintenance and operation (UNSD, 1992).

**Resilience:** The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning, and transformation Progressive Implementation (Sutton et al., 2011). The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012).

**Risk:** Potential for adverse consequences for human or ecological systems as a result from dynamic interactions between hazards, exposure and vulnerability of the affected human or ecological system (IPCC, 2022)

**Runoff:** That part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water (IPCC, 2022)

**Urban heat island:** The relative warmth of a city compared with surrounding rural areas, associated with changes in runoff, the concrete jungle effects on heat retention, changes in surface albedo, changes in pollution and aerosols, and so on (IPCC, 2012).

**Urban Waters:** is a concept of sustainable urban water management. Urban waters within the city (including reservoir and aquifer water, desalinated water, recycled water and stormwater) are managed in a way that maximises the achievement of urban liveability outcomes and resilience to unexpected social, economic or bio-physical shocks (IWA, 2016)

**Vulnerability:** The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC, 2022). The characteristics and circumstances of a community, system, or asset that make it susceptible to the damaging effects of a hazard (UNEP, 2019)

**Wastewater:** is the mixture of urine, faeces and flush-water along with anal cleansing water (if water is used for cleansing) and/or dry cleansing materials). Wastewater contains the pathogens of faeces and the nutrients of urine that are diluted in the flush-water (IWA, 2016).

**Water security:** is defined here as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UNU-INWEH, 2013).

**Water sensitive urban development:** In helping cities transition to ecologically based systems that also address climate change impacts, urbanization, and population growth, the Water Sensitive Urban Design (WSUD) approach has been evolving and implemented in existing and new developments around the world since the 1990s, including Asia through the use of various tools and technical solutions that integrate the natural elements of water, plants and soil while maintaining the natural water cycle. With new designs for building suburbs mitigate water discharge from heavy rainfalls by absorbing, storing and using stormwater runoff (rather than losing runoff to direct drainage from impervious surfaces to waterways), WSUD can deliver multiple benefits including increased, better-quality water supply, stormwater quality improvements, flood control, landscape amenity, healthy living environments, and ecosystem health. Essentially, WSUD emphasises alternative urban water supplies that reduce the stress on a town's water treatment facilities, re-naturalize water courses and associated riparian areas, and install vegetative technologies that create attractive urban streets while providing much-improved stormwater quality (Sharma et al., 2018). In directly, such improvements to the urban living environment can increase land values and expand tourism and other business opportunities (IWA, 2016).


# Kratié, Cambodia

**Location:**
Northeast Cambodia, Kratié Province

**Villages:**
16

**Population (2019):**
31,843

**Figure 1.** Location of Kratié (Source TUB, 2020)

# Overview and Application of the Study Results

## Targets of the Study

PolyUrbanWaters[1] – an international network of practitioners, scholars and experts – in 2020 was invited by the Kratié provincial and municipal government to give support to the application of possible interventions to contribute to the localised approach to achieving the selected Sustainable Development Goals in Krong Kratié[2].

Instruments applied by the polycentric approaches to the water-sensitive management of urban development should contribute to the improvement of:

- The liveability of the city;
- The livelihood of the local population and of economic development dynamism;
- Provision of public services, such as sanitation;
- The resilience of the city to flooding events.

## Towards a Vision for the Sustainable Development of Krong Kratié

The results of the study show that a possible vision for Krong Kratié that focuses on both greening and modernizing the city could make it an attractive place to live, visit and do business, contributing to the Krong's long-term sustainable development. To give guidance to the sustainable development of the Krong/ municipality, associated underlying strategic fields of activities are needed:

1 The PolyUrbanWaters (Polycentric Approaches to the Management of Urban Waters) project is funded by the German Federal Ministry for Education and Research (BMBF) and is implemented in three partner secondary and tertiary cities in Southeast Asia: Kratié, Cambodia; Sam Neua, Lao PDR; Sariharjo in Sleman Regency, Indonesia.

2 Krong is the Khmer language word for both town and city

- Krong Kratié sustainably manages and develops its rich natural and water resources to the benefit of its citizens;
- Krong Kratié sustainably develops its urban areas, contributing to the creation of a more convenient and conducive business environment, encouraging forms of investment in the Krong;
- Krong Kratié becomes famous for its green spaces and its recreational infrastructure that promotes a comfortable urban life for its citizens and local and international visitors; and
- Krong Kratié provides good quality basic-needs services that protect public health and the environment.

# Summary of Findings and Recommendations

With increasing economic integration in the region and more bridges crossing the Mekong River in the vicinity of Krong Kratié, there is **significant development potential as a regional centre and as an eco-tourism-based destination**. At the same time, its development challenges are exemplary for other secondary and tertiary cities[3] in Cambodia.

With the urban development of the last thirty years, **public services and infrastructure (road construction, electricity supply, water supply, etc.) have been substantially improved**. This has provided good foundations for the Krong's future development.

**Significant challenges remain for the development of efficient infrastructure, such as effective storm water and waste water management systems**. While grey infrastructure development is crucial for the development of Krong Kratié, alone it will not solve the existing and upcoming water challenges: Grey infrastructure can only meet a certain range of the Krong's and peri-urban areas' urban water management needs in addition to the challenges of long-term financing and sustainable operation as identified by the World Bank, for instance.

**What is required is the coordinated and integrated development of green-grey infrastructure**. The Krong's existing wealth of green infrastructure should be perceived as a strategic "asset" for infrastructure and urban development. However, the importance of these 'natural' areas for the city and its residents is little understood beyond being a source of supplementary income for many of the city's poorer residents as reported during qualitative household conversations.

**The city's economic development and liveability is highly dependent on the sustainable management of its ecosystems and its water resources**. These

3 The term 'secondary and tertiary cities' is not defined by Cambodian standards. The distinction is between the capital city, Phnom Penh, and smaller urban areas known as Krongs, which include Battambang, Siem Reap, Pursat, Kampong Cham and Kratié among others

have come under pressure in the wake of increases in population and urbanization over the past century. Initially, population increases contributed to the loss of tall trees and vegetation in the urban area as timber was traditionally used for construction. Later modern building practices favouring the use of concrete contributed to the filling of low-lying urban areas and the loss of permeable surfaces. Furthermore, these pressures may increase considerably due to the manifestations of the impacts of climate change.

Currently, the **Boeung Meleach and Boeung Kbal Dun Saong (lakes) behave as natural ecosystems providing a variety of benefits to citizens including evaporative cooling**[4]. Possible interventions in the future can decrease the goods and benefits provided by such ecosystems. Compared to other larger cities in Cambodia, such as Siem Reap and Battambang, the urban area of Krong Kratié has relatively little tree and vegetation cover, and along with building stock development and sealing, the city is heating up. The current low level of green spaces and shaded paths offer little opportunity for residents and tourists to spend time in the open, even during the daytime, limiting the types of activities and businesses that can take advantage of foot traffic. With a changing climate, negative impacts on public health and the loss of liveability and attractiveness of the city may further increase.

Moreover, **land use and technical changes** in the upper reaches of the Mekong River can be causal in their interactions with **land use changes and new land use patterns in the region of Krong Kratié resulting in flooding events** similar to those experienced in 2019.

The **"boeungs" located behind the main residential areas of the Krong, often perceived as "wild areas", have an important function in flood protection**[5]. These wetlands with their water flow regime counteract water accumulation and serve with their vegetation as water buffers for the city. Widespread infilling of these areas or substantial alteration of water flow would inevitably increase the flood vulnerability of the Krong and its adjacent areas.

The **importance of such wetlands' ecosystems services in providing multi-faceted benefits and functions to the liveability and livelihood of the urban area are**

4 BORDA. (2022) *Field Observations during Field Missions to Krong Kratié; World Bank. (2021), A Catalogue of Nature-based Solutions for Urban Resilience*, World Bank Group. Washington, D.C.
5 'Boeung' in the Khmer language means pond and/or lake.

**increasingly recognized by local stakeholders**. For example, in addition to their flood management capacity, these 'boeungs' serve as a source of income and food (traditional agriculture and fisheries) for local communities and, especially because of their rich habitat, hold the potential for recreation that is of strategic importance for urban and tourism development as identified by local eco-tourism businesses.

Besides the attraction of the endangered Irrawaddy dolphin, the **island "Koh Trong" is currently one of the main tourist attractions in Krong Kratié**. The further development of tourist infrastructure on this island, such as bicycle paths and nature observation trails, should be accompanied by the development of effective wastewater treatment and waste management. Similar approaches to localized infrastructural development can also be applied to the 'boeungs' behind the main residential areas on the mainland.

Because of their vital function for local climate and water management and for urban comfort, **green space and green infrastructure development in the whole urban area should be perceived as being strategic for Krong Kratié**. "Green" infrastructures may include more public parks, playgrounds and sports fields, more rows of shade-trees along the river or streets, and more trees and bushes on private properties.

From the early stages, **the sustainable management of these spaces and infrastructure in terms of responsibility and financing should be addressed in**

**the planning processes** - this is especially needed because of the general fragmented-nature of the mandates and responsibilities of the government structures, limited public financial sources and lack of public capacities. The need for technical and organizational capacity development and for a coordinated approach among the relevant government institutions is recognized by many stakeholders.

Enhanced **participatory planning processes and awareness building campaigns** that include the active participation of communities, the private sector and civil society actors may create a sense of ownership and an understanding that can mobilize local capacities. These are crucial for effective green infrastructure management, storm water management, waste management and waste water management.

**Consistent planning and law enforcement go hand-in-hand with stimulating the 'buy-in' of motivated households and operators of commercial and institutional facilities**. For instance, there should be a realization among these local stakeholders that the separation of waste, i.e. the separation of organic and residual waste, is a prerequisite for the relief of local landfills, that the regular and paid emptying of their septic tanks serves the protection of their water bodies, that the responsible disposal of waste-packaging is not only in the interest of the city, but also in their own interests in terms of the health of their children and families and pride in the attractiveness of their homes and neighbourhoods.

**Figure 2.** Introduction of blue-green infrastructure is relevant to the livability of Krong Kratié (Source PUW, 2019, 2023)

# Methodological Approach

In 2020, the "PolyUrbanWaters" project was invited by the Sub-National Administration[6] of Krong Kratié to contribute to the implementation of the mainstreamed 2030 Agenda for Sustainable Development (SDGs).

There has been increasing recognition that infrastructure exclusively driven by the development of water-related hardware, such as the expansion of the water supply network and water drainage, would only partly develop the resilience that Krong Kratié will need in the future.

Ineffective approaches that promote 'ideal-typical' urban planning are to be overcome and relevant approaches are to be developed for the specific

6 In this instance, Sub-National Administration (SNA) refers to provincial and municipal administrations.

**Figure 3.** Dimensions of Baseline Study and Strategy Development, Krong Kratié
(Source: BORDA, 2023)

conditions of Cambodia's cities. Such approaches should include the identification of strategic fields of action for urban development and realistic options for their implementation.

To enable informed decision-making and strategy development for a comprehensive management of urban waters in Krong Kratié, the unique characteristics of the Krong need to be taken into account. Therefore, to fully understand this uniqueness, a baseline study was conducted:

- Build a qualitative and quantitative understanding of "water" within urban development dynamics by providing information on current water resources, water use patterns, and water-related vulnerabilities as well as existing and emerging water challenges for Krong Kratié;
- Elaborate a comprehensive understanding of the water cycle within the natural context of Krong Kratié, the context of the urban development dynamics and urban spaces;
- Elaborate a robust information base for informed decision-making;
- Identify strategic interventions as entry points for the future water-sensitive development of Krong Kratié.

This executive summary presents the findings and recommendations of the base-line study. The final version will be available from July 2023.

