2025

ICFMS Report

Integrated Climate-Resilient Flood Management Strategy

Aluvium and Hydrotech Consulting

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Abbreviations

DAFO	District Agriculture and Forestry Office
DICT	Department of Information, Culture and Tourism
DLSW	Department of Labour and Social Welfare
DoNRE	District Office of Natural Resources and Environment
DPI	Department of Planning & Investment
DPH	Department of Public Health
DPWT	Department of Public Works and Transport
DWR	Department of Water Resources
EbA	Ecosystem-based Adaptation
EWS	Early Warning System
GEDSI	Gender equality, disability, and social inclusion
GPT	Gross pollutant trap
GRET	Group for Research and Technology Exchanges
ICFMS	Integrated Climate-Resilient Flood Management Strategy
LPC	Luang Prabang City
LPSIUS	LPC Smart and Integrated Urban Strategy
LSWO	Labour and Social Welfare Office of Luang Prabang District
LWU	Lao Women's Union
MoICT	Ministry of Information, Culture and Tourism
MPWT	Ministry of Public Works and Transport
O&M	Operation and maintenance
PAFO	Provincial Agriculture and Forestry Office
PoNRE	Provincial Office of Natural Resources and Environment
PWTO	Public Works and Transport Office
RUCAS	Resilient Urban Centres and Surrounds
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USO	Urban Services Office
WHMD	World Heritage Management Division
WSCA	Water Sensitive Cities Australia
XBH	Xe Bang Hieng River Basin

Definitions

Fluvial Flooding: Fluvial flooding, also known as riverine flooding, happens when a river, stream, or other watercourse overflows its banks due to excessive rain or snowmelt upstream. This leads to the inundation of surrounding land. Fluvial floods are often more extensive and can affect both rural and urban areas, depending on the scale of the river system involved.

Gross pollutant trap: A gross pollutant trap is a type of stormwater treatment system designed to capture large debris, litter, and coarse sediments from urban runoff before it enters waterways.

Pluvial Flooding: Pluvial flooding occurs when heavy rainfall overwhelms drainage systems or accumulates on the ground due to poor absorption, leading to localised flooding. This type of flooding can happen even if a body of water (such as a river or lake) is not nearby. It is commonly associated with urban areas where stormwater drainage systems are insufficient to handle intense rainfall.

Sluice gate: A sluice gate is a movable barrier that controls the flow of water in channels, rivers, or dams. It can be raised or lowered to regulate water levels, control flow rates, or manage water releases.

Other technical terms are described directly in the document.

Preface

The Integrated Climate-Resilient Flood Management Strategy (ICFMS) for Luang Prabang City provides a detailed Action Plan to enhance the resilience of the local community to the impacts of floods and ensure effective socio-economic development that achieve the best outcome for the economy, communities and the environment. The ICFMS aligns with the direction of the Law on Water and Water Resources (revised in 2017), the Strategic Plan for the Management and Use of Water and National Water Resources until 2030, the Plan of the Natural Resources and Environment Sector, and National to district level Socio-Economic Development Plans.

The ICFMS has been developed in cooperation with related sectors such as the Department of Water Resources, the Provincial Department of Natural Resources and the Environment and the Administration of Luang Prabang District under the IWRM-EBA Project which is supported by the World Environment Fund (GEF) and the United Nations Development Organization (UNDP).

We on behalf of Luang Prabang District Administration, the Natural Resources and Environment Department of Luang Prabang Province and the Water Resources Department, Ministry of Natural Resources and Environment have coordinated harmoniously in developing this Strategy with support from central and local stakeholders. We will continue this close cooperation in implementing the Action Plan including with international organizations, private sector, project developers and the community in order to achieve the goal and objectives of the Strategy.

We would like to express our gratitude to the responsible committee for their hard work, conscientiousness and authority in creating this Strategy and its implementation. We also express our gratitude to the relevant parties who have contributed information and comments on this Strategy. In particular, I would like to express my gratitude to the donors who provided financial and technical support. The document will be implemented and integrated with the Socio-Economic Development Plan of the district, and relevant plans for other sectors. It will also be reviewed and updated periodically.

At Luang Prabang District, December 20, 2024

Director of DWR | Head of the Luang Prabang PoNRE | The Governor of Luang Prabang District

1 Enhancing climate resilience of communities to floods

1.1 Background

The Integrated Climate-Resilient Flood Management Strategy (ICFMS) for Luang Prabang City (LPC) aims to enhance the resilience of communities to the impacts of floods in the district, which are projected to become more intense and frequent with climate change.

The ICFMS for LPC outlines a strategy and set of actions over the next five years (2025-2029) to enhance the resilience of communities to the impacts of floods (including the effects of climate change) in the district. It serves as a blueprint for enhancing resilience by adopting Integrated Catchment Management (ICM), Integrated Water Resources Management (IWRM), Ecosystem-based Adaptation (EbA), and Early Warning approaches, while promoting sustainable, inclusive, and gender-responsive solutions. The ICFMS is also designed to strengthen both technical and institutional capacities, ensuring that communities can better plan for, respond to, and recover from flood.

The ICFMS covers the following key areas within its scope:

- **Geographical Coverage:** The strategy applies to LPC (Figure 1), including a focus on five target villages: Nasangwei, Nasamphan, Na Louang, Phou Xang Kham and That Louang (Figure 2).
- **Sectors:** The strategy involves cross-sectoral collaboration, focusing on drainage and waterway management, land-use planning, ecosystem management, infrastructure implementation, early warning and preparedness to ensure a holistic approach to flood resilience. While LPC is impacted by both fluvial and pluvial flooding, the ICFMS objectives and actions focus on pluvial flood impacts.
- **Stakeholders:** The project engages national and local government bodies, community organizations, civil society, and development partners to co-develop and implement the strategy. Attention is also given to involving vulnerable groups, such as ethnic minorities and women, in the planning and decision-making process.
- **Timeframe:** The proposed action plan spans five years, from 2025-2029, and includes short-term actions to build immediate resilience, as well as longer-term structural and non-structural actions, including infrastructure investments and ecosystem restoration initiatives.

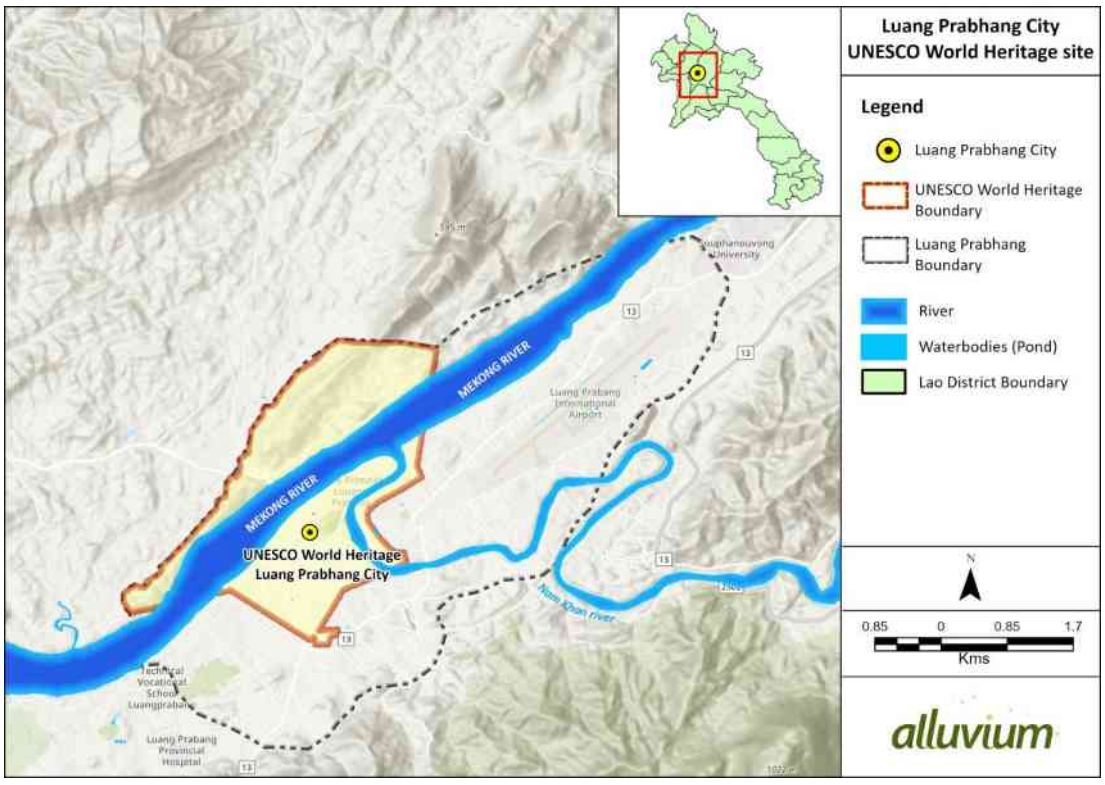
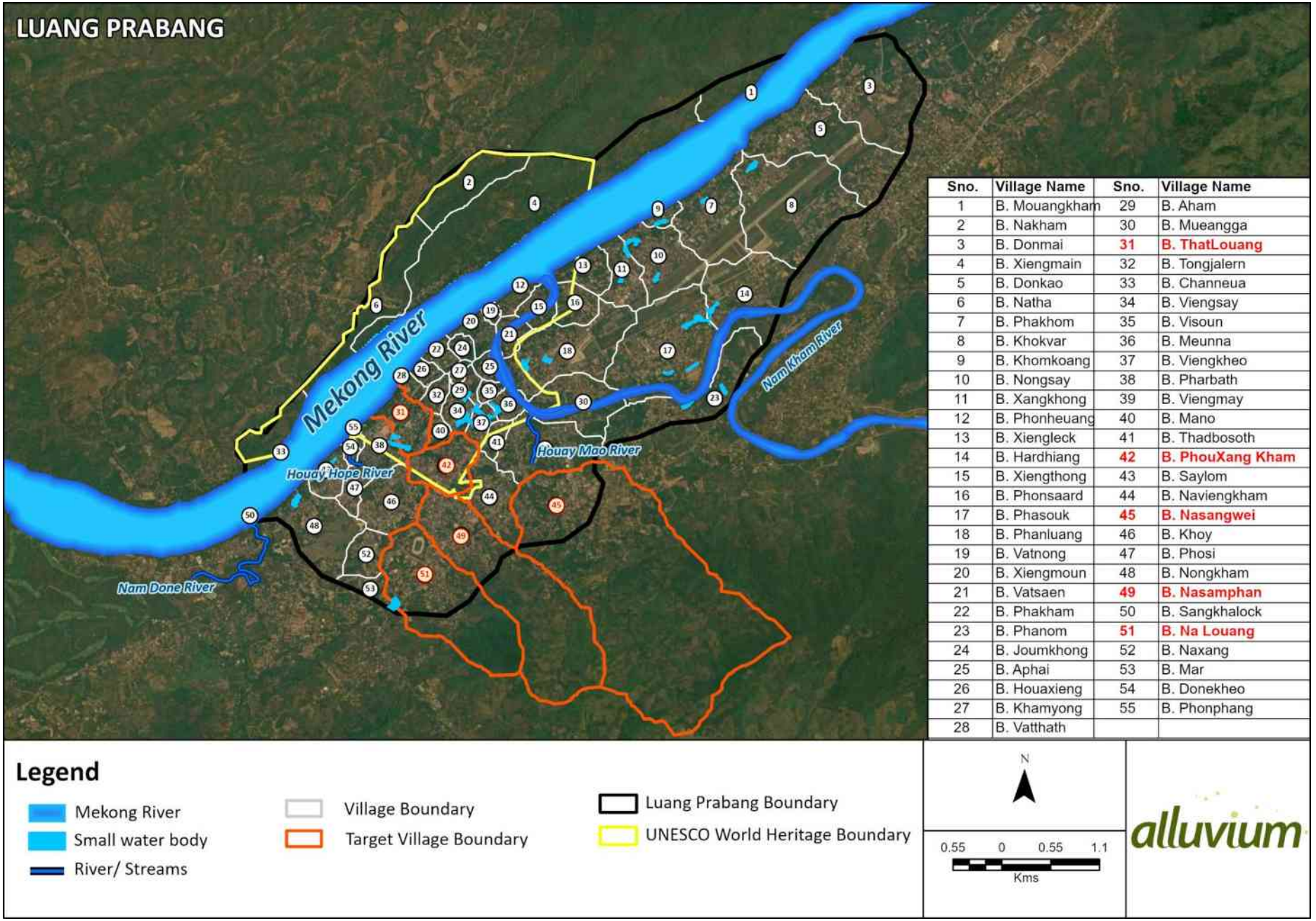