# Policy Framework

## Key Messages of Section

- While the Royal Government of Cambodia (RGC) is committed to implementing the SDGs and has made progress in their achievement, significant vulnerabilities associated with urban development and weak public services need to be overcome.
- The RGC's National Strategic Development Plan's (NSDP) monitoring and evaluation framework adopts approximately 50% of the SDGs' indicators (88 out of 169) with the Cambodian SDGs (CSDGs) providing performance measures and budget outcomes: an innovative step by connecting the SDGs to public sector-budgeting.
- The RGC's strategic planning documents for socio-economic development address the risks from climate change by promoting multi-sector approaches to urban development bringing together critical factors that contribute to improvements in socio-economic development currently at risk from poorly planned urbanization, environmental changes and climate change ultimately impacting public health and the liveability of urban residential areas.
- Although substantial progress has been made in decentralization policies, significant challenges remain to ensure the water security and liveability of cities, including at the governance level.

The following section highlights the relevant policy frameworks that align with and support the realization of water-sensitive urban development in Cambodia.

In its most recent version of the Government's NSDP (2019 to 2023), the RGC indicates its strong commitment to the implementation of the SDGs and has provided a review of the progress to date in achievement of the Cambodian Millennium Development Goals and localisation and mainstreaming of the SDGs in the RGC's CSDG Framework 2016 to 2030[7]. Cambodia's updated Nationally Determined Contribution (NDC) identifies at least five adaptive actions (#31, #33, #34, #35, #37) to address these to be developed by the Ministry of Land Management, Urban Planning and Construction and for resilient cities (#39) by the National Committee for Democratic Development with at least two relevant mitigating actions for the Ministry of Land Management, Urban Planning and Construction. Nevertheless, despite these achievements significant challenges are recognized from a 'growing vulnerability, both economic and environmental' and from 'industrialization/ urbanization, migration, [and] public service weaknesses'[8].

According to Cambodia's Voluntary National Review 2019 of the Implementation of the 2030 Agenda, the CSDGs have been fully integrated within planning and policy-making[9]. This is through their inclusion in the 2109 to 2023 NSDP Monitoring and Evaluation framework, where around 50% of the indicators have been adopted; and via ministry and agency Budget Strategic Plans, where the CSDGs will provide the performance measures for budget outcomes. The latter, undertaken via national public financial management reforms, is especially innovative, marking Cambodia out globally for offering a concrete connection between the SDGs and public sector budgeting.

The NSDP promotes a multi-sectoral approach in urban areas posing health, environmental, and climate change risks in order to provide effective responses. It gives priority to improving services in cities through waste and waste water management[10].

The National Strategic Plan on Green Growth 2013 to 2030 focuses on promoting economic development

7 RGC. (November 2018). *Cambodian Sustainable Development Goals (CSDGs): Framework (2016-2030)*, Royal Government of Cambodia, Phnom Penh
8 Ibid, p.4
9 Ibid
10 RGC. (2019). *National Strategic Development Plan 2019-2023*, Royal Government of Cambodia, Phnom Penh

based on green growth principles and environmental sustainability[11].

The Rectangular Strategy – Phase IV –places a high priority on formulating infrastructure master plans for main cities and urban areas to support the development of roads, railways, and water ways as well as electricity networks and sewerage and wastewater treatment system[12].

The Cambodia Climate Change Strategic Plan (CCCSP) 2014 to 2023 was developed as the first comprehensive policy document to respond to climate change issues. Strategic Objectives detailed in the Plan include: Promotion of climate resilience through improving food, water, and energy security; Promotion of low-carbon planning and technologies to support sustainable development; Improvement of capacities, knowledge, and awareness to respond to climate change[13].

The National Program on Sub-National Democratic Development Phase II 2021 to 2030 is the national strategy for decentralization with the municipal administration's responsibilities relevant to urban planning, developing urban infrastructure, garbage and waste water management, and environmental protection[14] .

The National Policy on Water Supply and Sanitation, issued in 2003 and currently under review, identifies areas for update based on the emerging context and global good practices. It gives particular reference to coherence and adequacy of policy, functional mandates, institutional and sector capacity, achievement of increased coverage, delivery models, planning and investment, tariffs and regulations, institutional coordination, consumer engagement, and water tenure[15].

The 2017 Sub-Decree (#235) on the management of drainage systems and wastewater treatment systems, currently regulates wastewater management. Once the draft law on wastewater is ratified by the National Assembly and Senate, 'newer' relevant Sub-Decrees and Prakas will be prepared to support this law[16].

11 RGC. (2013). *National Strategic Plan on Green Growth 2013-2030*, Royal Government of Cambodia, Phnom Penh
12 RGC. (2018). *Rectangular Strategy Phase IV*, Royal Government of Cambodia, Phnom Penh
13 RGC. (2013). *Cambodia Climate Change Strategic Plan 2014–2023*, National Climate Change Committee, Phnom Penh
14 RGC. (2021). *National Program on Sub-National Democratic Development Phase 2* (2021-2030), National Committee for Sub-National Democratic Development, Phnom Penh
15 RGC. (2003). *National Policy on Water Supply and Sanitation*, Royal Government of Cambodia, Phnom Penh
16 Publication pending approval

Efforts to decentralize and strengthen governance structures at the local level are on-going, considerable challenges remain. Thus, for example, responsibility for managing water issues is scattered and dispersed across multiple agencies with limited coordination between the involved actors at national levels. While functional responsibilities have been transferred to municipal and district levels by the 2019 Sub-decrees 182 and 184, it is premature to say how effective this has been, as limited guidance has been provided to effectively take up the roles and responsibilities associated with water and other issues. The roles and responsibilities for the municipal and sangkats' authorities are being strengthened. Provincial line departments will have to improve their understanding, capacities, and resources to address identified water issues as well as for municipalities and sangkats to address the population's demands. Effective technical guidance and tools to facilitate inclusive water planning processes are missing and need to be developed and elaborated.

For effective infrastructure development and sustainable operation (and maintenance), the mandate and capacities of local governance structures (municipality and sangkats) must be strengthened. They must be better resourced to be able to meet public (local resident) demands, and more systematically involved in higher order decision-making processes that have so far taken place largely at the national level.

# Urban Development Characteristics

## Key Messages of Section

- Krong Kratié can be considered representative of water challenged cities across Cambodia (~19/31).[17]
- There are dense urban areas (high density of buildings) along the Mekong, and less around the lakes/ wetlands.
- As with other large Cambodian settlements and towns, Krong Kratié has been built on raised land (natural or man-made) close to rivers and lakes and in areas with high water tables.
- The urban development tendency is to fill the area required for living with soil to raise the building leaving the other areas to continue flooding. Poorer sections of the population may be most affected as those least likely to have the capacity to raise their properties.
- There are limited parks, unpaved, and biologically active green areas in the whole urban area: trees are individually planted in small plots, road side greening is done only to a limited extent with concrete predominate.
- A green urban development strategy for Krong Kratié should comprehensively address a number of challenges, such as gradual densification of the residential areas, the heating of the residential areas, increased flood risk due to urban expansion and climate change, and vulnerability especially of poorer sections of the population in the context of urban beautification.

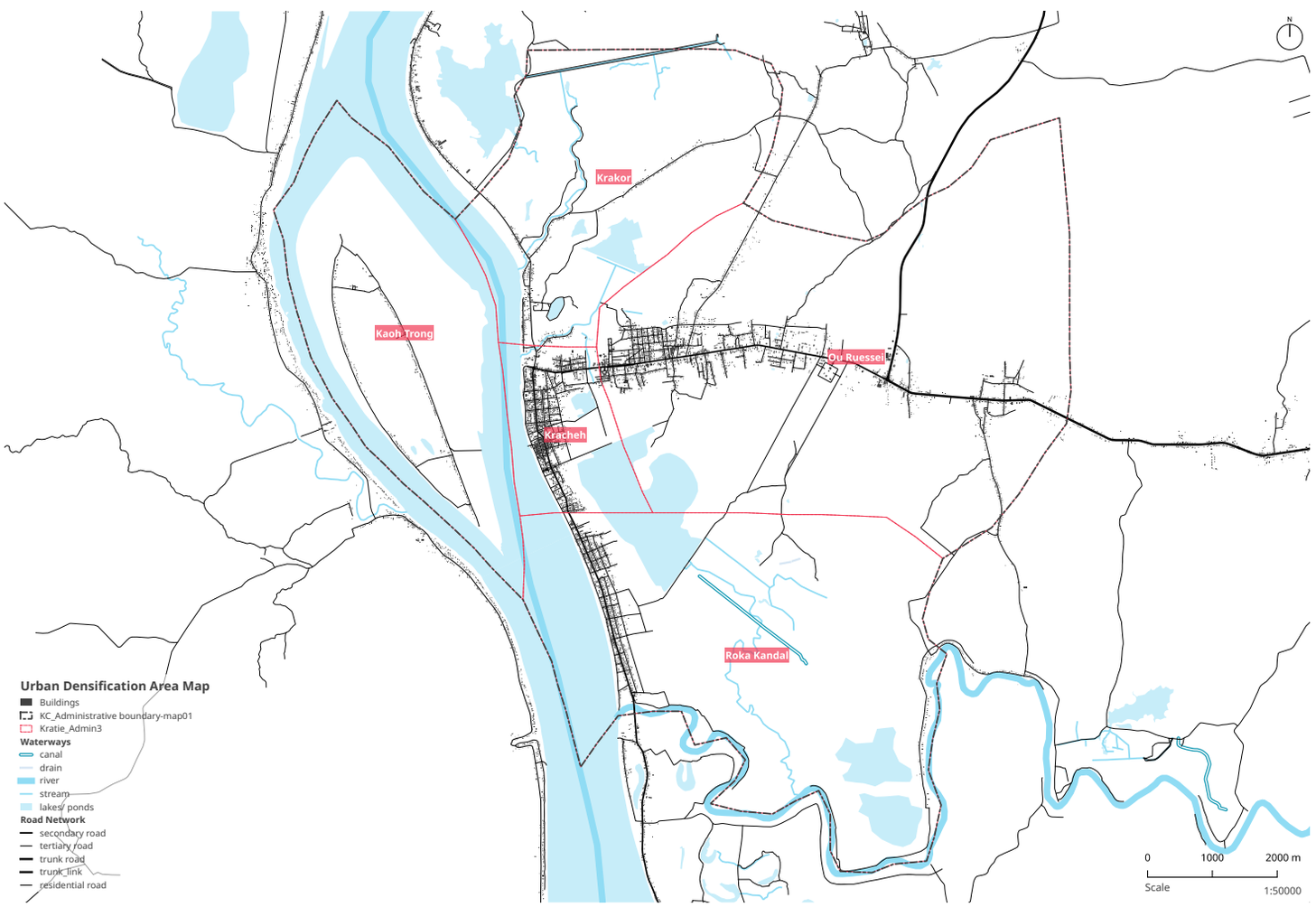
17 RGC has designated three new Krongs across the country in December 2022.

Kratié Province is located in the northeast of Cambodia lying on the banks and floodplain of the Mekong River, approximately 220 km northeast of the capital Phnom Penh. The Municipality of Kratié is designated as a “Krong” (city/town) due to the presence of the provincial capital and administration.

Krong Kratié can be considered representative of water challenges for many cities across Cambodia. It is worth keeping in mind that 19 of the now 31 urban municipalities/ cities in Cambodia are located on riverine flood plains associated with the Mekong catchment, four other municipalities are on/in other river catchments, five municipalities are coastal, and four municipalities are mountainous.

Krong Kratié is an important node for regional trade. Freshwater fisheries and agriculture are the primary industries in the region. The economic potential for

**Figure 4.** Administrative Boundary Map (Based on the Dept. of Land Admin 2022) (Source: TUB, 2022)



tourism in the vicinity is estimated as significant due to critically endangered Irrawaddy dolphins and the Province's diversity of fish. At this time, tourism appears fairly untapped because of an insufficient development strategy and infrastructure for the Krong, part of which is the sustainable development and management of the island sangkat, Koh Trong, and the boeungs.

The Municipal area covers 88.6 $km^2$ some of which is the Mekong River. 37% is reported as built-up (33 $km^2$). A further 29% (25 $km^2$) is reported as given over to fields and agricultural usage, mainly (wet and dry season) rice growing. The remaining 35% (31 $km^2$) is reported as for other uses (forests, lakes, etc.)[18].

Administratively, the Krong is divided into five "sangkats"/ communes, which are themselves made up of a total 16 villages. With the number of villages in a sangkat varying between two and five (See Table 1).

The Commune Database (CDB) 2020 reports 7,701 families (31,843 people 51% female: 49% male) resident in Krong Kratié. With 37% of the population under the age of 18 years of age and a further 8% considered as (>61 years of age). 895 of the total 7,701 households/families are headed by women (12%). The 2019 national census indicates that national population growth has been averaging 1.2%, while the indicative growth rate for Kratié Province is 1.4%. A recent study by the Ministry of Public Works and Transportation on the Krong's drainage indicates an annual growth rate of 0.7%.

The Government currently recognises 1,336 families out of a reported 8,000 families in Krong Kratié as being poor (16%) but only 14% of the population in the one Sangkat the IDPoor programme considers as being urban (Kracheh 100209). Nearly a third (30%) of these (397 families) are category 1 poor (extremely poor) with the remaining as category 2 poor (939 families) based on the Ministry of Planning's Identification of Poor Households Programme (IDPOOR).

18 RGC. (2020). *Commune Database*, Ministry of Planning, Phnom Penh

| Sangkat | Villages | Number of families | | Family poor 1 | | | | Family poor 2 | | | | Total poor families | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sangkat Koh Trong | Head of the island | 227 | 448 | 4 | 2% | 10 | 2% | 35 | 15% | 81% | 18% | 39 | 17% | 91 | 20% |
| | End of the island | 221 | | 6 | 3% | | | 46 | 21% | | | 52 | 24% | | |
| Sangkat Krakor | Krakor | 770 | 1067 | 25 | 3% | 39 | 4% | 74 | 10% | 135 | 13% | 99 | 13% | 174 | 16% |
| | Toul Monorom | 297 | | 14 | 5% | | | 61 | 21% | | | 75 | 25% | | |
| Sangkat Kratié | Daun Chram | 340 | 1554 | 53 | 16% | 106 | 7% | 30 | 9% | 113 | 7% | 83 | 24% | 219 | 14% |
| | Kratié | 380 | | 10 | 3% | | | 14 | 4% | | | 24 | 6% | | |
| | Phsar Veng | 168 | | 18 | 11% | | | 28 | 17% | | | 46 | 27% | | |
| | Trapeang Pring | 385 | | 23 | 6% | | | 35 | 9% | | | 58 | 15% | | |
| | Pagoda | 281 | | 2 | 1% | | | 6 | 2% | | | 8 | 3% | | |
| Sangkat Orussey | Squirrel | 254 | 3536 | 20 | 8% | 216 | 6% | 59 | 23% | 417 | 12% | 79 | 31% | 633 | 18% |
| | Kapo | 771 | | 45 | 6% | | | 90 | 12% | | | 135 | 18% | | |
| | Orussey 1 | 754 | | 64 | 8% | | | 101 | 13% | | | 165 | 22% | | |
| | Orussey 2 | 785 | | 25 | 3% | | | 62 | 8% | | | 87 | 11% | | |
| | Sre Sdao | 972 | | 62 | 6% | | | 105 | 11% | | | 167 | 17% | | |
| Sangkat Rokha Kandal | Kandal 1 | 668 | 1395 | 8 | 1% | 26 | 2% | 91 | 14% | 193 | 14% | 99 | 15% | 219 | 16% |
| | Kandal 2 | 727 | | 18 | 2% | | | 102 | 14% | | | 120 | 17% | | |
| **Totals** | | **8000** | **8000** | **397** | **5%** | **397** | **5%** | **939** | **12%** | **939** | **12%** | **1336** | **17%** | **1336** | **17%** |

**Table 1.** Total Rates of IDPoor Classified Household, IDPoor Category 1, and IDPoor Category 2

(Source: https:www.idpoor.gov.kh - Date of data is not presented: cited in 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)

## Historical background of Krong Kratié

Krong Kratié was founded in order to tax the trade on the forest-related goods, primarily timber, that were sourced in the nearby forests and transported down the Mekong River through French Indochina to colonial-era Phnom Penh, Vietnam and the wider world. Prior to the French-Protectorate's administration formalising changes to Cambodia's borders in 1907, Krong Kratié was on the Cambodian border neighbouring what is currently Stung Treng Province, formerly located in Champasak in Laos.

Krong Kratié began its formal existence with the government offices and institutions located in Roka Kandal Village where they remain to this day, while residential and commercial areas expanded north along the riverside and what was the main highway and now is National Road No. 73. In recent decades the Krong has expanded eastwards towards the new National Road No. 7 as well as north and southward along the former national road. If road

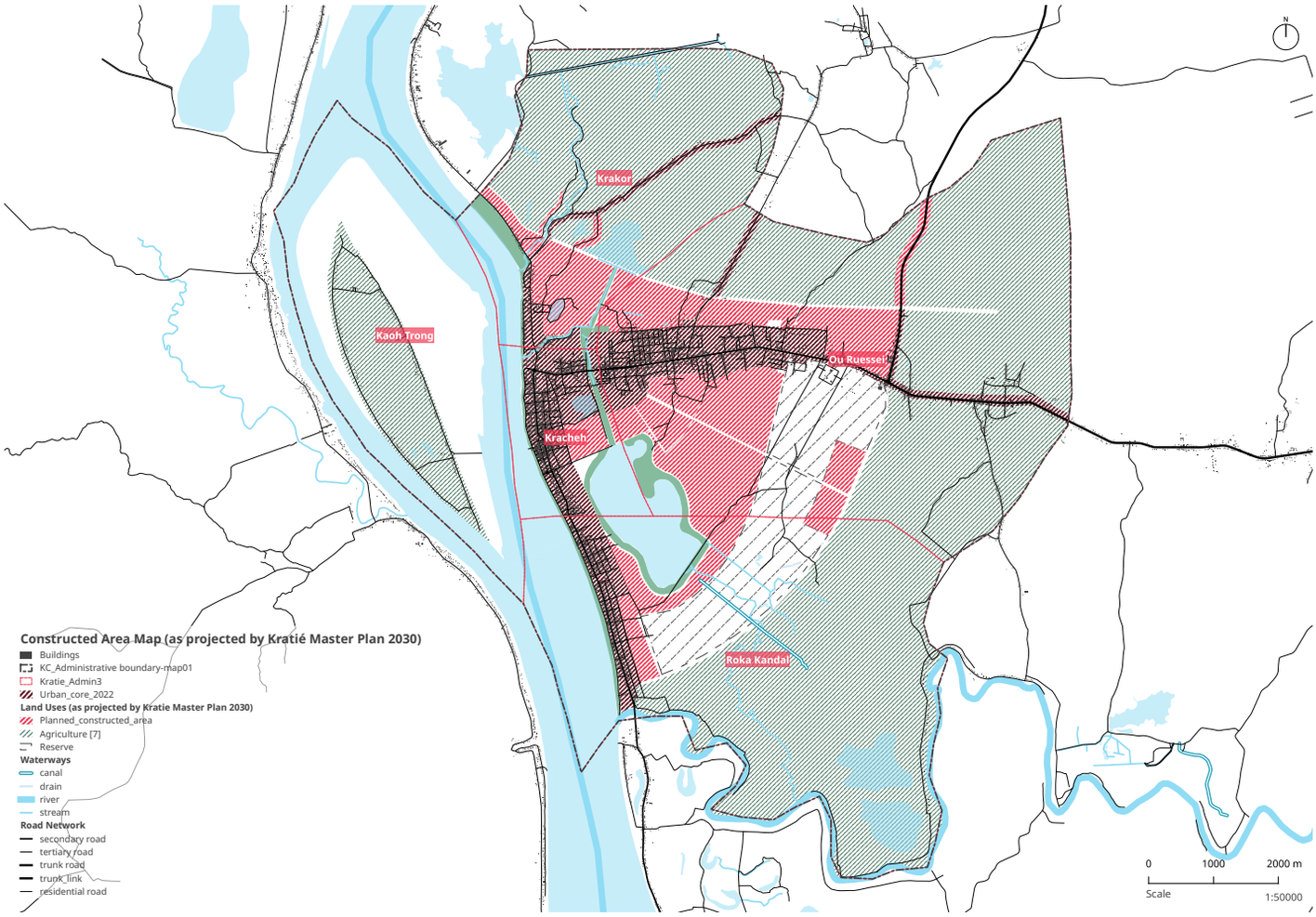



**Figure 5.** Constructed Area Map (Land Use Master Plan 2030)

networks are formalized, the Krong has the potential to expand south and west to encircle the existing large Boeung Meleach situated behind the Krong: areas of low elevation that are currently flood prone.

Krong Kratié's focus has always been the Mekong River due to its importance as the main form of transportation and communication until road infrastructure and motor vehicles became more reliable in the late French protectorate and post-independence periods. Nevertheless, river transport remained the most efficient transport mode until the 1990s and early 2000s when road improvements made land travel more feasible and economical.

## Settlement structure

Currently, the municipality is generally T shaped in the layout of its built up area. With the head of the T running for 8 km north south along the banks of the Mekong, while the 8.5 km leg of the T connects with the redirected National Road No. 7 (@ 5.8 km) and onward to the municipal boundary.

There are ~31,843 people in ~7,240 houses, with more than 900 business enterprises including six markets (two normal markets and six small markets but zero night markets), 16 restaurants, 15 hotels and 30 guesthouses, three health centres, one referral hospital, 13 public primary schools, seven lower secondary schools and three high schools[19].

The table below provides an analysis of the available sangkat data against the Ministry of Planning's Urban Criteria. As can be seen one sangkat may not meet the criteria but overall the Krong meets the required criteria.

However, another part of the Ministry of Planning (IDPOOR) only considers one of the five Sangkats (Kratié) as being urban, while the remaining four sangkats are (socially and economically) rural in nature. As of 2020, 7,701 families reside in 7,240 houses/properties of different types[20]. The following chart shows the reported distribution by housing type.