Figure 1. *Luang Prabang City (LPC)*



Sno.	Village Name	Sno.	Village Name
1	B. Mouangkham	29	B. Aham
2	B. Nakham	30	B. Mueangga
3	B. Donmai	31	B. ThatLouang
4	B. Xiengmain	32	B. Tongjalern
5	B. Donkao	33	B. Channeua
6	B. Natha	34	B. Viengsay
7	B. Phakhom	35	B. Visoun
8	B. Khokvar	36	B. Meunna
9	B. Khomkoang	37	B. Viengkheo
10	B. Nongsay	38	B. Pharbath
11	B. Xangkhong	39	B. Viengmay
12	B. Phonheuang	40	B. Mano
13	B. Xiengleck	41	B. Thadbosoth
14	B. Hardhiang	42	B. PhouXang Kham
15	B. Xiengthong	43	B. Saylom
16	B. Phonsaard	44	B. Naviengkham
17	B. Phasouk	45	B. Nasangwei
18	B. Phanluang	46	B. Khoy
19	B. Vatnong	47	B. Phosi
20	B. Xiengmoun	48	B. Nongkham
21	B. Vatsaen	49	B. Nasamphan
22	B. Phakham	50	B. Sangkhalock
23	B. Phanom	51	B. Na Louang
24	B. Joumkhong	52	B. Naxang
25	B. Aphai	53	B. Mar
26	B. Houaxieng	54	B. Donekheo
27	B. Khamyong	55	B. Phonphang
28	B. Vatthath		

Figure 2. *Villages in LPC, with target villages shown with orange polygons and red labels*

1.2 Process for developing strategy

The ICFMS for LPC forms part of a larger project titled "Integrated Water Resource Management and Ecosystem-based Adaptation in the Xe Bang Hieng River Basin and Luang Prabang" (referred to as the IWRM & EBA Project).

The IWRM & EBA Project is funded by the Global Environment Facility and delivered by the United Nations Development Programme in the Lao People's Democratic Republic (Lao PDR). This project aims to support the Government of Lao PDR to promote the integrated management of land and water resources for targeted rural and urban communities in the Xe Bang Hieng River Basin (XBH) and LPC.

The IWRM & EBA Project has three Outcomes:

- **Outcome 1:** Enhanced national and provincial capacities for integrated catchment management and integrated water resource management in target rural and urban communities.
- **Outcome 2:** Reduced flood risk through headwater conservation, restoration and protective infrastructure, supported by climate-resilient and alternative livelihoods.
- **Outcome 3:** Effective knowledge management and Monitoring and Evaluation through awareness/advocacy and monitoring of climate change impacts and adaptation opportunities in target rural and urban communities.

Outcome 1 consists of two Outputs:

- **Output 1.1:** An assessment of EbA and protective infrastructure options for XBH and LPC, flood- and drought-risk maps of XBH, and an economic evaluation of urban ecosystem services for LPC.[1]
- **Output 1.2:** Integrated Climate-Resilient Flood Management Strategies (ICFMS) developed for LPC and the XBH, supported by an updated hydrometeorological monitoring network, early-warning systems (EWS) and revised emergency procedures for the XBH. [2]

This ICFMS is part of Outcome 1.2 and builds on the data gathered from previous risk mapping and hydrological models (from Output 1.1). These strategies will align with broader IWRM and ICM goals, ensuring that interventions are sustainable and support long-term climate resilience.

The process and timeline for developing the ICFMS is summarised in Figure 2. The process was highly consultative and guided by the key approaches outlined below – ICM, IWRM, EbA, and Early Warning Systems.

Figure 3. *Process and timeline adopted in developing ICFMS*

[1] Flood- and drought-risk maps were developed by Antean as part of a separate work package for XBH as part of Output 1.1, no flood- and drought-risk maps were prepared for LPC.

[2] The hydrometeorological monitoring network, early-warning systems (EWS) and revised emergency procedures were only investigated in detail for XBH.

1.2.1 *Integrated Catchment Management*

Integrated Catchment Management is a process that recognises "catchment" as the organising unit for understanding and managing ecosystem processes in a context that includes social, economic and political considerations, and guides communities towards an agreed vision of sustainable natural resource management in their catchment.

1.2.2 *Integrated Water Resource Management*

Integrated Water Resources Management (IWRM) is a process that promotes the coordinated development and management of water, land and related resources to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. The basis of IWRM is that the many different uses of finite water resources are interdependent, and that unregulated use of scarce water resources (surface and groundwater) is wasteful and inherently unsustainable.

1.2.3 *Ecosystem based Adaptation*

Ecosystem-based Adaptation (EbA), also referred to as Nature-based Solutions for Adaptation, harnesses biodiversity and ecosystem services to enhance the resilience and reduce the vulnerability of people and the environment to climate change (Figure 4, p2). Eba involves the conservation, sustainable management and restoration of ecosystems (such as forests, floodplains, rivers and wetlands).

1.2.4 *Early Warning Systems*

The Early Warning System (EWS) analysis presented in this strategy draws on the UNDP framework for Early Warning Systems (UNDP, 2018) (Figure 5).[3] The framework provides expected elements of successful EWS across themes of risk knowledge; monitoring and warning system service; dissemination and communication; and the response capability of agencies and communities.

Figure 4. *Ecosystem-based Adaptation conceptualised in the Driving Forces-Pressures-State-Impacts-Responses framework (Source: UNEP-UNDP-IUCN, 2010)*

Figure 5. *UNDP framework for early warning systems (Source: UNDP, 2018)*

[3] The hydrometeorological monitoring network, early-warning systems (EWS) and revised emergency procedures were only investigated in detail for XBH. These matters were considered at a high level and in less detail for LPC.

2 Situation assessment

2.1 Context

2.1.1 Location and geography

LPC is located in the heart of the mountainous region of Northern Lao PDR. It is one of the country's most popular tourist destinations, having been declared a World Heritage Site by UNESCO in 1995 for its rich architectural, cultural, and religious heritage. The city is bordered by mountains and lush jungles (in particular the Phou Thao and Phou Nang mountain ranges), and the surrounding landscape is dotted with waterfalls, natural pools, and wetlands. The urban area of the city lies on a relatively flat clay basin, enclosed by limestone hills that dominate the region.

The city is part of the largest municipality within Luang Prabang District, which is one of 15 Districts within the larger Luang Prabang Province (Table 1, Figure 6). The city is located 300 metres above sea level at the confluence of the Mekong River and the Nam Khan River approximately 425 km north of Vientiane.

Table 1. *Summary of Luang Prabang city and region.*

Name	Description
Luang Prabang City (LPC) *(also known as Luang Prabang Town and Municipality of Luang Prabang)*	• The Municipality of Luang Prabang consist of 72 villages, has a population of about 60,232 inhabitants and covers ~138 km^2 (13,800 ha), consisting of approximately 20% urban and 80% rural land use. • Most citizens of LPC are engaged in the service industry, processing, trade or agricultural production.
Luang Prabang District	• Luang Prabang District consists of total 115 villages across an area of ~774 km^2 (77,400 ha). • The total population of the district is ~83,843 people (2011), of which ~60% live in the Municipality of Luang Prabang.
Luang Prabang Province	• Contains 15 Districts and ~429,900 people over an area of ~16,875 km^2. • In recent years the province has attracted major infrastructure projects, including the Lao–China High-Speed Railway, new hydropower developments, and a planned expressway to Vientiane. A 4,850-hectare development zone is also planned to support tourism and residential expansion, encompassing areas around the high-speed railway station, Chomphet district, and Kuangsi Waterfalls (AASCTF 2023a). • Neighbouring provinces consist of Phongsali to the North, Huaphan and Xieng Khoung to the East, Vientiane Province to the South and Oudomxai Province to the West.

Figure 6. *Relative Location of LPC within Luang Prabang District and Province (Egis 2023).*