The difference between number of families and number of households (551 families) is due to the fact that in some instances multiple generations of recognised/ registered

19 Commune Database (CDB) 2020
20 Ibid

**Table 2.** Kratié Population by Sangkat
(Source: CDB 2020)

| Urban Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Comm GIS** | **District** | **Commune** | **Areas (Ha)** | **Area ($Km^2$)** | **Population (>2000 pers)** | **Pop$^n$ /$km^2$ (>200+)** | **% of Adult Popn in Agriculture (<50%)** |
| 100208 | Kratié | Krakor | 1,325 | 13.25 | 4,189 | 316 | 42% |
| 100209 | Kratié | Kratié | 490 | 4.9 | 6,475 | 1,321 | 0.09% |
| 100211 | Kratié | Roka Kandal | 2,203 | 22.03 | 6,208 | 282 | 28% |
| 100210 | Kratié | Ou Russey | 2,940 | 29.4 | 13,111 | 446 | 26% |
| 100207 | Kratié | Koh Trong | 223 | 2.23 | **1,860** | 834 | **73%** |
| | | | **7,181** | **71.81** | **31,843** | **443** | |

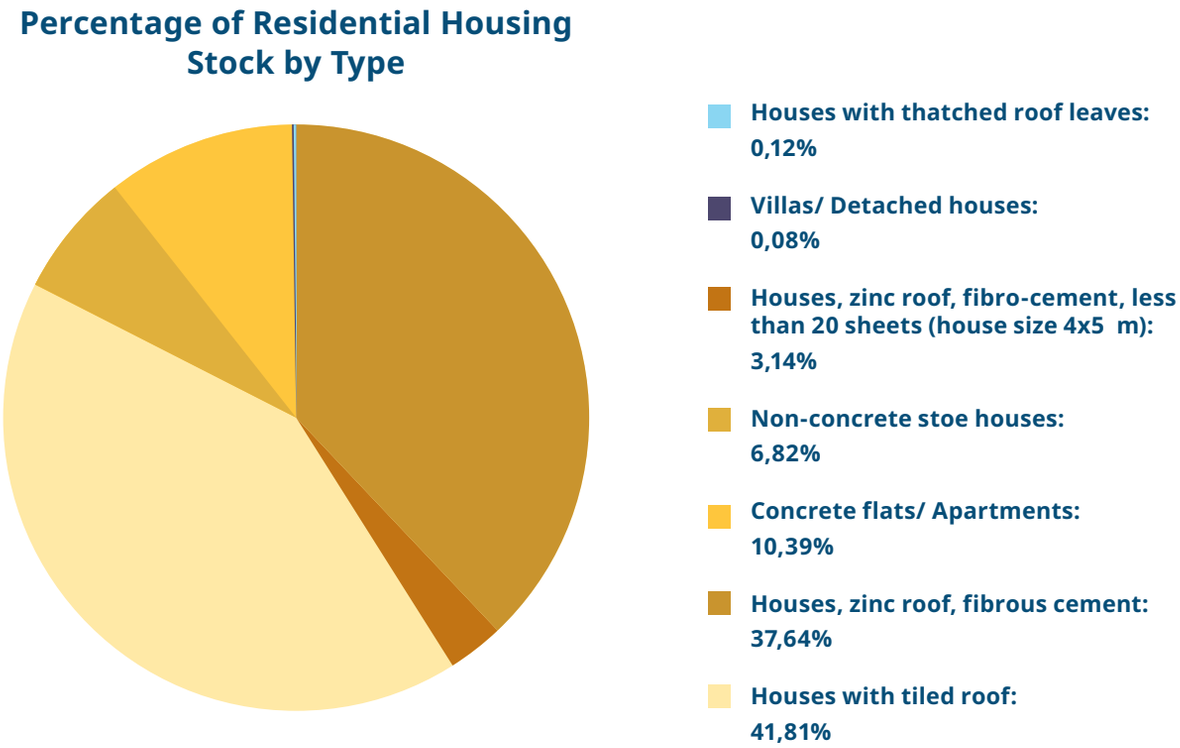



**Figure 7.** Residential Housing Stock by Type
(Source: CBD 2020)

families may reside in one household. In terms of slum housing (as defined by UNHabitat[21]) 4% (279 houses) of the municipal housing stock could be considered as being in slum conditions. If one excludes land tenure issues (as is commonly done around the world by most governments), the greater percentage of households are reported as not having land titles.

If tenure issues are included, the average rate of slum households is 16% of the total. This is far lower than the rates of urban slum housing reported for the whole of Cambodia by the United Nations, as 55% of the Urban Population as Living in Slums[22].

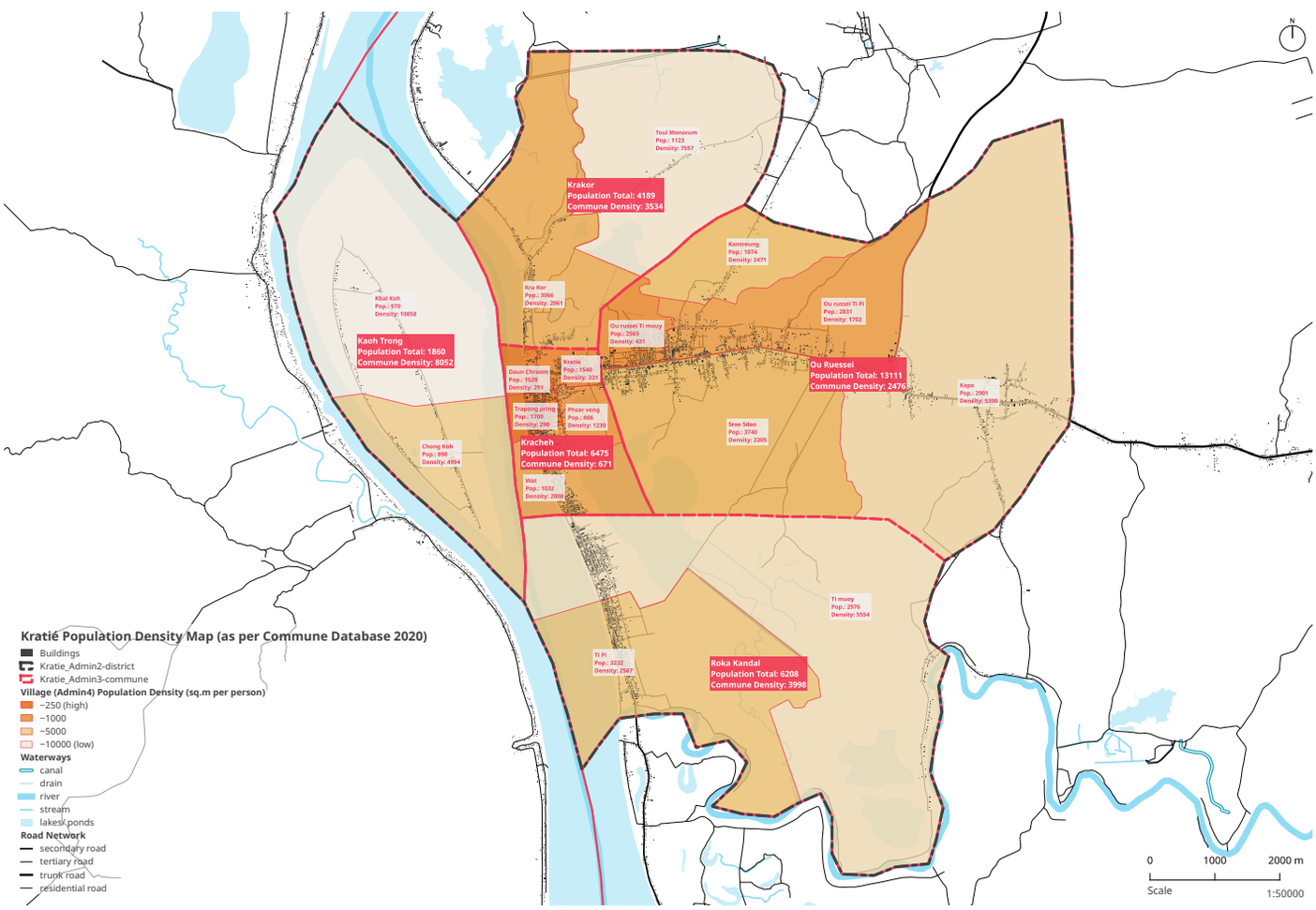
21 UN-HABITAT defines a slum household as "a group of individuals living under the same roof in an urban area who lack one or more of the following: (i.) Durable housing of a permanent nature that protects against extreme climate conditions. (ii.) Sufficient living space which means not more than three people sharing the same room. (iii.) Easy access to safe water in sufficient amounts at an affordable price. (iv.) Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people. (v.) Security of tenure that prevents forced evictions", https://mirror.unhabitat.org/documents/media_centre/sowcr2006/SOWCR%205.pdf

22 UNHABITAT (2016) World Cities Report 2016, Urbanization and Development: Emerging Futures, World Cities Report 2016

| No | Slum Criteria | No of Houses | Percentage of Housing Stock |
|---|---|---|---|
| 1 | Lacking durable housing of a permanent nature that protects against extreme climate conditions. | 77 | 1% |
| 2 | Lacking sufficient living space which means not more than three people sharing the same room. | 202 | 3% |
| 3 | Lacking access to safe water in sufficient amounts at an affordable price. | 425 | 6% |
| 4 | Lacking access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people. | 274 | 4% |
| 5 | Security of tenure that prevents forced evictions (as expressed by families without land titles, data CDB 2018) | 4,827 | 68% |

**Table 3.** Slum Criteria (Source: UN-Habitat, 2006)

**Figure 6.** Kratié Population Density Map (Source: TUB, 2022)



There are dense urban areas (high density of buildings) along the Mekong River, and less around the lakes/ wetlands. This may be due to the fact that lakes are used to discharge wastewater and land is cheaper there where people can build their houses. Houses are mostly built from wood and not very high from the ground, indicating a potential greater risk of losses due to flooding in those areas.

Across the built up urban areas, there are limited parks, unpaved, and biologically active green areas where trees are observed as individually planted in small plots and road side greening is scarce. Ultimately, a high intensity of built-up areas around Krong Kratié and a lack of parks and linear planting of trees, create an urban heat island effect: with reductions in natural cover, heat is trapped in densely built-up areas by surfaces absorbing, retaining and reflecting heat[23].

According to interviews made with the local planning department, in the event of flooding, the Krong is only able to provide basic support, such as provision of

23 World Bank. (2021), A Catalogue of Nature-based Solutions for Urban Resilience, World Bank Group. Washington, D.C

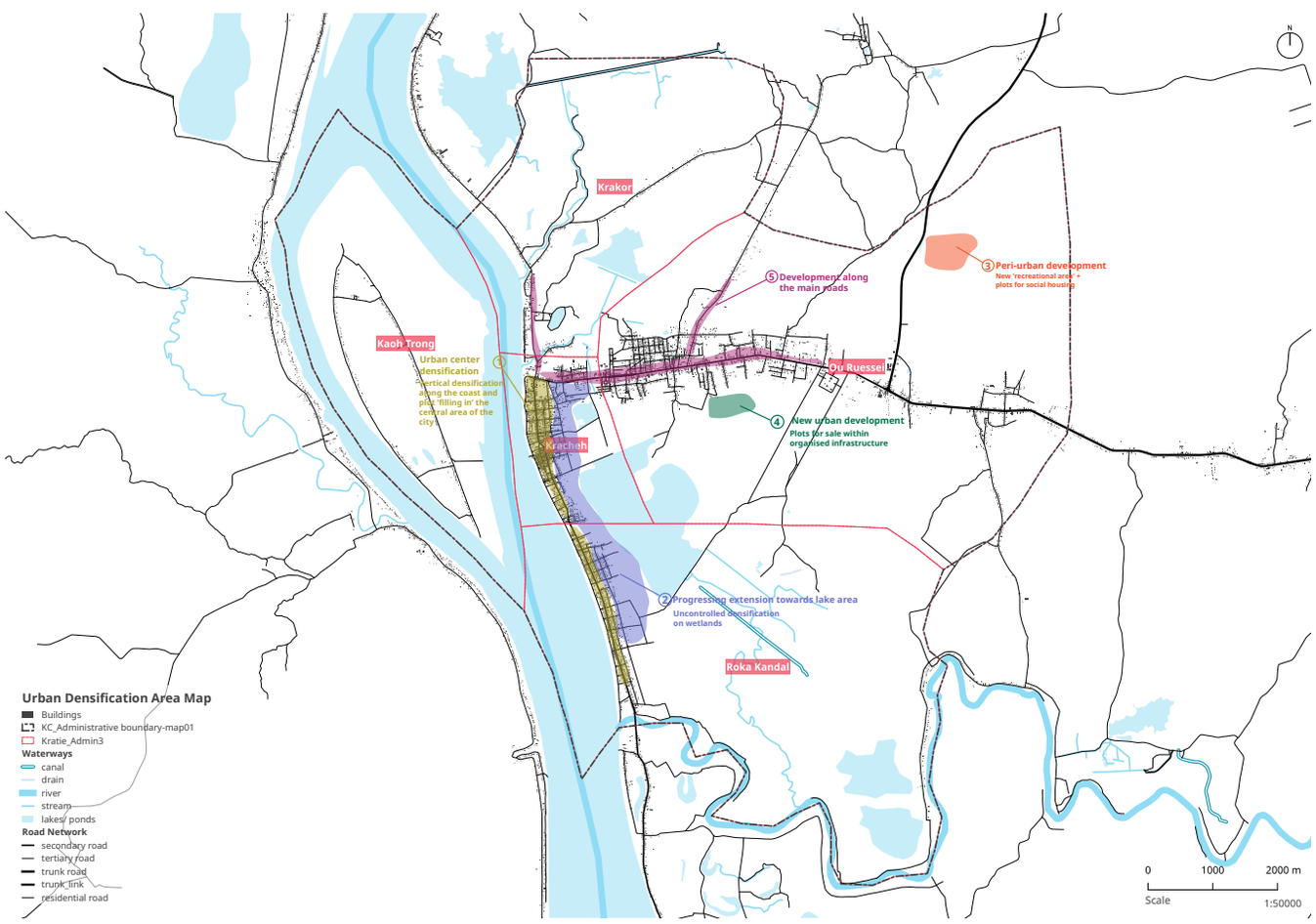



**Figure 8.** Identified types of urban densification (based on direct observations)
(Source: TUB 2022)

food and medicine especially to poorer communities. Flooding results in business and everyday life having to stop, as a consequence of inaccessible streets and urban infrastructures

On closer inspection, many residential and commercial areas of Krong Kratié remain stilted with the upper floors now on a level with the road that has also been raised. Therefore, there is still potential for retention of rainwater and stormwater, yet these waters cannot flow away due to adjacent buildings filling in their ground floors. This creates obstacles to water flows and (may) pose health risks associated with stagnant water, such as dengue fever[24].

**Figure 9.** Across the built up urban areas, there are limited public green areas (Source PUW, 2022)

24 BORDA. (2022). *Field Observations during Field Missions to Krong Kratié*

## Traditional stilted houses and modernity

Cambodian houses have traditionally been built on stilts to accommodate flooding as well as promoting cooling breezes to upper floors and shade. Cambodians have traditionally placed ponds for rainwater retention and to source aquatic life near their homes. As Cambodia has modernized, these stilted houses have been replaced by modern concrete two story houses on raised land. In many cases, ponds have been filled in to make greater use of the land space for more buildings, roads and drains.

**Figure 10.** Stilted houses and construction of new buildings (Source PUW, 2022)

# Natural Characteristics and Trends

## Key Messages of Section

- Krong Kratié is generally low-lying apart from some elevated areas and is dominated by the Mekong River but also by other local river catchments, such as the Prek Te acting as the southern boundary of the Municipality.
- Krong Kratié's climate is dominated by the wet and dry seasons with greater precipitation predicted for the wet season and less for the dry season in relation to climate change impacts[25].
- Krong Kratié is prone to various forms of flooding and this impacts residential and agricultural areas.
- The loss of wetlands and local forests has been on-going for many decades and has a considerable impact on the Krong's climate and water balance[26]. This development may accelerate in future as the urban population increases.
- In some cases, water quality measurements conducted on behalf of PolyUrbanWaters show significant contamination of the water. The results show that water conservation should not only address the management of used water from households, but also from commercial and agricultural activities.
- The fact that there may be significant arsenic contamination of ground waters is inconclusive without consistent monitoring data, and this highlights the need to establish effective water monitoring systems.

25 Christensen, J. H., Hewitson, B., Busuioc, A., Fu, C., Christensen, J. H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R. K., Kwon, W.-T., Laprise, R., Rueda, V. M., Mearns, L., Menéndez, C. G., Räisänen, J., Rinke, A., Tignor, M. (2007). Regional climate Projections. In S. Solomon, Qin D., Manning M., Chen Z., Marquis M, Averyt K.B., Tignor M., & Miller H.L. (Eds.), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA; IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability.Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Pörtner, Ed.). Cambridge University Press. https://doi.org/10.1017/9781009325844

26 Mekong River Commission. (2005). *Overview of the Hydrology of the Mekong Basin, Mekong River Commission, Vientiane,* Campbell, I.C. (2009). *The Mekong Biophysical Environment of an International River Basin*, Academic Press, Cambridge

Krong Kratié is located on the Cambodian floodplains along the eastern bank of the Mekong River. The Mekong river has a length of approximately 4,800 km and a catchment area of 795,000 km$^2$, extending across China, Laos, Myanmar, Thailand, Vietnam, and Cambodia. The landscape surrounding Krong Kratié is part of the river floodplain that is 12 km wide and features only minor elevation changes, except for some places, which are elevated due to the underlying geology[27]. Krong Kratié is located downstream on the banks of the Lower Mekong River, after the tributaries of the Se Kong, Se San, and Se Pok rivers enter the Mekong. In addition to the Mekong, parts of Krong Kratié are influenced by the river catchment of the Prek Te.

Krong Kratié is situated in the tropical monsoon climate belt close to the equator. The whole of the Lower Mekong basin, including the Cambodian Floodplains, are affected by the regional south west monsoon weather system causing accumulated precipitation between May and October (wet season) and low precipitation between November and March (dry season). A hot and dry transition time between March and April is also part of the regional climate dynamic. Projections regarding climate change in Cambodia predict an overall increase in temperatures and in precipitation patterns becoming more extreme in both seasons. 10 - 15% less precipitation is expected during the dry season and 5 - 10% more rainfall during the wet season, with extreme rainfall and cyclone winds likely to increase across the whole of Southeast Asia[28].

An increase in precipitation in the upstream areas of the Mekong River basin during the wet season can cause downstream flooding. Flood events in Cambodia are natural but have become more unpredictable. Krong Kratié is prone to different types of flooding: Flood waves from the Mekong River, rapid monsoon rainfall and onset flooding from smaller rivers that flow from the eastern backcountry towards the Mekong River and confluence north and south of Krong Kratié. Regionally, during periods of high discharge a hydrologic phenomenon can be observed whereby by flows reverse in the Tonlé Sap Basin, due to the rising Mekong River's water level which causes a reverses in the flow of the Tonlé Sap River and lake further south.

27 Campbell, I.C. (2009)
28 Christensen et al., (2007)

The Krong is surrounded by large seasonal floodplains, and has to cope with regular riverine and flash floods as a result while flooding from the Mekong River itself is not common. Climate change has increased the frequency and intensity of climatic variability and natural hazards that manifest into intense rainfall, irregular timing of extreme rain, and more prolonged droughts. Water presents both opportunities as well as threats to the Krong. The flood events can lead to a shutdown of urban life (in parts of the municipality) and are likely to increase in frequency and intensity due to the effects of climate change, essentially reducing the economic potential of Krong Kratié[29].

Droughts and floods are near annual occurrences with their incidence and impacts influenced and exasperated by the El Niño–Southern Oscillation (ENSO) and its reversal through the La Nina. Parts of Cambodia had recently gone through a number of rolling droughts between 2016 and 2018, which had significant adverse livelihood impacts on those parts of the country affected[30]. One of the identified challenges related to droughts is the lack of an effective system at national and local levels to monitor triggers and qualify droughts. While inputs (from the Asian Development Bank, Mekong River Commission, the World Bank Group and the United Nations Development Programme) have been made to begin addressing this, limited progress appears to have been made. While automated weather stations have been installed, communications with stakeholders indicate that the most recent stations are yet to be calibrated and fully integrated into the national data collection mechanism.

Krong Kratié is prone to both flooding and droughts due to its topography and the hydrological/water resource issues relevant to the municipality and the Krong's location[31]. During the dry season, a number of peri-urban villages in the municipality experience insufficient water resources to sustain agricultural production potentially impacting the livelihoods of dependent families[32].

29 Ngin, et al. (2020). *Climate change impacts and disaster resilience among micro businesses in the tourism and hospitality sector: The case of Kratié, Cambodia*, Environmental Research 186 April 2020
30 ITT (2023). Based on De Sousa et al., 2020, generated with R.
31 Räsänen, T. A., et al (2017). *Observed river discharge changes due to hydropower operations in the Upper Mekong Basin*, Journal of hydrology 545: 28-41
32 BORDA. (2023). *Household interviews*

Deforestation and loss of wetlands have a significant impact on Cambodia's climate and its water balance[33]. Kratié Province and the areas immediately surrounding Krong Kratié have experienced considerable deforestation over the previous century since the protectorate-era French resident complained of the uncontrolled destruction of the forests along the banks of the Mekong River. Significant pressure on forests and on wetlands translates in to a change of local climate adversely affecting water resources.

While the Mekong River regulates the overall flood risk of the area immediately behind the Krong, the low lying topography of that area and the numerous streams and small rivers that traverse it and flow into the Mekong River contribute to creating a tub-effect exacerbated by the reduction in natural forest cover and human development practices.

Behind the raised embankment/banks of the Mekong River, the land falls away and is annually progressively flooded by

33 Mekong River Commission. (2005). *Overview of the Hydrology of the Mekong Basin, Mekong Basin, Mekong River Commission, Vientian,* Campbell, I.C. (2009)

the rising Mekong River over the course of the monsoon "rainy" season between June and November. There are riverine water gauges (both automatic and manual) on the Mekong River bank, which feed into the national and regional flood management systems. These relay data to national institutions for top-down decision-making on significant/ national disaster/emergency alerts. However there is no localised measuring network (apart from observations) to provide timely information on risks to vulnerable areas for local decision-makers to act upon, in fact there appears to be no (publically available) regular mapping of flood vulnerable areas in Krong Kratié

As in many krong in Cambodia, the lakes behind Krong Kratié have retained their character as '*wild*' wetlands from which the Krong can extract food resources, such as fish and other aquatic animals, while their rainy season flood waters allow rice farming. Traditionally, these areas supplemented the food in the local markets imported from other provinces and the food sourced from the forests. Today, the lakes continues to act as a water buffer for

**Figure 11.** Blue-green north-south corridor Kratié (Source: TUB, 2022)

waste water and storm water runoff and their hydrology contributes to flood management for the residential and commercial areas. Furthermore, these areas also provide a cooling effect for the Krong considering the lack of natural shade in the built-up urban areas[34].

While comprehensive monitoring systems for regularly measuring water quality of piped systems exist, this is much more limited for surface water in Krong Kratié[35]. An analysis of surface water sources carried out on behalf of PolyUrbanWaters at four sites in 2022 yielded the following results:

- At sampling site one, approximately four parameters (TDS, COD, Phosphorus, Turbidity, and Mn) of the sample code taken in Krakor village, Krakor commune, Krong Kratié of the water tested exceeded the standard values for parameters and may pose risks mostly to the health of the aquatic ecosystem.
- At the second sampling location in Rokha Kandal 1 village, Sangkat Rokha Kandal, Krong Kratié, the water tested exceeded the standard level for COD and phosphorus, which can indicate pollution from human activity, such as the discharge of agricultural chemicals into the water source
- Sampling point three was located in Ro Louch village, Kantot commune, Chet Borey district, Kratié Province, upstream of the Prek Te flowing into Krong Kratié. The results show that TDS, COD, Turbidity and Phosphorus were above the desirable limit for surface water, due to the agricultural activity and discharge of waste water from markets and households directly into the stream.
- The fourth sample was taken in Rokha Kandal 2 village, Sangkat Rokha Kandal, Krong Kratié. The Ministry of Environment's 2021 Surface Water Quality Standards have been exceeded with respect to DO, Nitrate, Turbidity and Phosphorus. The sources of nitrate may come from the nitrogen cycle caused by industrial waste, nitrogenous fertilizers, etc.