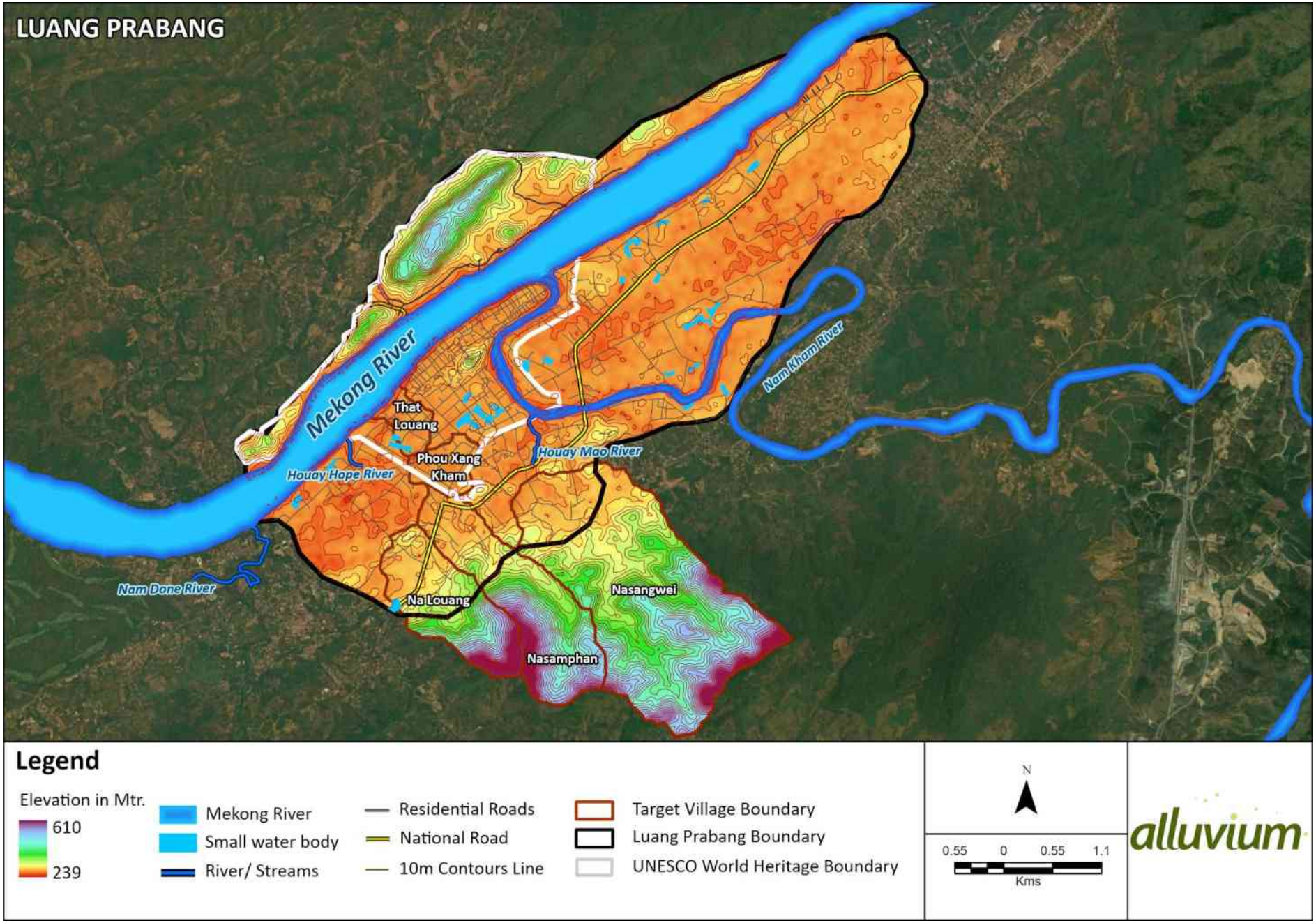


Figure 7. *LPC elevation and villages (target villages in orange)*

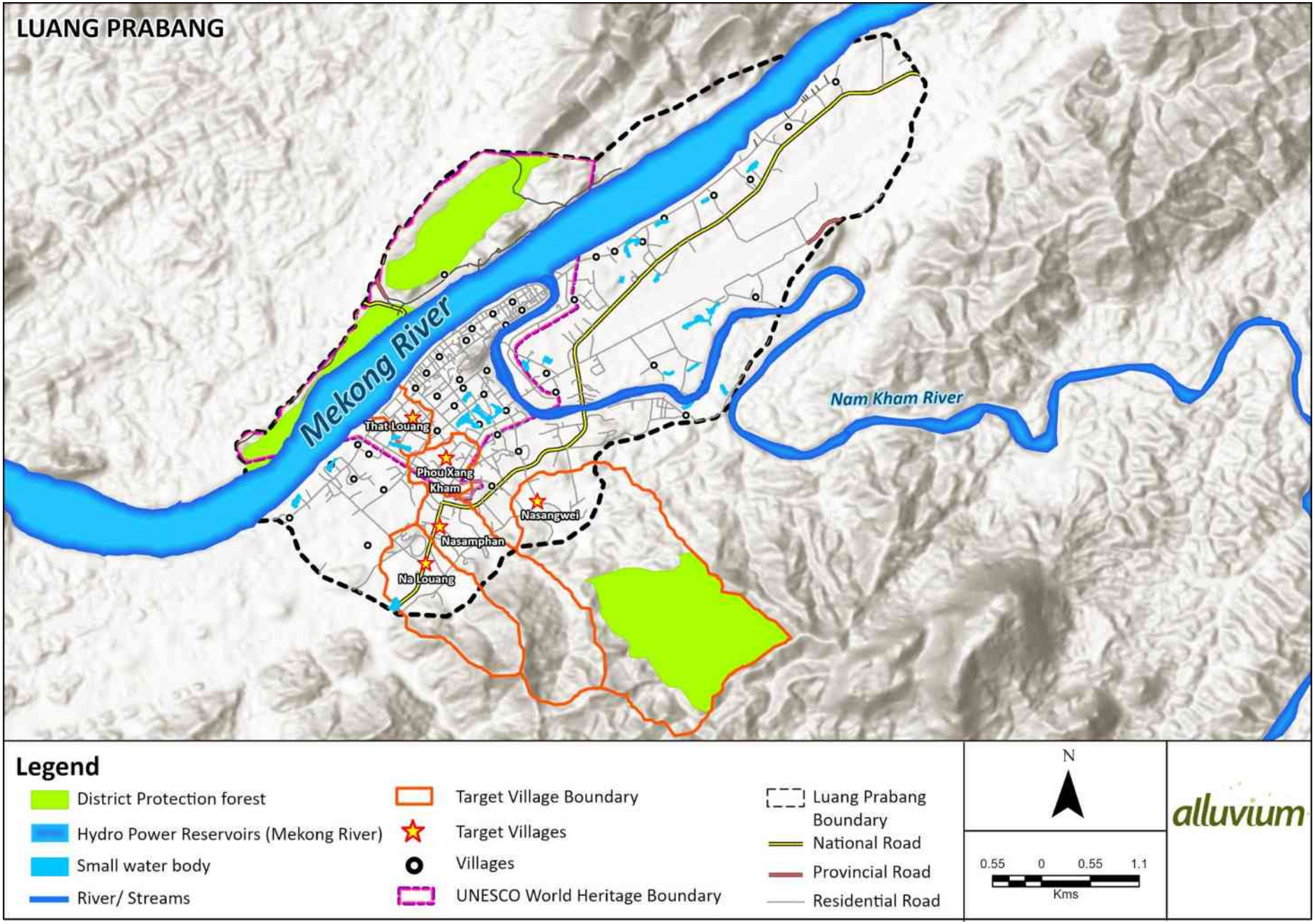


Figure 8. *LPC major waterways (Mekong River and Nam Khan River), villages (target villages in orange), protected forests and road networks (data sourced from Lao PDR Map Analyst 2024)*

2.1.2 *Socio-economic analysis*

A summary of key socio-economic factors influencing LPC and its surrounds are presented in Table 2.

Table 2. *Summary of socio-economic analysis*

Topic	Level	Key Issues
Economics	National	Developing economy with high dependency on agriculture, showing signs of modernization.
	Provincial	Gross Provincial Product of $1.2 billion; key sectors are agriculture, tourism, manufacturing.
	District	Rural-urban migration due to tourism jobs, contributing to urbanization.
	City	Significant growth in tourism, creating challenges in urban infrastructure and socioeconomic divides.
Social Development	National	Gender inequality, low social safety coverage, and limited health access.
	Provincial	Human Development Index of 0.65; 85% of adults can read and write and have 45% access to healthcare; but only a small portion of people receive social aid.
	District	Rural areas lack access to social security, pensions, and healthcare.
	City	High poverty rate among vulnerable populations (ethnic groups, women-headed households), see also Figure 9.
Infrastructure and Services	National	Inadequate waste management, sanitation issues, and capital investment shortages.
	Provincial	850 km of paved roads, 2,400 km of unpaved roads; growing digital connectivity.
	District	Poor waste management, lacking sanitation, and minimal urban planning.
	City	Tourism-driven infrastructure strain; limited waste management systems.
Agriculture and Rural Development	National	Agriculture as a primary economic activity, with rice as main crop.
	Provincial	120,000 hectares dedicated to rice, livestock, and forestry; 65,000 farm households.
	District	Rural economy with limited market access for agricultural products.
	City	Challenges in linking agricultural production to broader markets.
Education and Human Capital	National	High primary enrolment; educational infrastructure with high student-teacher ratios.
	Provincial	95% primary enrolment, decreasing at secondary and tertiary levels.
	District	Unequal educational access in rural areas, especially for secondary education.
	City	Limited educational attainment in urban areas due to poverty and resource gaps.
Healthcare System	National	High infant and maternal mortality rates, with a lack of healthcare access in remote areas.
	Provincial	12 hospitals, 85 health centres; 75% healthcare access, 80% vaccination rate.
	District	Rural healthcare challenges; limited facilities and personnel for effective coverage.
	City	Urban areas have better access to healthcare facilities but still face service gaps.
Environmental Considerations	National	Extensive forest cover and biodiversity under pressure; growing impact of climate change.
	Provincial	Forest coverage, which accounts for 65% of the total land area with 25% of land as protected area. There is a 1.2% annual deforestation rate with soil erosion ranging from moderate to severe.
	District	Soil erosion and water pollution impacting rural areas significantly.
	City	Urban pollution and deforestation affecting the local environment.

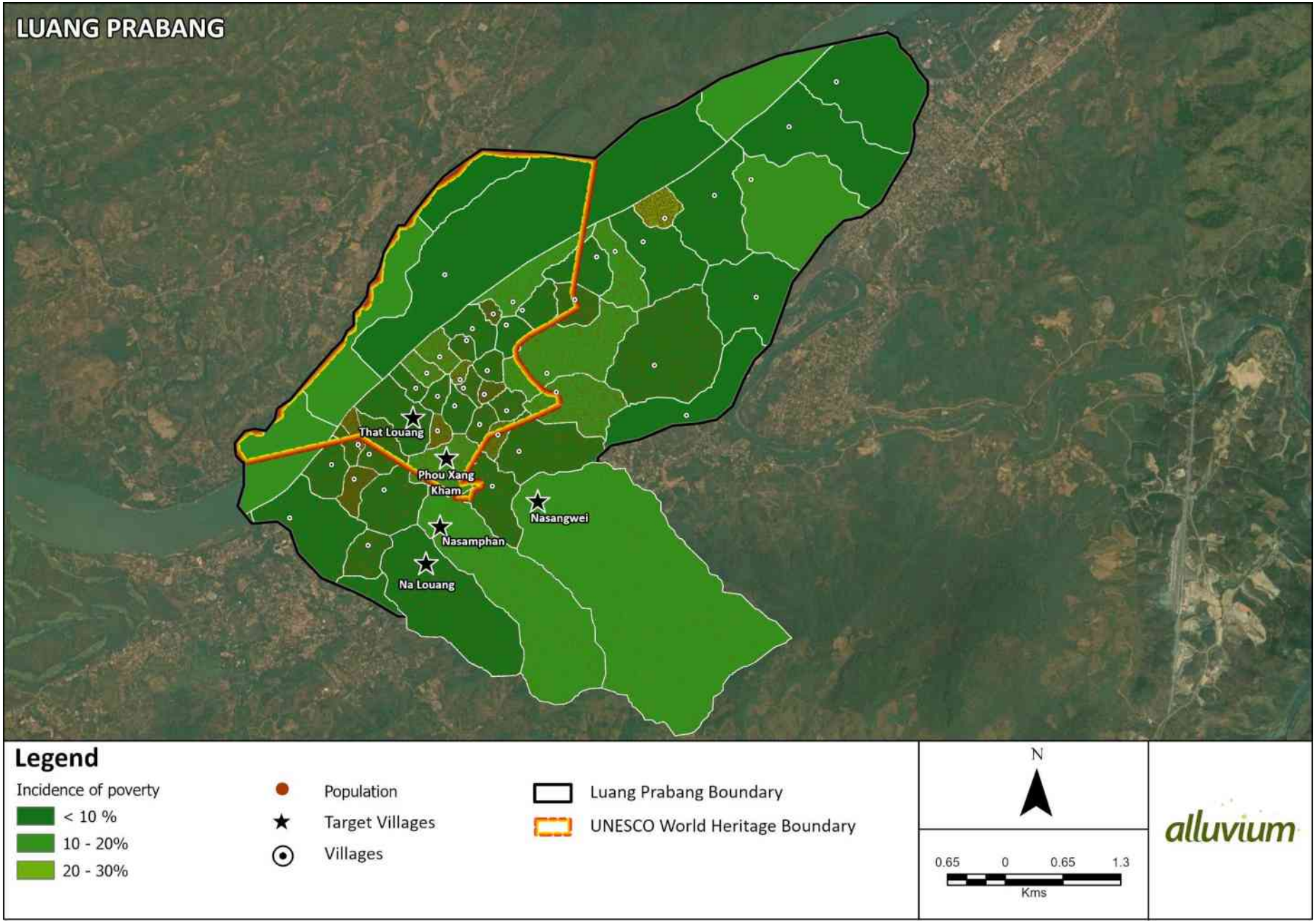


Figure 9. *Incidence poverty in LPC (data sourced from Lao PDR Map Analyst 2024)*

2.1.3 Cultural heritage

LPC served as the royal capital of the Lan Xang Kingdom, one of Southeast Asia's largest kingdoms from the 1350s until the early 1700s, before falling under French colonial rule in the 1800s. The historic city has a rich heritage, including:

- Man-made and well-preserved temples, traditional wooden dwellings and colonial houses. The city reflects an exceptional fusion of Lao traditional architecture and 19th and 20th century European colonial style buildings.
- Natural spaces located in the heart of the city and along the riverbanks, and wetlands (a complex network of ponds used for fish farming and vegetable growing).