34 World Bank. (2021), *A Catalogue of Nature-based Solutions for Urban Resilience*, World Bank Group. Washington, D.C.
35 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

There is a possible risk of arsenic contamination of ground water along the banks and on the floodplains of the Mekong River. Aggregate results from previous testing rounds (2004-2009)[36] indicated that 14% of tube wells in Kratié may be contaminated at levels exceeding the national standards for water supplies as per the Ministry of Rural Development's National Guideline for Rural Drinking Water Quality (2020)[37] and the Ministry of Industry, Science, Technology and Innovation's drinking water quality standards (2022)[38].

Note that in order to arrive at definitive statements on water quality, a series of tests would have to be carried out over a longer period of time and over a wider area.

36 https://rdic.org/arsenic/ and mapped (in 2009) by https://cambodiawellmap.com/worldbank/maps/44789/arsenic-contamination-by-well#
37 Pending Publication
38 Pending Publication

# Flood and Storm Water Management

## Key Messages of Section

- As is the case in many cities and towns in Cambodia and the region, the residents in Krong Kratié have been living with floods for centuries.
- The stilted construction of many houses today testify to how the population has adapted to these natural conditions.
- As in many cities, towns, and large settlements in Cambodia, Krong Kratié has been built on raised land (natural or man-made) close to a river and in areas with high water tables. As noted, as roads are made permanent and raised above the level of localized flooding, the tendency is for property owners to fill the area required for living with soil to raise the buildings leaving the adjacent areas prone to continue flooding.
- The current storm water drainage system primarily flows to the "boeungs" and is insufficient to manage the greater risk of flash flooding as an increasing population growth and density create more areas requiring storm water drainage.
- The emerging land use changes in the areas around the "boeungs" will increase the flood vulnerability of the Krong, which even the planned modernization of the drainage infrastructure can only partially counteract.
- Regular cleaning of drainage systems, especially before the rainy seasons are central to comprehensive flood protection.
- A new drainage system is planned, at a projected cost of 41.63 million USD. While it is clear that the municipality is responsible for operating and maintaining the systems, it also recognised that there is a need to secure financing to sustain such grey infrastructure.
- The complementary or integrated development of grey and green infrastructure are essential to maximize resilience to flood hazards. Such solutions may be more cost-effective and sustainable even in respect of sustainable management.
- The development and implementation of a "Lake/ Wetland/Boeung" Management and Development Plan should be part of a comprehensive strategy to mitigate flood vulnerability.

Parts of the municipality are prone to frequent annual flooding (usually between July and October) for different lengths of time: in some locations flooding can persist for over a month. The urbanised core of the municipality is also at risk from periodic flooding, either from the rapid monsoon downpours, a frequent occurrence during the rainy season and the irregular inundation of the urban centre due to the rise of the Mekong River.

In 2019, an estimate of over 60,000 people were directly affected by flooding in Kratié Province, with over 11,000 people evacuated and both agricultural land and infrastructure inundated. In Krong Kratié, over 9,000 people were directly affected by flooding in 2019 with over 1,500 evacuated[39]. To date, the infrastructural equipment and institutional disaster preparedness is insufficiently developed to adequately address flood vulnerability that may even increase with climate change.

As mentioned, historically the urban development approach for larger settlements in Cambodia is to fill and raise land to the level of the road to ensure mobility during the rainy season. This contributes to a patchwork of raised and unraised properties where flood water is prevented from freely flowing away. This urban development pattern applies to Krong Kratié as well.

Flooding vulnerability is further compounded by deficient and aged infrastructure in parts of the municipality. While a combined sewerage drainage system exists in the urban core, the majority of the municipality lacks access to effective and comprehensive drainage systems, while sections of drainage have been constructed their associated outflows and access to wetlands (boeungs) have in some instances been blocked or significantly reduced, resulting in the drain flows rapidly backing up and flooding surrounding areas.

In parts of the municipality, the least frequent form of flooding is by direct inundation through the overflow of the Mekong River. The stated flood alert level[40] for Krong Kratié is 22 metres with flooding occurring at 23 metres. It is worth noting that the Mekong River annually rose by over 14 metres from an average low of 7 metres compared to the peak levels in 2019 at 21.38 metres (in September 2019).

39 CAMDI. (2023). Cambodia Disaster Damage & Loss Information System, National Committee for Disaster Management, Phnom Penh accessed 02 February, 2023 at http://camdi.ncdm.gov.kh/

40 According the Mekong River Commission's https://portal.mrcmekong.org/monitoring/river-monitoring-telemetry

While inundation has and does occur, it is the least frequent form, but it is exasperated by the topographic nature of the municipality, as the built-up areas of Sangkat Kratié lying directly behind the slightly raised river embankment are lower than the raised embankment, and can become flooded when river inundations occurs.

Surface drainage systems are challenged by a combination of:

(i) Deficient functionality - it is reported that sections of the existing drainage system have deteriorated due to age and limited maintenance[41];

(ii) Outside of Sangkat Kratié, the coverage of surface drainage systems is limited, while the municipal expansion, has been on-going particularly along or around the east-west access road connecting with National Road No. 7 in Sangkat Ou Russey where sections of open drainage channels and piped section with inlets along unpaved roads have been constructed, frequently becoming dysfunctional as piped sections are blocked by soil, requiring removal;

(iii) Additionally constructed drainage is often unconnected and does not form a coherent drainage system;

(iv) Drainage outflows become blocked as previously open land that was used for drainage is filled, thus limiting the flow of drainage outflows;

(v) Hardening of the municipality in which, increased growth and development of the built-up areas of the municipality has resulted in some hardening of surfaces, reducing infiltration and increasing runoff;

(vi) The topography of the municipality can be described as having slight rises and depressions, which decrease and increase the risks of flooding for these areas. One of the low points of the municipality are parts of Sangkat Kratié's most built-up area, a slightly low lying area particularly around the main market, which floods annually after regular downpours during the monsoon season;

(vii) There is a lack of a connection between the town and the river. There are limited infrastructure networks from which runoff can be discharged to the Mekong River. As there are only two to three pipes discharging

41 ADB. (2018). Project Administration Manual - Kingdom of Cambodia: Fourth Greater Mekong Subregion Corridor Towns Development Project, Project Number: 50099-003, Asian Development Bank, Manila

to the Mekong River, rainwater potentially accumulates and runs in the streets causing flooding zones along the main road as water accumulates.

Typical of many krong in Cambodia, the lakes behind Krong Kratié play an important role as green infrastructure, i.e. as natural “air conditioning” for the whole area, as a water buffer, water storage and water runoff, as rich habitat for flora and fauna (birds, insects, aquatic life) and as a source for agriculture and fisheries. Often overlooked or ignored due to the perception of these locations as ‘wild’ wetland areas, Krong Kratié’s boeungs are coming under increasing pressure from urban development and uncontrolled discharges. There is a tendency among residents and local authorities to regard these lakes as ‘empty‘ or ‘unused‘ spaces providing little benefit to the Krong as a

**Figure 12.** Flood event and its impact in 2019
(Source: BORDA, 2019)

whole that cannot be provided from elsewhere. The fact that the boeungs contribute to the overall liveability of the urban area as existing nature-based solutions, essentially blue-green infrastructure that supplements and supports the existing grey infrastructure, is largely overlooked by developers and planners that regard these areas, if filled, as providing opportunities to accommodate population growth and for investment.

The RGC proposes an extensive separated storm water drainage system. 'To solve the issue of rainwater flooding Krong Kratié, we must construct a rainwater drainage system ... which is a projected spend of about 41.63 million USD. This project will benefit the economic development in Krong Kratié and Kratié Province with the Economic Interests Return Rate of about 20%, [net present value] has a value of about 30.63 million USD, and the benefit's rate/ the costs... of expenditures are equal to 1.9'[42]. Nevertheless, budgetary and funding limitations may present obstacles to the successful implementation of such a proposal and its long-term operation and maintenance.

42 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, p.291

# Waste Water Management

## Key Messages of Section

- Though the regulatory framework for the management of waste water in Cambodia is improving, there is still a large gap to its implementation in terms of ensuring households are connected to existing and future sewer networks – this also applies to Krong Kratié.
- Official maps indicate about half of the Krong's area is covered by a combined sewer and storm water system – this discharges into the "Boeung" behind the Krong – causing significant risks to public health and the environment.
- Most households appear to have constructed some form of non-standard unsealed soak-pit – reports of infrequent desludging indicate that existing septic tanks are likely leaking into the environment and maybe contaminating water bodies.
- During the rainy season and resulting floods, the risks to public health increase because of flooded septic tanks discharging into the local environment.
- Regulations exist instructing property owners and constructors of their obligations to install standardised septic tanks and/or sewer systems. However, implementation of these regulations are inconsistent.
- Regulations exist for new buildings to include containment units although this practice is likely haphazard and not monitored by local authorities.
- Faecal Sludge Management (FSM) Services Providers (or FSM Operators) need more formal operations: Consistent law enforcement and monitoring by a public authority is needed to create an enabling environment for private sector engagement in sludge emptying and sludge management.
- A centralised waste water treatment plant (WWTP) and piped network system has been proposed to be financed through loans to the government by the Asian Development Bank through the Greater Mekong Sub-region (GMS) project "Fourth Greater Mekong Sub-region Corridor Towns Development Project" (GMSCTDP-4).
- As in other Cambodian cities, while it is clear that municipalities are responsible for wastewater systems, their anchoring in local governance structures and the associated establishment of efficient operator

structures continues to be challenged.

- Experience from other Cambodian cities indicates that households might be reluctant to pay for the sewage service provided by this plant unless enforced or subsidized.
- Budget limitations may contribute to challenges to effectively operating and maintaining the WWTP.
- Arrangements for sewerage and FSM, such as emptying septic tanks, sludge disposal arrangement, etc. need to be formalized[43]
- Awareness raising programs to support behaviour change should aim to increase the appreciation of the benefits of environmental sanitation and therefore the users' willingness to pay.
- A strategic plan for the management of waste water in the different parts of the city should be guided by the contextual reality. In the event that Krong Kratié's central sewage system in the municipal centre (one sangkat) is realized, a large number of households will still have to rely on improved septic tanks and the sludge has to be treated professionally, particularly in areas devoted to attracting nature-based tourism.

43 Namo, S. (2022). *Policies and Strategies Wastewater Management in Cambodia*, Presentation given at the Cambodia-Australia Wastewater Knowledge Exchange Workshop, Ministry of Public Works and Transport, Phnom Penh

## Waste water management in Cambodia

The situation for the waste water management sector reflects challenges and opportunities that may be considered as framework conditions for Krong Kratié and krong in the country and the region.

In Cambodia, there is increased public investment in provincial towns and more alignment among different investments with the legal enabling environment improving: For example, the Water Supply and Sanitation Policy (2003) is being updated, and the Water Supply and Sanitation Law will be subsequently prepared. The waste water cost recovery framework is finalized, and the wastewater and sanitation tariff framework is in preparation[44].

However, there are a number of negative aspects of waste water management in Cambodia: Nearly 80% of toilets are connected to collection units, broadly described as 'septic tanks' although potentially not conforming to the anticipated standards for a septic tank system in which effluent is naturally broken down before being further treated prior to being discharged to the environment. Toilets with 'septic tanks' increased 5.6 times faster than toilets with connections to sewers. Even with sewerage connections, not all are treated. Improved sanitation is on track, but the rate for safely managed sanitation is unknown. Where sewer connections exist, low bill collection is a common issue: getting those connected to the sewer to pay is a huge challenge in cities with sewer systems[45].

Investments in wastewater need to pay more attention to sustainability (house connections, tariffs, institutional set-up for operation, etc.). Operational management of waste water systems often face limited capacity and low financial revenue. A city-wide inclusive sanitation concept has not been widely adopted[46].