In recognition of its cultural heritage, the area was designated a UNESCO World Heritage Site in December 1995, encompassing the villages on the peninsula at the confluence of the Nam Khan River and the mountains on the opposite side of the Mekong River.

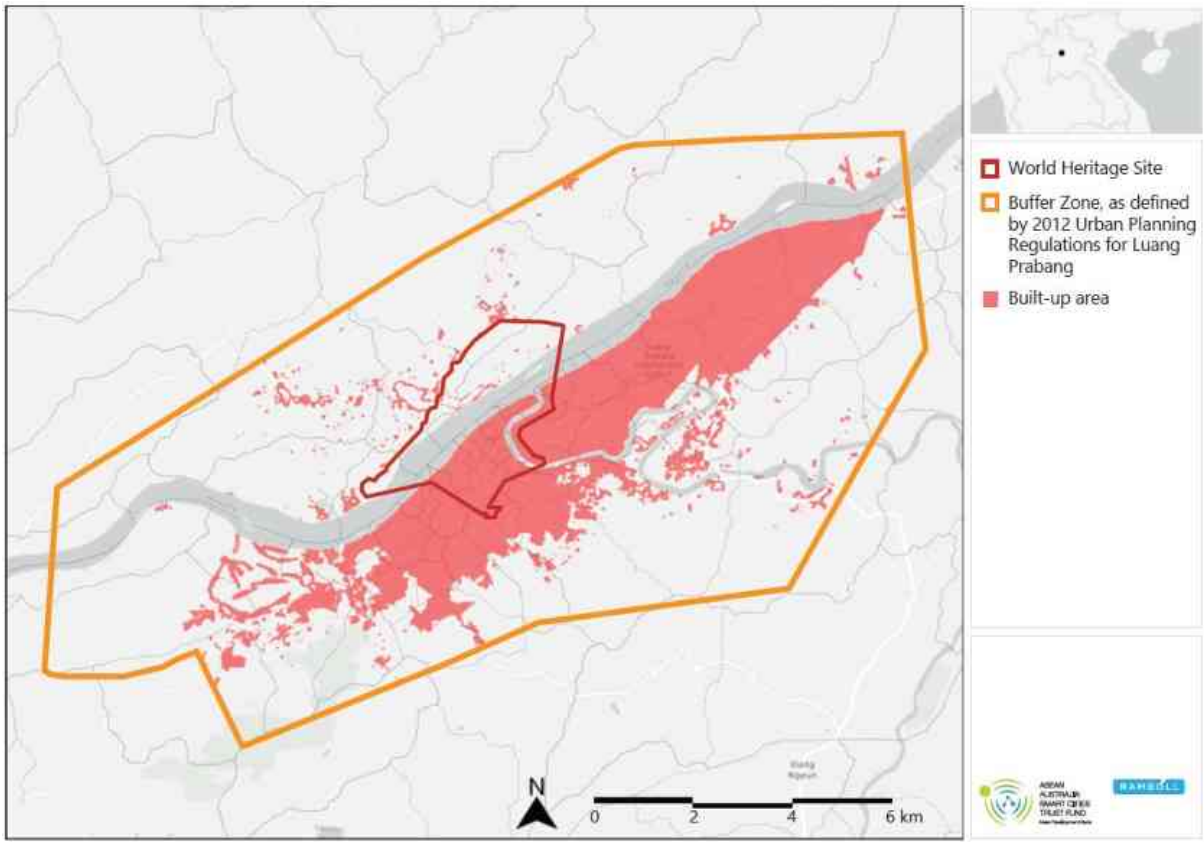


Figure 10. *World Heritage site, buffer zone and existing built area, as of February 2022 (AASCTF 2023c)*

The protection of LPC heritage is guided by several decrees and laws,[4] the Safeguarding and Enhancement Plan (SEP) and Urban Plan (UNESCO 2024). The SEP provides both regulatory and adaptable guidance to balance protection with development. The plan includes regulations that mitigate the impacts of rapid urban growth. The restructured Heritage Division, established in 2009, plays a central role in preserving Luang Prabang's heritage. This includes enforcing the SEP and Urban Plan, and providing guidance on development and infrastructure projects to ensure alignment with heritage standards. In particular, large-scale projects (e.g., new towns, big hotels) are deferred until comprehensive impact assessments align them with heritage guidelines. These Heritage Division's efforts are strengthened by significant community involvement in heritage preservation activities and the implementation of sustainable tourism practices.

[4] E.g. Law on Environmental Protection No. 09/NA (1999) includes Article 16, focusing on historical, cultural, and natural heritage, and Article 7, mandating socio-environmental impact analyses before development.

2.1.4 Tourism and growth

Luang Prabang is the top tourist destination in Lao PDR, known for its rich cultural heritage and scenic landscapes. In 2019, the city welcomed an estimated 638,000 international visitors and 222,000 domestic tourists, generating around $266 million USD in revenue (AASCTF 2023a). Tourism plays a vital role in the local economy, supporting businesses, creating jobs, and attracting investment.

Between 2010 and 2019, Luang Prabang Province saw nearly a 200% rise in international tourist arrivals, reaching over 638,000 visitors in 2019 (Figure 11). Most of these visitors concentrate around the city's World Heritage Site. The city itself has also grown rapidly, with its population increasing by over 60% from 1995 to 2015, driven in part by rural migration for tourism-related jobs (AASCTF 2023a). This growth brings economic opportunities but also creates challenges, impacting the city's physical and social landscape. Vulnerable populations, including ethnic groups, older residents, and low-income households, often live on the city's outskirts, widening the socioeconomic divide.

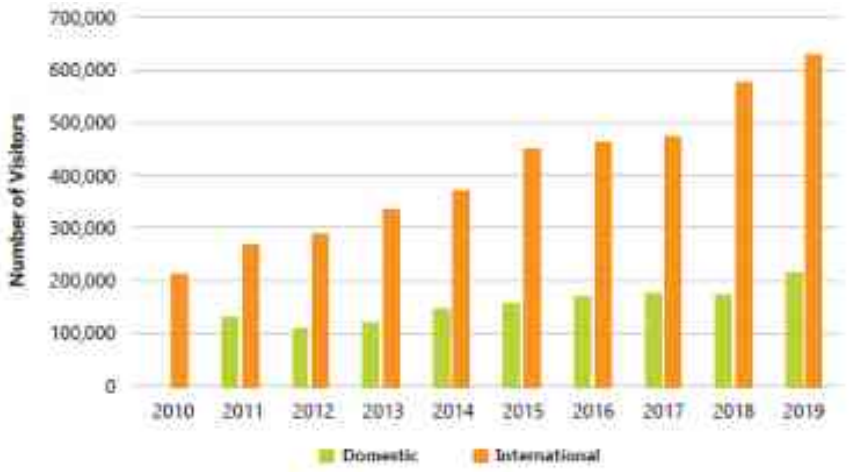


Figure 11. *Luang Prabang Tourist Arrivals, 2010–2019 (AASCTF 2023a)*

2.1.5 Land use and land use planning

There are two key land use planning instruments in LPC, the SEP and the 2012 Urban Planning Regulations. The SEP regulates urban development within the 820-hectare World Heritage Site through the establishment of zones and permissible activities within each zone. The Urban Planning Regulations (2012) were prepared by the Ministry of Public Works and Transport (MPWT) for a larger 12,560-hectare buffer zone designed to further protect the World Heritage Site (Figure 14). The zoning regulations for new building activity in accordance with the SEP and Urban Planning Regulations are presented below in Table 3. Building permits for construction in these zones are issued by the Luang Prabang World Heritage Management Division (LPWHMD), Department of Public Works and Transport (DPWT) and Office of Public Works and Transport (OPWT) (Figure 15).

Despite the above-mentioned zoning and permitting process, urban land use planning and enforcement remains a challenge in LPC. For instance, key issues reported by the ASEAN Australia Smart Cities Trust Fund (AASCTF 2023b) include:

- Lack of zoning regulations and enforcement.
- Risk of residential areas and wetlands being converted to commercial use, threatening community cohesion and heritage characteristics.
- An erratic property market with very low property taxes that discourage property rental or usage, affecting business activity.
- The need for guidelines on ratio of guesthouses, hotels, shops, and residences to maintain heritage and support equitable development.