For the waste water unit at the municipal level, there is unclear accountability between them and the provincial administration. There is no performance agreement and indicators do not exist. Human resource management remains lacking, and there is a lack of managerial autonomy. There is a lack of strategic and activity plans due to limited financial resources and advisory groups, yet sustainable

44 Kov. P. (2022). *Cambodia Urban Sanitation: Issues and Opportunities*, Presentation given at the Cambodia-Australia Wastewater Knowledge Exchange Workshop World Bank Group, Phnom Penh
45 Ibid
46 Ibid

finance is needed to offer good service delivery. Some basic systems and policies do exist, but these are inadequate or need to be strengthened or developed further to make the unit effective in service-delivery[47].

## The situation and plans in Kratié

Currently, in Krong Kratié, the drainage system is generally a combined system of sewer and storm water and are mostly old and not sufficient in proportion with the volume of waste water generated. Approximately, 48% (12,173m of total roads) of the Krong is covered by the existing combined sewer and storm water system with the network discharging into the Boeung behind the Krong[48].

The wastewater discharges to a public system, much of this is directed to the drainage system then to the water body (lake, wetland, river). In non-sewered areas (urban sangkats and peri-urban areas), there is a heavy reliance on on-site sanitation facilities, for example, septic/collection tanks, and pit latrines. Most waste water is primarily treated in septic tanks at each house before discharging into public drainage systems. Sludge from septic tanks collected by private enterprises and often improperly dumped in the open. The most common method for sludge treatment is dumping and backfilling[49]. There are two FSM operators in the Krong. One operator confirmed only one or two emptying's of cesspits/septic tanks per week. They operate two small locally constructed 'vacuum trucks' (a tanker with an attached pump). Sludge and sewage is collected and disposed of informally, with it being reported that depending on the season affecting how the sludge/ sewage is disposed of: in some instances it is dumped on farmland (for a small fee) as fertilizer, on other occasions pumped onto vacant land, the owner's land or into watercourses. There is apparently no system in place to record/ document and monitor faecal sludge disposal[50].

47 Ibid
48 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, p.115)
49 Namo, S. (2022). *Policies and Strategies Wastewater Management in Cambodia*, Presentation given at the Cambodia-Australia Wastewater Knowledge Exchange Workshop, Ministry of Public Works and Transport, Phnom Penh
50 PUW. (2018). *Urban Water Sensitive City Assessment: Krong Kratié, Kratié Province – Inputs for Phase II, The Definition Phase*, PolyUrbanWaters Consortium, Phnom Penh; BORDA. (2022). Field Interviews during Field Missions to Krong Kratié, July, 2022

Field observations and the infrequency or irregularity of desludging suggest most households have likely constructed some form of unsealed soak-pit, which may pose a risk if the households are in flood prone areas as the contents of the soak-pit escape when the soak-pit becomes inundated, or during the rainy season it may escape when the rising ground water table causes the effluent in the tanks/pits to be dispersed close to the surface[51].

Out of 363 households surveyed in 2020, 14% reported not having some form of toilet in their household. They indicated that they either used a neighbour's or practiced some form of open defecation. Socio economic issues appear to be a significant factor in the lack of access/ usage of toilets with three quarters of those households without household sanitation being either poor or low income households. Half of the poor households reported being without sanitation compared with 15% of low income and 7% of middle income households[52].

Of those households with sanitation, the majority were either pour-flush (93%) or flushing toilets (7%). However, households were generally unable to describe the type of on-site sewage treatment process used. The law (Construction Sub-decree #96 1997) requires all (new) constructed urban houses to have a septic system (which infers a sealed retention storage either connected to a soak pit or connected to the municipal combined drainage system). 85% of the surveyed households with toilets reported having never emptied their septic tanks/ soak-pits[53].

There are regulations instructing property owners and constructors of their obligations to install standardised septic tanks and/or sewer systems. However, the reality is that these regulations are not adhered to and properties are regularly built with insufficient waste water management that contributes to septic tanks and sewers overflowing during periods of flooding and high water tables[54].

51 BORDA. (2022). *Field Interviews during Field Missions to Krong Kratié*, July, 2022
52 PUW. (2018). *Urban Water Sensitive City Assessment: Krong Kratié, Kratié Province – Inputs for Phase II, The Definition Phase*, PolyUrbanWaters Consortium, Phnom Penh
53 PUW. (2018). *Urban Water Sensitive City Assessment: Krong Kratié, Kratié Province – Inputs for Phase II, The Definition Phase*, PolyUrbanWaters Consortium, Phnom Penh
54 Ibid; BORDA. (2022). Field Discussions during Field Missions to Krong Kratié

A centralised WWTP and piped network system have been proposed to be financed through loans to the government by the Asian Development Bank as part of a GMS project, "Fourth Greater Mekong Subregion Corridor Towns Development Project" (GMSCTDP-4)[55].

It is estimated to cost 18.62 million USD and its benefits are described as promoting people's well-being, a clean Krong, sanitized Krong, protection of environment work in the town, prevention of the Mekong River's water being polluted, and economic development, especially the tourist service sector in Krong Kratié as well as Kratié Province[56]. However, while there is no formal management of this sector, the Asian Development Bank's (ADB) plan for a modern WWTP may be undermined by the availability of the capacity and finances to sustainably operate the facility being unclear with local people reticent to pay fees to connect and use the service because limited enforcement will not motivate them to connect to and fund the system.

55 Ibid
56 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, p.291


**Figure 13.** Large parts of the city do not have adequate wastewater infrastructure. (Source: BORDA, 2019)

More specifically, a World Bank's assessment of the challenges for existing and planned wastewater utilities in Cambodia, may also apply to Krong Kratié: (i) Clarify the legal status, (ii) Stabilize operations: Set up performance agreements, set up advisory board/committee overseeing the operations, consider bridging funds, undertake customer verification, review organizational structures and include faecal sludge services, strengthen human resource system/policies; (iii) Consider a cost reflective tariff and combine this with the water supply bill; and (iv) Set up the WWTP as a State-Owned Enterprise or engage the private sector[57].

**Figure 14.** Effective fecal sludge management must also be ensured for the new Extension Areas.
(Source: BORDA, 2022)

57 Kov. P. (2022). *Cambodia Urban Sanitation: Issues and Opportunities*, Presentation given at the Cambodia-Australia Wastewater Knowledge Exchange Workshop World Bank Group, Phnom Penh

# Water Supply and Water Quality for Household Consumption

## Key Messages of Section

- The Current water supply network(s) forms a good basis for improvement and expansion in the future with the vast majority of the residents of the four mainland sangkats connected to one of the two private utility suppliers.
- The available data suggest that residents are satisfied with the quality of the water and the service provided although most respondents reported boiling the water before consumption or preferring to drink bottled water.
- There is little evidence of household rainwater harvesting even in areas without access to the water supply network, such as the island sangkat, Koh Trong.
- Krong Kratié's water supply upgrades are forecast as sufficient to satisfy the needs of the future population given the relatively low rates of anticipated population growth.
- It is unclear to the extent that residents in areas not served by the formal water supply networks will be willing to pay to connect to the network and whether expansions to the network into less dense areas, and neighbouring districts outside of the municipality, such as the peri-urban commune of Chet Borey, will provide a return on investment for water operators and their investors, given the relatively small network size and the related costs of ensuring good quality water (inputs and electricity costs), local capacity and expected profits, especially the need to reduce reported non-revenue water (NRW) of 16%.
- Krong Kratié's water supply comes from the Mekong River, and therefore, is unlikely to run out although changes to the water quality may challenge the water treatment.

Most of the population (97%) of the four main-land sangkats is serviced by the water supply network with Koh Trong sangkat the notable exception due to it being an island[58]. For those communities accessing ground water, there are concerns over the potential for wells to be contaminated by arsenic that is identified along the Mekong River's floodplains[59]. Surface water sources, such as ponds and lakes, in and around Krong Kratié are widely perceived by local inhabitants as unsafe due to the proximity of human activities from domestic waste water and chemicals used in agriculture, and, therefore, are not used for drinking water. Rainwater harvesting is evident in some areas but is not a common practice and is not an observed standard feature of public buildings, institutions or large private buildings, including hotels[60].

The water supply networks are managed by two separate operators with households generally reporting satisfaction with the service forming a good basis for future upgrades, expansions and improvements. Those reliant on other sources of water complain that these sources are limited during the dry season, and water is purchased in 20-litre blue bottles during periods of the year when wells run dry[61]. For those households accessing water via 'tube' wells, these are reported as being between 20 and 30 metres deep but are not used for drinking as they are reported as contaminated with excessive 'lime'[62].

The vast majority (90%) of the total water demand comes from the central downtown areas of Krong Kratié[63]. Moreover, as the population of Krong Kratié is not forecast to increase exponentially, proposed upgrades to the system are likely to be sufficient to ensure the future

58 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, p.63
59 PUW. (2018). *Urban Water Sensitive City Assessment: Krong Kratié, Kratié Province – Inputs for Phase II*, The Definition Phase, PolyUrbanWaters Consortium, Phnom Penh
60 BORDA. (2022 & 2023). *Field Interviews and Observations during Field Missions to Krong Kratié*, July, 2022 & January 2023
61 PUW. (2018). *Urban Water Sensitive City Assessment: Krong Kratié, Kratié Province – Inputs for Phase II, The Definition Phase*, PolyUrbanWaters Consortium, Phnom Penh
62 BORDA. (2023). *Household interviews*
63 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, p.97

population's needs, and with the Mekong River providing the raw water, it is unlikely that there will be a water shortage in the future. Nevertheless, poorer households are more likely not to access the water supply system and are potentially accessing unsafe and unimproved water sources for drinking and bathing – 78% access for poorer households compared to approximately 90% access for other socio-economic groups[64].

Of those households interviewed across the city, most reported that they boiled the water from the water supply network before consuming it and none of those households reported using a form of water filter: ceramic, charcoal or bio-sand filter[65]. Some households reported that they only used the water supply for bathing and washing while water for consumption would be purchased in 20-litre blue bottles. This indicates a lack of trust in the water supply's water quality as well as indicating an additional cost burden, opportunity cost, and environmental cost for those boiling their water in terms of paying for charcoal, wood or gas for boiling and the associated boiling time.

However, there are questions over the financial viability of the operators and the maximization of profits given the relatively small size of the networks, the cost of inputs (chemicals and electricity), local capacity to operate the system, and reported 16% non-revenue water, and the extent that this situation will improve if networks are expanded into new areas outside of the municipality, such as neighbouring Chet Borey district. Moreover, it is unclear whether changes in the quality of the Mekong River's will negatively impact the efficiency of water supply operators' treatment systems.

64 PUW. (2018). *Urban Water Sensitive City Assessment: Krong Kratié, Kratié Province – Inputs for Phase II, The Definition Phase*, PolyUrbanWaters Consortium, Phnom Penh

65 These forms of household water filtration systems are commonly purchased at local markets and pharmacies or donated by local non-governmental organizations or civil society organizations supporting the most vulnerable households.

# Waste Management

## Key Messages of Section

- Currently about two-thirds of Krong Kratié is served by a solid waste management (SWM) service collecting waste to be disposed of at a dumpsite approximately 15 km outside of the town. A new landfill is currently being constructed with increased capacity 17 km outside of the city.
- Recycling efforts are generally informal in nature practised by local families of recyclers with valuable waste resold to intermediary companies and waste recyclers in other parts of the country and Phnom Penh.
- Separation of waste at source and localized composting of organic waste is limited and was not observed in any part of the Krong, especially on the island, Koh Trong.
- Current SWM services are inadequate to manage the Krong's existing waste and while a new landfill site is proposed with better management standards, significant areas of the Krong are left un-served with the population managing their own waste, usually to the detriment of the surrounding environment.
- There is currently a community based project underway in Krong Kratié to improve understanding of SWM and how local communities not covered by the SWM operator can manage their waste effectively or be incorporated into the existing service network.
- The private enterprise collecting solid waste experiences challenges in collecting the waste collection fee. Such experiences suggest there might be difficulties in ensuring the new landfill site is a financially viable operation.
- Comprehensive awareness campaigns are needed to educate the population and communities on the need for and benefits of waste separation and management at the household level.

Kratié Municipality has contracted a private waste collection company, Tok Kun, to manage solid waste in the four mainland sangkats. An average total of 31,897 kg/day of waste generation is estimated in Kratié Municipality, 0.97 Kg/cap./day with 24.53 tonnes per day disposed at the landfill[66]. The municipality's fifth sangkat is located on the island and excluded from this waste collection service due to no road access. As a result, large quantities of waste are dumped in open areas around the island causing pollution of soils and water sources. Some of this waste is burned or buried by residents[67].

For those sangkats that are included in the waste collection network, collected waste is disposed at a hilly dumpsite located about 14 km away in Khsar Village, Chet Borey District, Kratié Province. The current landfill has been operating since 2014 and is 10 hectares in size and sited on provincial land[68]. Currently, the site uses approximately 70% of its allocated area. Sometimes open burning is practiced at this site[69].

Furthermore, there is a new landfill under construction as part of an ADB project located 17 km from the Krong along National Road No. 7 in Chet Borey District, Kratié Province. The new landfill's size is 27.85 hectares and sited on provincial land[70]. The site has been open since 2015 but as the road is of poor quality making it impassable during the rainy season and, compared to the older site, as it is further away, it has been underused. Officially, construction began in March 2022 and has reached approximately 5 to 7% completion as of early 2023[71].

An analysis of the physical composition of the waste at the landfill conducted indicates the following categories and quantities of waste: organic waste is 46%, including kitchen waste and garden waste; plastic makes up 21%,

66 GIZ. (2022). *Baseline Study on Solid Waste Management and Informal Sector*, Asia Foundation in Partnership with Composted and CRDT, Phnom Penh
67 BORDA. (2023). *Household interviews*
68 See coordinates: X619157.814; Y1379131.656
69 GIZ. (2022). *Baseline Study on Solid Waste Management and Informal Sector*, Asia Foundation in Partnership with Composted and CRDT, Phnom Penh
70 See coordinates: X626454; Y1381700
71 GIZ. (2022). *Baseline Study on Solid Waste Management and Informal Sector*, Asia Foundation in Partnership with Composted and CRDT, Phnom Penh; BORDA. (2023). Household Interviews

paper is 6%; and other waste totals 23%[72]. Similarly, the analysis of physical domestic waste composition at the source of waste generation indicates 44% organic waste, composed of kitchen waste and garden waste; 24% plastics, 11% paper and 16% other waste with a waste density of 87.06 kg/m$^3$ [73].

For the waste collection service operation, the service coverage has increased from 35% of the Krong in 2017 to 65% as of 2022. Households and businesses have to have their own garbage bin at their property for storing their waste for the company to collect it. The waste collection schedule varies according to the location and the quantity of waste generated. For example, waste from markets and more densely populated areas is collected on a daily basis with less densely populated areas having their waste collected two to three times per week. A monthly service fee based on the amount of waste produced and the type of business is collected by the waste company's staff directly from households and businesses in the service area.

The informal waste sector is largely responsible for managing recycling with valuable paper, plastic, steel, aluminium and glass waste recycled by twelve families of informal garbage recyclers/scavengers and by a small number of 'middle-men' at the landfill sites. This valuable waste is sold to larger-scale waste recyclers in other parts of the country and ultimately to Phnom Penh and Vietnam[74].

In some locations around the Krong, there are signboards in the public areas to educate and remind people to put their waste into the rubbish bin, but there is no messaging about reduce, reuse or recycle. Moreover, these signs are old and images and messaging has faded[75].

72 GIZ. (2022). *Baseline Study on Solid Waste Management and Informal Sector*, Asia Foundation in Partnership with Composted and CRDT, Phnom Penh
73 Ibid
74 Ibid; CRDT. (2022). *Households and Businesses Survey Report Solid Waste Management of Kratié Town*, GIZ and Asia Foundation, Phnom Penh
75 CRDT. (2022). *Households and Businesses Survey Report Solid Waste Management of Kratié Town*, GIZ and Asia Foundation, Phnom Penh

On land or near the streams and along the river bank outside of the more densely populated areas of the city, often mixed waste is dumped, such as plastic bags, beer bottles, plastic sacks, and other plastic waste. It can be estimated that approximately 35% of the households and businesses burned and buried their solid waste because they are not using waste collection services[76].

In addition, the current waste operator struggles to collect the waste collection service fee. This raises a question about whether the new dumpsite can financially support viable businesses considering the additional transportation time and associated costs[77].

76 CRDT. (2022). *Households and Businesses Survey Report Solid Waste Management of Kratié Town*, GIZ and Asia Foundation, Phnom Penh
77 GIZ. (2022). *Baseline Study on Solid Waste Management and Informal Sector*, Asia Foundation in Partnership with Composted and CRDT, Phnom Penh; CRDT. (2022); *Households and Businesses Survey Report Solid Waste Management of Kratié Town*, GIZ and Asia Foundation, Phnom Penh

**Figure 15.** Regular cleaning of drainage systems is a crucial element for effective storm-water management
(Source: PUW, 2022)

Nevertheless, during discussions, a local organization involved in the solid waste management in Krong Kratié reported that plans were being discussed with local officials and GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) to identify ways to incorporate Koh Trong into the solid waste network and transport non-compostable waste off the island. More broadly, these activities would aim at improving the solid waste management practices in areas and for households and businesses not enjoying the solid waste management collection service, such as via composting of organic waste[78].

**Figure 16.** The establishment of a sanitary landfill and of robust business models fo waste management are crucial for sustainable development of Kratié (Source: BORDA, 2022)

78 BORDA. (2023). *Household interviews*

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# Profile of PolyUrbanWaters

PolyUrbanWaters is a research and project network funded by the German 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, Laos, Thailand, Vietnam and Germany.

PolyUrbanWaters responds to the strong need to generate deeper, transferable and scalable know-how for the effective localization of polycentric approaches to urban water resources management in secondary and tertiary cities of the SEA region.

The project intends to demonstrate the importance of polycentric approaches to the management of urban water resources, contributing to the water-sensitive transformation of secondary and tertiary cities in SEA towards resilient, inclusive and livable urban areas, thus contributing to the fulfillment of national and global sustainability agendas.

In order to do this, the project will elaborate an empirically proven conceptual framework for these approaches with: a) development of relevant instruments for its implementation and scalability; and b) a sustainable contribution to the systematic emergence of a new interdisciplinary practice-oriented research and economic-academic cooperation context.

The PolyUrbanWaters international research collaboration focuses its research activities around three Living Labs located in Sleman (Indonesia), Sam Neua (Laos) and Kratié (Cambodia), which provide a representative cross-section of the challenges faced by fast-growing secondary and tertiary cities in the SEA region in diverse governance contexts.

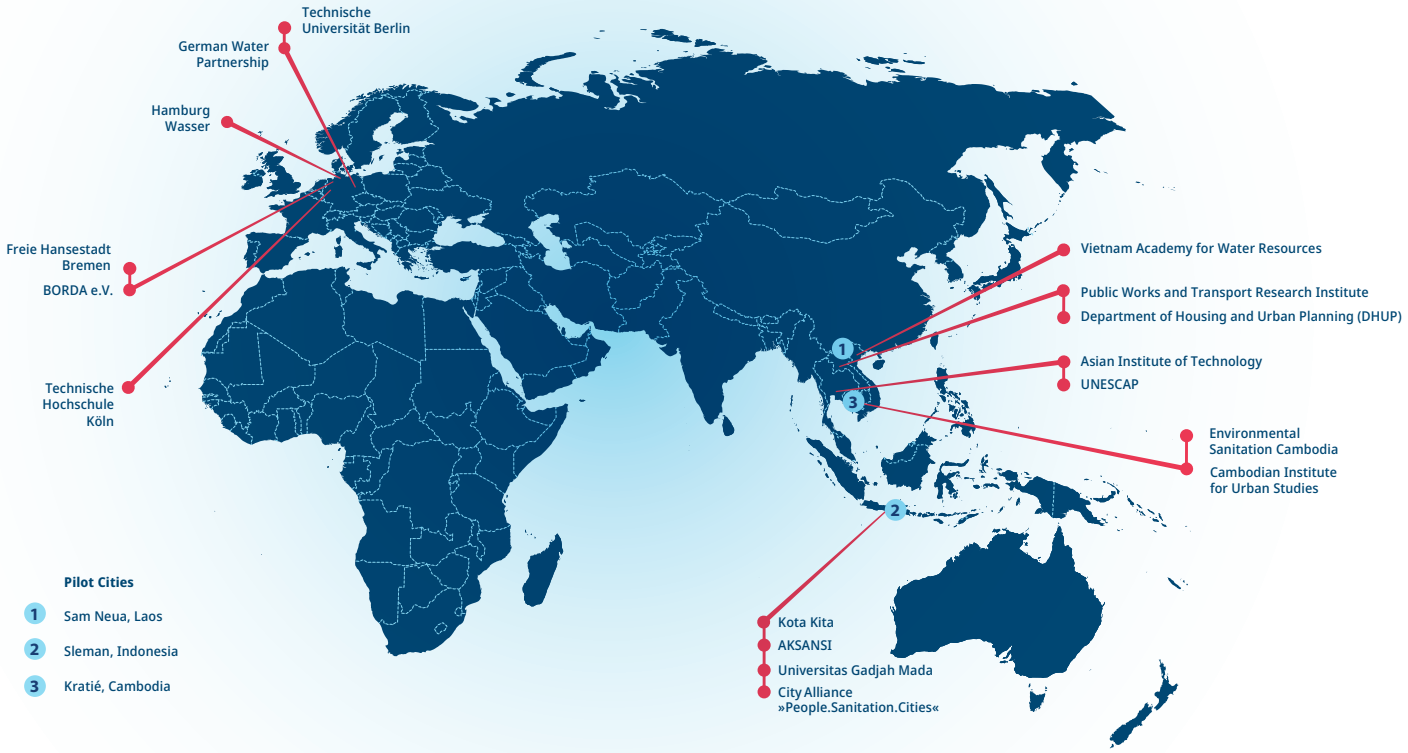
Within this framing, PolyUrbanWaters pursues the following core questions:

1. How can a diverse set of stakeholders contribute to building an inter- and transdisciplinary local knowledge base on water and urban development-related challenges in the SEA region? How can this knowledge be systematized, scaled and regularly updated to serve as a basis for inclusive and future-oriented municipal planning approaches across the region?

2. How can effective and sustainable water-sensitive urban development be fostered through a combination of centralized and decentralized technical and social-ecological innovations – including nature-based solutions, participatory strategic planning and effective water management structures – as an integral part of a systemic polycentric nexus approach (water, waste, energy, housing, IT, food, community development, etc.) and innovative financing schemes for the management of urban waters?

3. How can “water” serve as a strategic entry point to integrated, inclusive and resilient urban development that is guided by the SDG framework? Which polycentric, intersectoral and participatory governance approaches are required to plan, develop, sustainably operate and finance integrated, water-sensitive development with the capacity to evolve further in line with dynamic urbanization processes?

4. How can local innovation processes inform new practice-oriented pedagogies, capacity building approaches and research agendas to strengthen a network of academic institutions in the region?




The PolyUrbanWaters-Partnernetwork and Pilot Cities

**The economic development and liveability of Krong Kratié is highly dependent on the sustainable management of its eco-systems and its water resources. These have come under pressure in the wake of considerable deforestation in the region over the past century and recent increasing urbanization. Furthermore, these pressures may increase considerably due to the manifestations of the impacts of climate change.**

**polyurbanwaters.org**

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