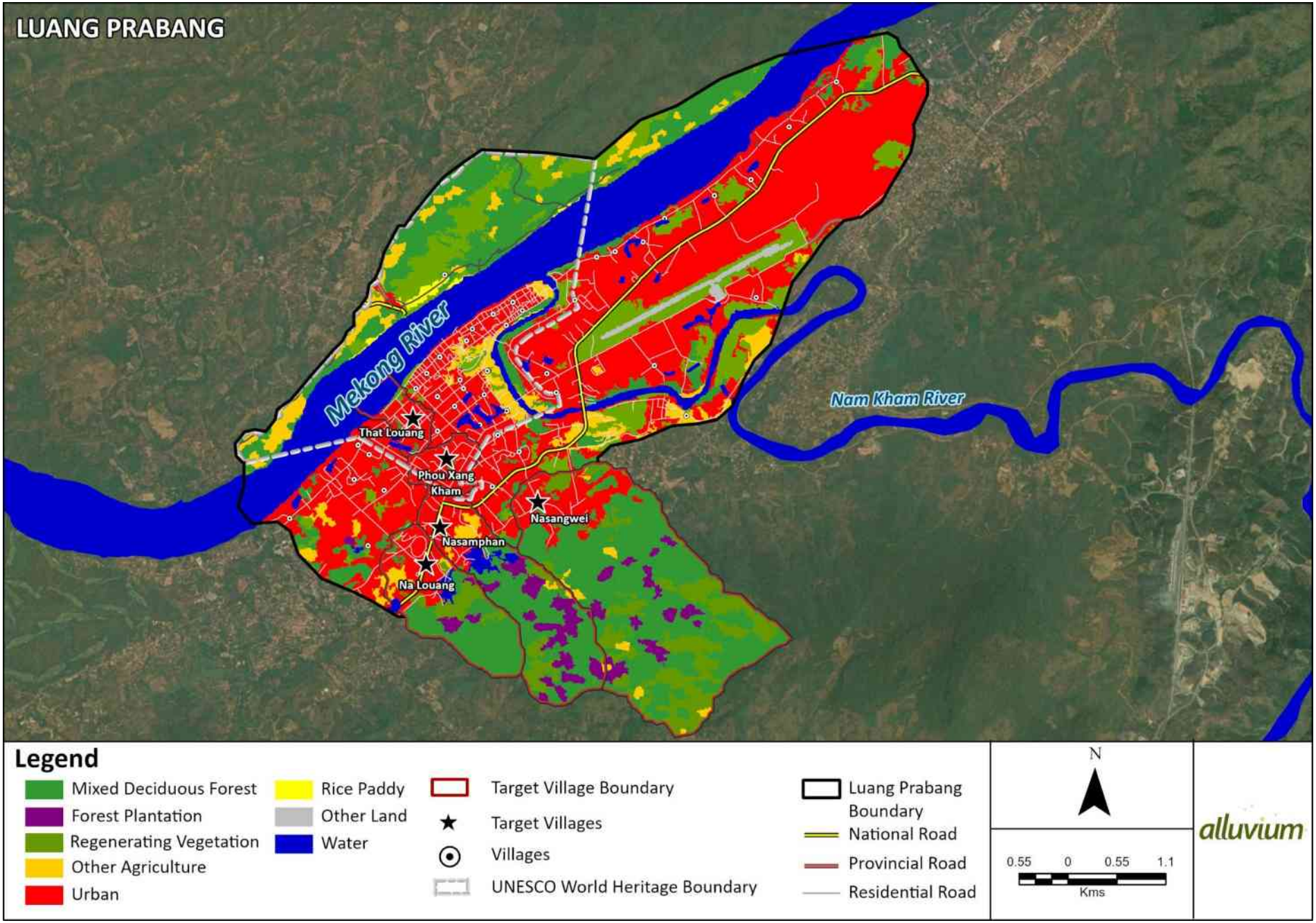


Figure 12. *Land cover in LPC (data sourced from Lao PDR Map Analyst 2024)*

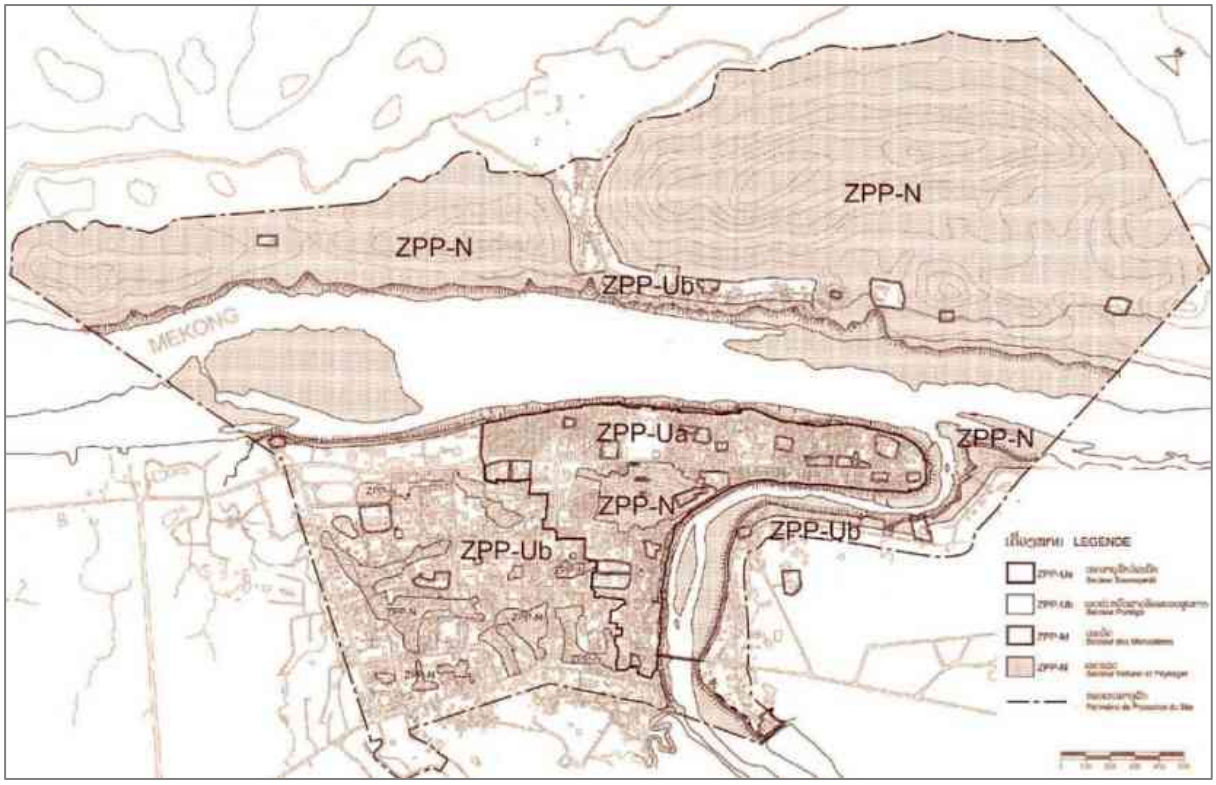


Figure 13. *Luang Prabang's Heritage Protection Areas (ZPPs) (AASCTF 2023b)*

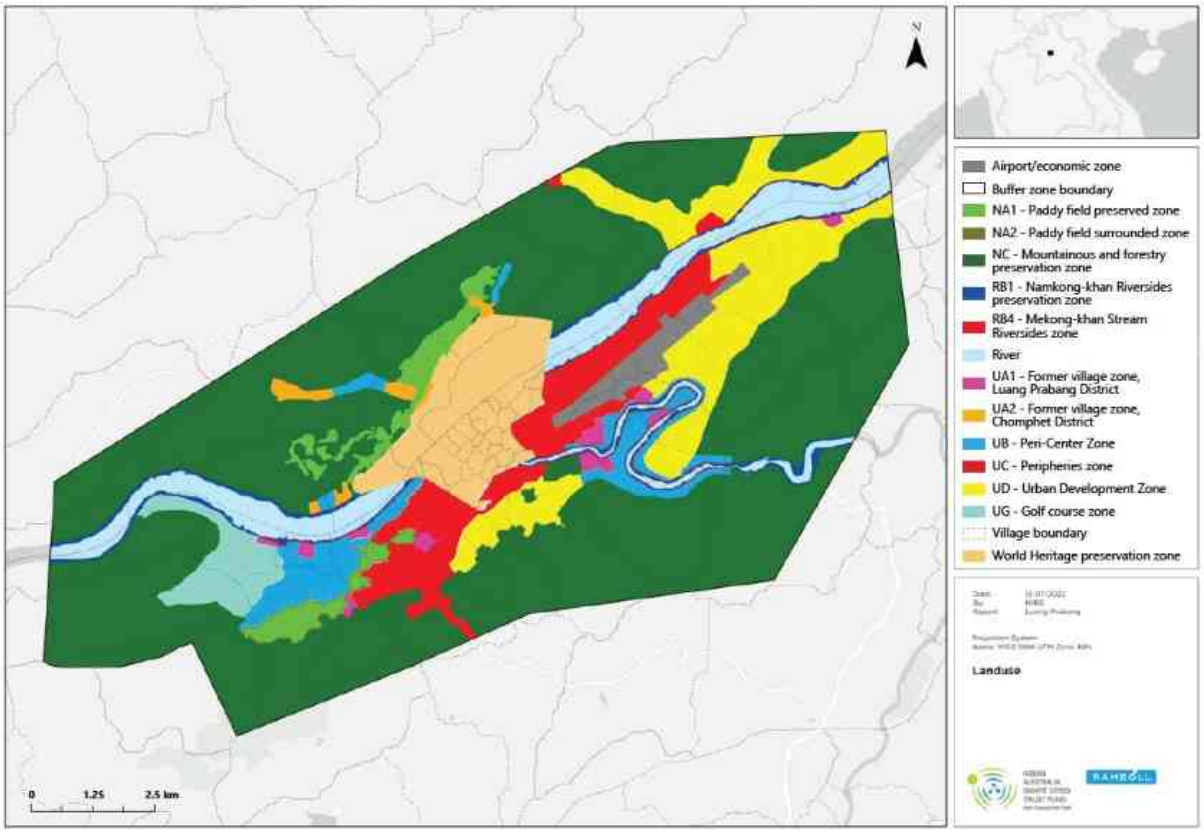


Figure 14. *2012 Urban Planning Regulations for Luang Prabang (AASCTF 2023b)*

Table 3. *Zoning regulations in LPC (AASCTF 2023b)*

Zone Name	Description
Safeguarding and Enhancement Plan (SEP)	
Preservation Zone (ZPP-Ua)	Covers the peninsula formed by the Nam Khan and Mekong rivers, excluding Phousi Hill; includes residences, markets, and amenities along main and secondary roads; high tourism impact.
Protection Zone (ZPP-Ub)	Covers area south of ZPP-Ua on the right bank of the Nam Khan and Mekong rivers; primarily residential with markets and amenities along main and secondary roads.
Monasteries Zone (ZPP-M)	Includes land plots within monastery boundaries; encompasses activities related to Buddhist worship, such as education and lodging for monastery residents.
Natural and Scenery Zone (ZPP-N)	Covers natural and forested areas, wetlands, riverbanks, and Phousi Hill; nature is key to Luang Prabang's outstanding universal value.
2012 Urban Planning Regulations	
Core Heritage Area	Refers to the World Heritage Site with boundaries corresponding to the SEP.
Preservation Zones (RB1, NA2, NA1, NC)	Comprises three land use zones; nature conservation areas around the World Heritage Site to control development and limit urbanization within this zone.
Urban Development Area and Peripheries Zones (UD, UB, UG)	Comprises three land use zones; future urban development area identified south of the World Heritage Site along the Mekong River and part of Chomphet District.
Urban Outskirt Area and Former Village Zones (UC, UA1, UA2)	Comprises three land use zones; areas adjacent to the World Heritage Site where urban development must contribute to heritage protection.

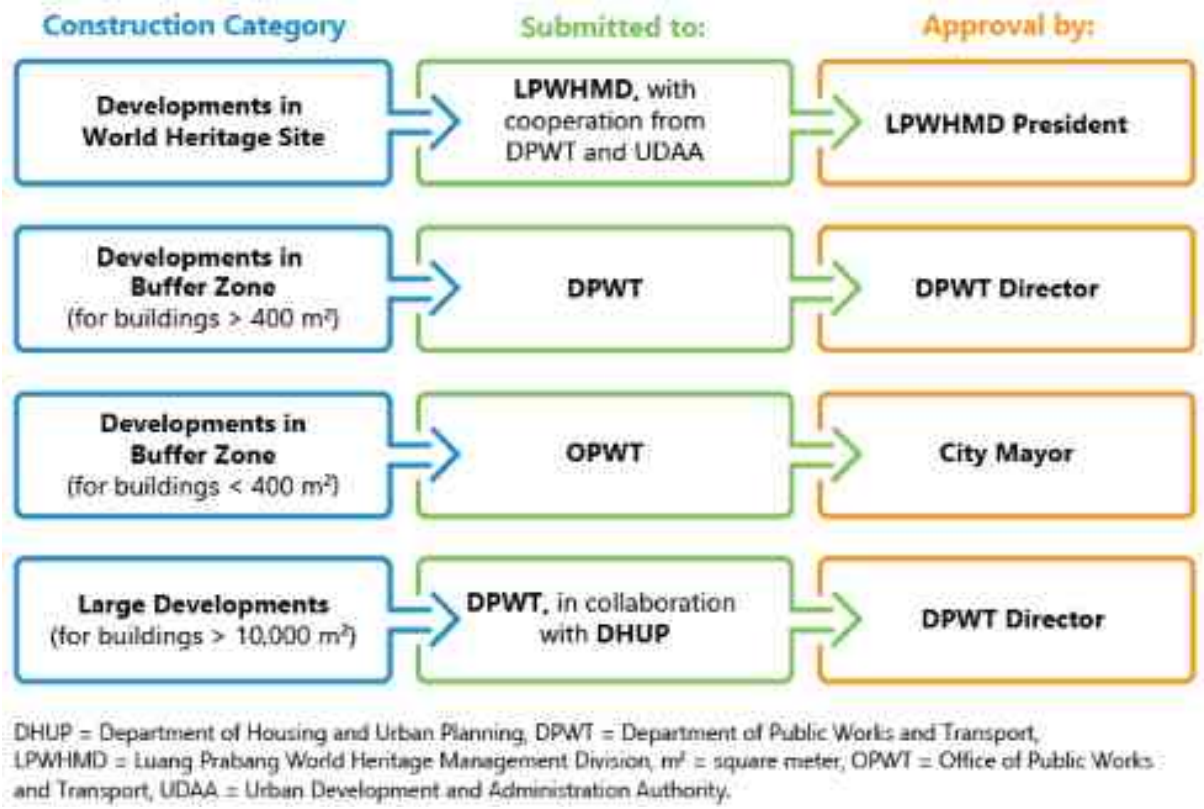


Figure 15. *Construction permit approvals process in LPC (AASCTF 2023b)*

2.1.6 Sanitation and solid waste management

Egis (2023a) note that "[d]espite Luang Prabang being a globally known tourism destination, and having had significant growth over recent years, the quality and scope of sanitation coverage is poor. Many of the septic tanks in this old Protected Heritage Area of Luang Prabang are in poor condition, being cracked or full of sludge to the extent that they are no longer operating as septic tanks." The city's drainage channels and ponds also hold large amounts of greywater, which often becomes stagnant and produces unpleasant odours during the dry season - negatively impacting both the city's liveability and visitor experience (Egis 2023b). AASCTF (2023a) also report that "[o]f the total solid waste generated in Luang Prabang, only 68% is collected and sent to the town dump. Less than 1% is recovered and sold as recyclables and the remainder is either burned in situ or illegally dumped. Littering is common, causing untidy streets, choked drains, and localized flooding." This is partially due to the lack of overarching national laws and regulations on sanitation and solid waste management.

2.1.7 Climate characteristics

Luang Prabang has a tropical monsoon climate with distinct wet and dry seasons. The wet season spans from April to October, while the dry season covers the remaining months. The city remains generally warm year-round but experiences cooler temperatures in December and January (AASCTF, 2023a). Weather data from the Luang Prabang City (LPC) station for 2019–2023 indicates that the dry season, from November to April, features warm to hot temperatures, with December and January being the coolest months. During the wet season, from May to October, high humidity prevails, with the heaviest rainfall occurring between June and August. The average temperature is around 24.6°C, with a maximum of 43.5°C recorded in April.

Annual rainfall in Luang Prabang ranges from about 970.1 mm to 1,365 mm, with the wettest period typically from May to October. The average annual rainfall is approximately 1,219 mm, based on LPC weather station data from 2019–2023. Egis 2023c reports that rainfall reaches its highest levels in July and August, with 77% of the total annual precipitation falling between May and September. The highest daily rainfall recorded was 179.5 mm in 2018.

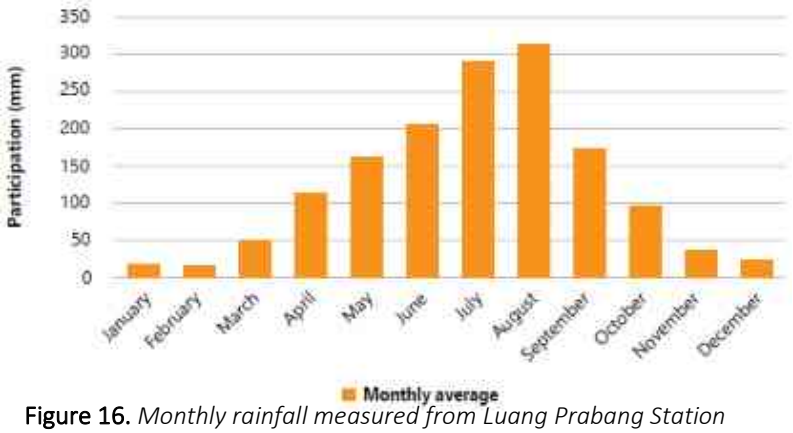


Figure 16. *Monthly rainfall measured from Luang Prabang Station (AASCTF 2023c).*

Looking at national climate trends under climate change, temperature in Lao PDR are expected to rise roughly 4.1°C by the 2090s under the highest emissions pathway (RCP8.5) compared to the 1986–2005 baseline, and 1.2°C under the lowest pathway (RCP2.6).Most models also predict increased annual precipitation, with greater changes under higher emissions pathways, though there remains high uncertainty. Some global trends indicate that sub-daily extreme rainfall events are intensifying with temperature increases, as seen in some Asian regions including Lao PDR. The CCKP model ensemble suggests that the average largest 5-day cumulative rainfall may rise from about 135 mm to over 150 mm under RCP6.0 and RCP8.5. Further research is needed due to the complex relationship with localised geography and El Niño Southern Oscillation (ENSO) impacts.

According to Egis (2023c), under the Shared Socioeconomic Pathway (SSP) 5-8.5 scenario, projections indicate that for Luang Prabang the maximum daily precipitation could rise from an average of 457 mm in the baseline period to approximately 683 mm by the end of the century, representing an increase of around 50%. This significant rise in rainfall intensity suggests that heavy rain events will become more severe, likely increasing the probability of flooding in the region.

2.1.8 Ecosystems and natural assets

The resources provided the natural ecosystems in the broader Luang Prabang region are vital assets. Forest regions comprise evergreen forests (35% of the total area), deciduous forests (30%), and protected areas (25%) %), and others area (10%). The province is abundant in minerals including gold, copper, iron ore, limestone, and gemstones. The agricultural potential is underpinned by several soil types: alluvial soils (15%), red soils (40%), and montane soils (45%), each conducive to various crops and species.

The city itself lies at the confluence of the Nam Khan and Mekong Rivers. Other key rivers in the area of the project include the Dong river, Houay Hope river, the Houay Mao river and the Houay Philock river. The city's ecosystems and natural landscape plays a significant role in defining the area's outstanding universal value (Figure 17). This encompasses open green spaces, wetlands, ponds, riverbanks, and natural landmarks. Scenic features also include tree-lined streets and green corridors along main roads and local alleys, contributing to a lush urban environment. Despite the importance of these assets, only wetlands/ponds currently benefit from regulatory protection, leaving many green spaces vulnerable to conversion into development sites (AASCTF 2023b).

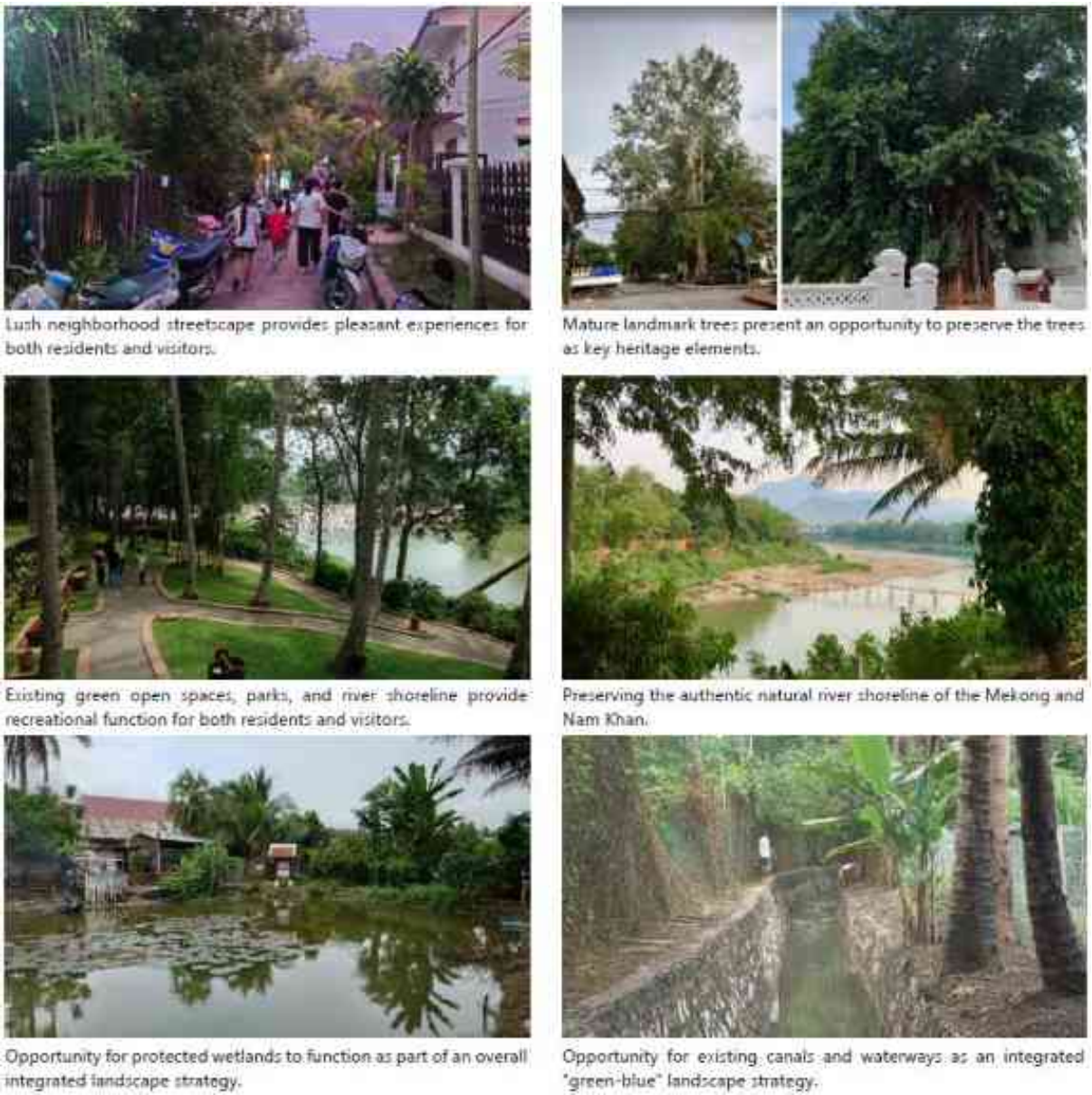


Figure 17 *Examples of Luang Prabang's landscape and streetscape (AASCTF 2023b)*

GRET (2024a) report that the threats to the manmade network of wetlands/ponds (hereafter referred to collectively as "wetlands") is particularly concerning as they are one of the elements that led to the site's inclusion on the UNESCO World Heritage list. GRET also note that:

- The wetlands play a role in reducing flood risks, treating household wastewater, and cooling the city.
- Wetlands are being polluted by effluent caused by a lack of wastewater management in the city.
- Traditional fish farming is declining, lowering community interest in wetlands.

Even though wetlands are nominally protected by the city's laws and regulations, they are mostly privately owned. A large number are deteriorating and disappearing, with local authorities report inga reduction from 183 wetlands in 1999 to only 120 today (GRET 2024a). This goes against planning regulations and leads to a reduction in the city's natural heritage and flood detention capacity. To safeguard this capacity, existing wetlands should be preserved, retrofitted with flood-resilient designs, and rehabilitated. This also provides an opportunity to enhance recreational opportunities for the city (AASCTF 2023b).

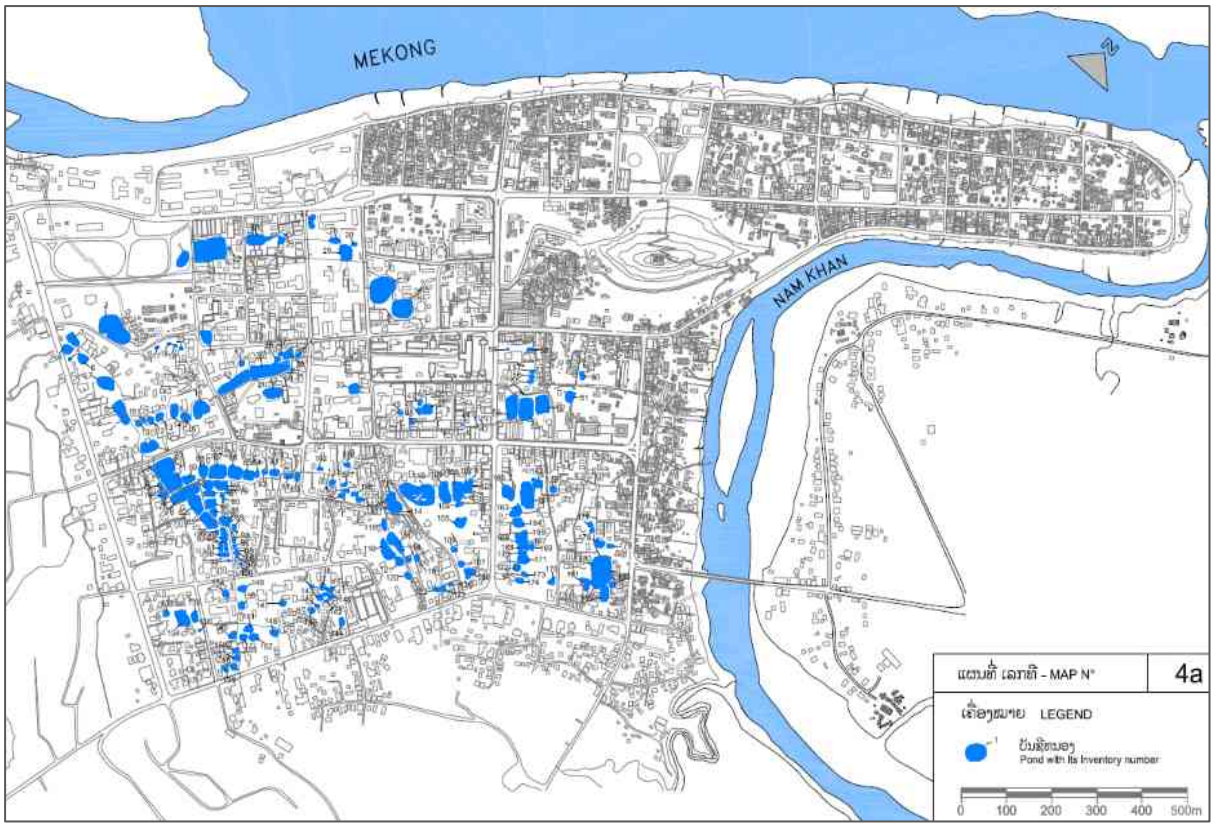


Figure 18 *Inventory of wetlands in Luang Prabang (GRET 2024b)*

A high-level overview of the ecosystem services being provided by ecosystems in and around LPC was recently completed by Alluvium and Hydrotech Consulting (2024b). The analysis highlights how weak regulation of urban development may reduce the delivery of ecosystem services, including flood mitigation, and leave the city less prepared to handle the effects of climate change.

A potential opportunity exists for LPC to use broader, city-wide approaches to address urban flood risk. This includes options for stronger regulation of urban development to protect ecosystem assets, such as forest and waterway buffers in and near the city. In addition to site specific actions, these types of city-wide approaches, and the preservation of natural assets, should be considered as part of future urban flood management plans.

This contention was explored through the lens of three case studies, which considered the value and risks associated with:

- Case study 1: Unregulated development of the land in the foothills surrounding LPC

- Case study 2: Urban development encroaching urban waterways in LPC
- Case study 3: Protecting and restoring wetland ponds in LPC

These case studies indicate that the use of EbA to address flood risk in LPC may provide additional benefits to the community in comparison to hard infrastructure alternatives or a 'do nothing differently' scenario (e.g. lack of planning and enforcement to prevent land use change). The case studies illustrate that the preservation and enhancement of natural systems has the potential to reduce flood risk, while also providing co-benefits such as food, climate regulation, and tourism services. Furthermore, EbA may also provide the opportunity to manage multiple issues for the city concurrently (e.g. flooding and urban heat).

Based on these findings, it is recommended that the ICFMS include actions that support:

- Regulating development, with planning controls more strongly enforced to reduce urban encroachment resulting in loss of forested and agricultural land.
- Restricted development near urban waterways and protecting existing waterway buffers to preserve flood protection (and other) values they provide.
- Protection and restoration of wetland ponds to prevent further ponds being infilled for development and maintain their drainage and flood protection function.

2.1.9 Existing strategies and plans

The Luang Prabang Smart and Integrated Urban Strategy (AASCTF 2023a) and Drainage and Sewerage System Master Plan (UDAA 2013) are important strategies related to flood risk management in LPC and are summarised below.

Luang Prabang Smart and Integrated Urban Strategy

The Luang Prabang Smart and Integrated Urban Strategy (AASCTF 2023a) outlines a smart city strategic infrastructure plan to achieve Luang Prabang's ambition to become a more liveable heritage city for all. This ambition is supported by three strategic pillars:

1. Integrated Tourism and Heritage Destination
2. Clean and Safe Environment
3. Sustainable Villages and a 15-Minute City

The strategy will be implemented under the supervision of a steering committee chaired by the provincial governor and supported by multisector working groups. Each working group will oversee one of the three strategic pillars, and smart city projects required to realize Luang Prabang's liveable heritage city ambition.

The strategy and supporting Urban Assessment Report (AASCTF 2023b) highlights that:

- Severe rainfall and floods are the most pressing climate change risk.
- Floods have a disproportional impact on women, older persons, people with disabilities, and other marginalized and vulnerable groups.
- Litter and the lack of solid waste management exacerbates local flooding, and water and land pollution issues.
- Heritage asset protection from flood and other disasters is important. Specific smart technologies to detect, report, and trigger rapid responses to floods (or fires) is proposed.
- Gross pollutant traps will be piloted in roadside drains to improve current solid waste collection systems by managing accumulated drain litter which have been found to obstruct water flow in drains and impact effluent quality. The installation of gross pollutant traps can contribute to:
    - Improved drain conditions with reduced occurrences of clogged drains and localized flooding.
    - Improved water quality in surface water systems.
- There is a loss of flood detention capacity due to ponds being backfilled for development. To prevent further loss in flood detention capacity, existing ponds should be preserved, retrofitted with suitable flood resilient designs, and rehabilitated to provide added recreational value for the city.

- There is an opportunity to integrate “blue-green” infrastructure which uses nature based solutions for flood risk reduction.
- One of the factors that contributes to flooding is the proximity of communities to the Mekong River and its tributaries, such as the Nam Khan. High water levels result in fluvial flooding of urban areas.
- A poorly maintained drainage system, suffering from blockages due to improper solid waste management, contributes to localized flooding in the city, reducing conveyance capacity of drains.
- Other factors, such as insufficient flood risk reduction measures and infrastructure, urbanization, and poor urban planning may also contribute to flooding risks.
- During localized flooding, wastewater in the existing decentralized sanitation infrastructure in the city (pit latrines and septic tanks) contaminates stormwater, leading to elevated public health risks.

Several relevant interventions are proposed under *Strategic Objective 2.2: Disaster Management System is Improved*, including hazard risks assessment, flood risk zoning, flood defence mechanisms, smart early flood response and a social inclusion study, with GEDSI mainstreaming considerations. A detailed list of relevant projects identified in the LPC Smart and Integrated Urban Strategy are provided in Figure 19 (p11). These actions are also considered in the ICFMS Action Plan (2025-2025) presented in Chapter 3 (p22).

Figure 19. *Relevant projects identified in the LPC Smart and Integrated Urban Strategy (AASCTF 2023a)*

Pillar	Project	Name	Relevance	Implementation	Responsibility	Page #	Related work
1	**4**	**Heritage Disaster Risk Management (DRM) Policy and Plans**	• Implement measures and smart technologies to detect, report and trigger rapid responses to threats or actual immediate risks such as fires or floods	Medium term (2026-2030)	Department of Information, Culture and Tourism (DICT)	79-80	Hydrology and Meteorology section of PoNRE is developing a standardised alarm system is being developed, supported by a modern command centre, to handle alerts for various emergencies, including fires and floods.
2	**9**	**Gross Pollutant Traps (GPTs)**	• Pilot project to support the waste management process and reduce flooding.	Immediate – pilot project (2023-2024)	Public Works and Transport Office (PWTO), Urban Services Office (USO)	99-100	The Department of Natural Resources and Environment (DoNRE) is proposing to implement an awareness raising campaign to encourage better waste management for target villages: Nasangwei, Nasamphan, Nalouang, Phouxangkham, That Louang.
2	**12**	**Hazard and Risk Assessment**	• Identify high risk areas, e.g., flood inundation areas by developing and calibrating relevant models. • Produce hazard maps, e.g., flood maps, to serve as foundation for resilience strategies development.	Nar term (2024-2026)	Department of Public Works and Transport (DPWT)	101-2	DoNRE previously conducted a survey to map the flood zones from the Nam Khan River to Xiengngeun District, as part of the integrated water management project. They are now drafting a proposal to install water level warning signs along the Mekong River tributaries.
2	**13**	**Flood Risk Zoning**	• Produce flood-proof spatial plans and design, e.g., avoid locating critical infrastructure in in flood-prone areas. • Develop land use processes to guide new developments and upgrading of existing developments in flood-prone areas. • Prepare clear building regulations, considering high water levels to eliminate downstream flooding impact. • Prepare clear action plans to relocate existing critical infrastructure and developments in flood-prone areas.	Near Term (2024-2026)*	DPWT	103-4	DoNRE is working on plans for flood protection, including changing the land title conditions and land zoning to prevent construction in flood-prone areas.
2	**14**	**Flood Defense Mechanisms**	• Flood defense through risk mitigation and adaptation focuses on measures that prevent stormwater from inundating urbanized areas, through implementation of infrastructure such as dikes or nature-based solutions. • Detention volume can also be added through implementation of detention ponds or widening of drains or rivers. • For example, the installation of GPTs can offer surface runoff pre-treatment and filter out the debris to prevent the drainage system from blocking, hence, runoff could enter the drainage and flow out of the site without obstruction.	Near Term (2024-2026)*	DPWT	103-4	DWR has issued legislation regulating the opening and closing of water channels during the dry and rainy seasons, based on water level fluctuations. DWR is also working to modify the drainage channel in areas like Ban Kok Nguyue and Nasamphan to reduce the risk of sudden flooding.
2	**15**	**Social Inclusion Study, with GEDSI Mainstreaming Considerations**	• Conduct a social inclusion study as part of the program to ensure that flood resilience measures are adapted to support vulnerable groups.	Near Term (2024-2026)*	Department of Labour and Social Welfare (DLSW)	105-6	Stakeholders suggest that regular evacuation drills are needed to prepare for disasters, along with the creation of effective response mechanisms. Additionally, a rain warning system is proposed to notify communities when heavy rainfall occurs over extended periods.
2	**16**	**Smart Early Flood Response System**	• Smart early warning systems with real-time data capture can be developed based on the results of the existing flood maps to ensure that communities are equipped to respond to flood events in a timely manner.	Near Term (2024-2026)*	DLSW	105-6	Stakeholders suggest flow and rainfall modelling tools should be used for real-time monitoring and to support timely response planning for potential flood events.
General comment			A project proposal is being prepared by PoNRE for the 2025 fiscal year, focusing on water resource management and ecosystem adaptation in the Xe Bang Hiang water basin and Luang Prabang town, covering five target villages. Ban Kok Nguyue village is also being considered for inclusion in the study plan. Key activities for the 2025 plan have been identified, but challenges remain in securing sufficient budget, vehicles, and equipment for implementation.				

** Requires "High Level Hazard and Risk Assessment" to be completed first.*

Drainage and Sewerage System Master Plan

The Luang Prabang Drainage and Sewerage System Master Plan (UDAA 2013) splits the municipality (72 villages) into three different Zones (Figure 20,p12), namely:

- Zone I is the World Heritage Protection Area and divided into two major areas:
  - Zone I-A: the old centre without natural wetlands
  - Zone I-B: the area with natural wetlands.
- Zone II is a high population density zone.
- Zone III is a low population density zone, mainly the Rural Areas of the municipality.

The Master Plan states that a drainage system was constructed in 2003 in Zone I. However, in Zone II and III, most of the streets have no formally constructed drainage channels for stormwater collection. Drainage problems are mainly caused by blockages which affect the operation of natural and constructed drainage.

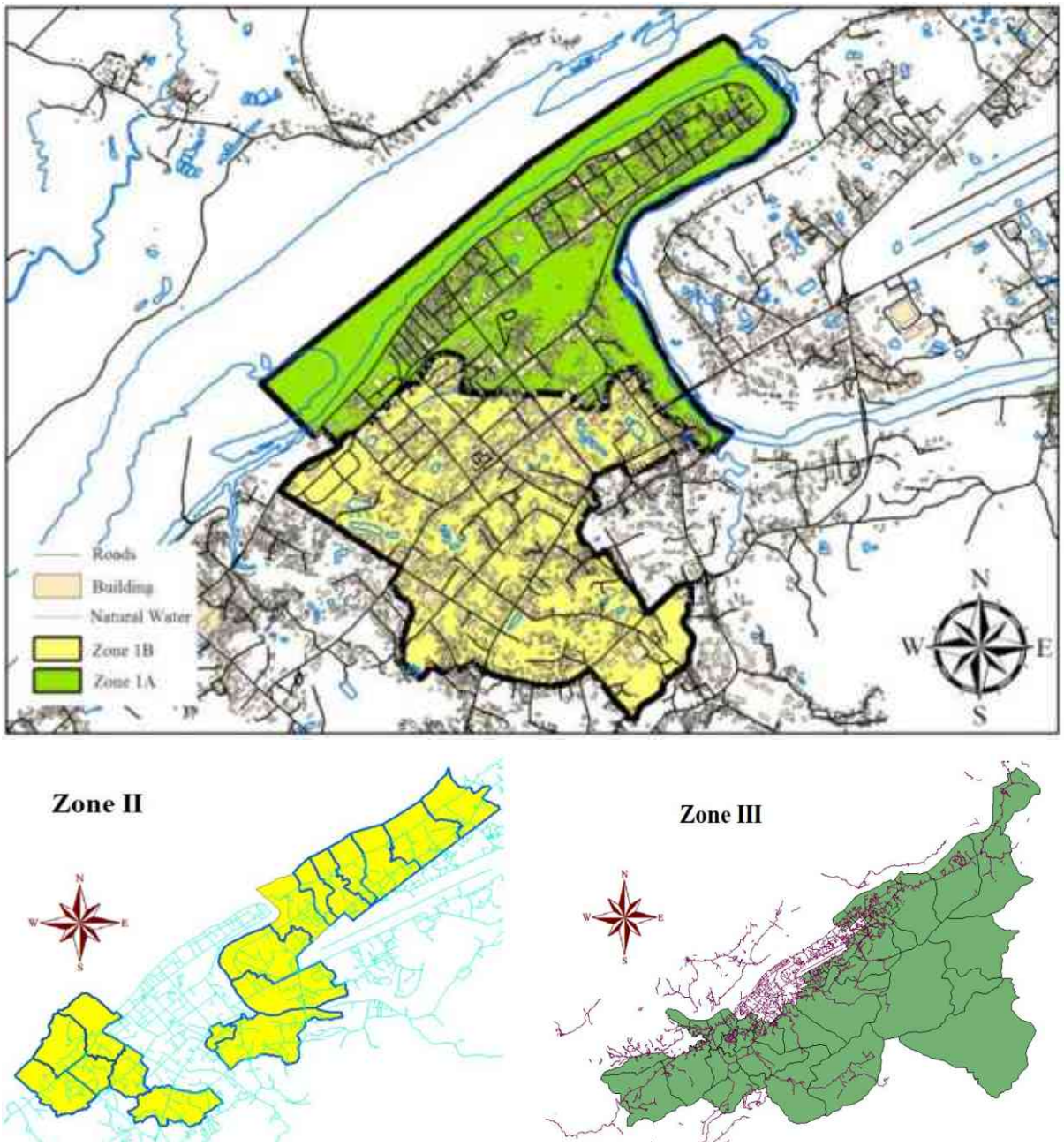


Figure 20. *Luang Prabanag City drainage zones (UDAA 2013)*

The Master Plan notes that:

- Urban development has one of the highest impacts on infrastructures in Luang Prabang municipality.
- Maintenance is not efficiently executed on a regular basis for all investments.
- Due to rapid urban growth, there is a big lag of drainage and sewerage systems.
- Each year a maintenance plan should be provided including all the assets of the municipality, enough financial budget and workforce should be made available to execute these tasks.
- It is highly recommended that repairs of the drainage network are given high priority to keep infrastructure in good condition.
- it is very important to keep the river banks and the creek banks free from obstacles, like buildings or other structures. The Luang Prabang Urban Development Plan has made strict Regulations about the distance for building along the river banks - firm control and enforcement is required.
- It is recommended that the ecological and hydrological functions of all the wetlands be improved or restored.

Figure 21. *Left: Cleaning activities of Drainage channel by the Luang Prabang Province - Urban Development and Administration Authority (UDAA), Right: Picture of Drainage repair works by UDAA (UDAA 2013)*

The Master Plan includes several recommendations / actions that are relevant to the LPC ICFMS (Table 4). However, it is noted that:

- Several of the recommendations are broad and generic, with little detail provided (e.g. priority, delivery timelines, responsible agencies etc.).
- It is unclear whether there is adequate funding for the actions, or where funding will be sourced from.
- The report was prepared 11 years ago and it is unclear if it is still activley being implemented.

Table 4. *Zoning regulations in LPC (UDAA 2013)*

Recommendations / actions
Zone I
Manage wastewater discharge from local use into public drainage to protect the environment and system capacity
Zone II
Construct new drainage and sewerage systems based on area needs and urban development plans
Zone I & II
Develop Urban Development Plan for future urban extension and 25-year master plan for drainage/sewerage systems
Operate, maintain, and improve existing drainage/sewerage systems at highest level
Preserve and restore wetlands for wastewater treatment, flood buffering, and ecosystem protection
Implement small-scale wastewater treatment units for all municipal wastewater before discharging into rivers
Raise public awareness about drainage and sewerage policy and management

Preserve rain infiltration areas by protecting pervious surfaces from urban development
Control and manage industrial wastewater quality to meet environmental standards before river discharge
Protect natural drainage networks (rivers, creeks, etc.) to ensure future surface water flow
General Recommendations
Establish a dedicated Department for Drainage and Sewerage Operation & Maintenance
Clearly define roles and responsibilities for the responsible organisation
Establish close cooperation with the Land Office
Strengthen the Urban Development Planning Department
Integrate Town Development Planning activities with consensus from all stakeholders
Enforce regulations on Urban Development by the Municipality

2.2 Flooding

2.2.1 Flood risks and impacts

Lao PDR ranks as one of the most flood-prone countries, placing sixth in flood exposure in the 2019 Inform Risk Index, which considers both riverine and flash flooding risks. The geography and hydrology of Luang Prabang make it particularly vulnerable to localized flooding. The following overview of flooding at the province, district and city scale is adapted from the:

- Climate Change Assessment and Natural Hazards (Luang Prabang) prepared by Egis (2023c) for the Ministry of Public Works and Transport (MPWT).
- Luang Prabang Smart and Integrated Urban Strategy: Urban Scenario Report prepared by AASCTF (2023b) with assistance from the ASEAN Australia Smart Cities Trust Fund (AASCTF).

Luang Prabang Province has experienced recurrent flooding events, which have impacted multiple districts and communities:

- 1996–2012: Eleven districts were affected by flooding, damaging 95 villages and 1,185 households across the province.
- 2016: Heavy rains in the Mekong and Nam Khan River Basins caused flash flooding in Phonxay, Viengkham, and Xiengngeun districts, severely impacting riverbanks and 155 villages, with damages exceeding LAK65 billion ($3.46 million).
- 2018: Northern Luang Prabang Province was hit by tropical storm Son-Tinh, followed weeks after by tropical storm Bebinca, which brought widespread flooding to all provinces. In 208, Luang Prabang Province was one of the most impacted areas with 95 village, 1,185 households and 5,734 people impacted (including 3 missing and 4 dead).

LPC faces significant riverine flooding risks due to its location along the Mekong and Nam Khan Rivers, where seasonal water level fluctuations are common. Communities situated near these waterways face heightened flood risks due to their proximity to water sources that can experience rapid water level increases. Between 1960 and 2019, the Mekong River at Luang Prabang Station surpassed the flood level (m) five times, underscoring the city's ongoing flood exposure.

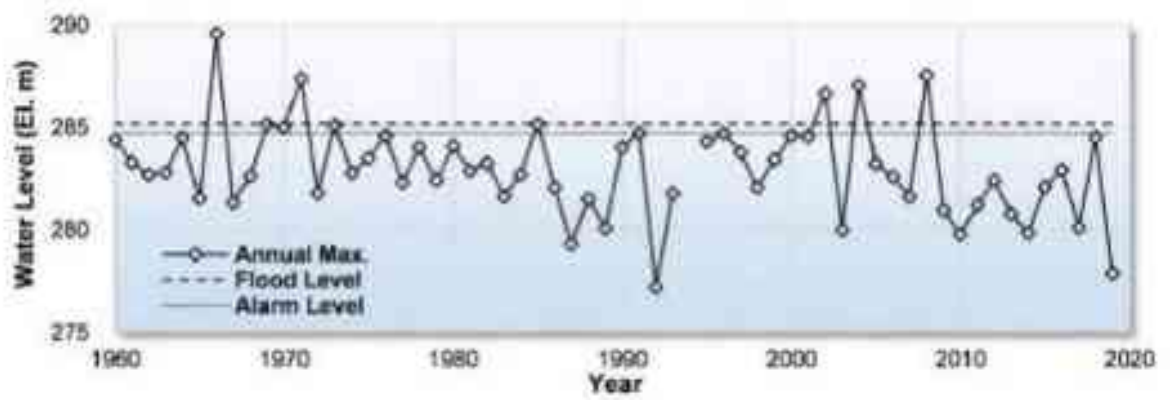


Figure 22. *Water level record of the Mekong River at Luang Prabang station (Egis 2023c)*

The city's vulnerability is heightened by the lack of flood risk reduction infrastructure. The annual flood pulse of the Mekong shapes the environment and local livelihoods, yet repeated monsoon flooding from June to November impacts communities where high river levels back up stormwater channels. Riverbank erosion along the Nam Khan, aggravated by annual floods and high flow velocities, also remains a persistent challenge, with the city's unprotected banks suffering annual damage.

The interaction of fluvial and pluvial flooding also poses a significant risk in LPC, with particular concern in five main drainage catchments: Nam Dong, Houay Hop, Misay, Mao, and Houay Kang. These areas experience annual flooding due to elevated river levels and stormwater backups in the primary channels. Several factors intensify localized flooding within the city. The existing drainage network has a limited extent (Figure 23), and it frequently experiences blockages, mainly due to inadequate solid waste management. This impairs the system's ability to efficiently channel water out of urban areas, thereby increasing flood risks. Limited flood mitigation infrastructure, ongoing urban expansion, and insufficient urban planning further exacerbate these vulnerabilities. Additionally, during flood events, stormwater can mix with wastewater from decentralised sanitation systems, such as pit latrines and septic tanks, leading to significant public health concerns.

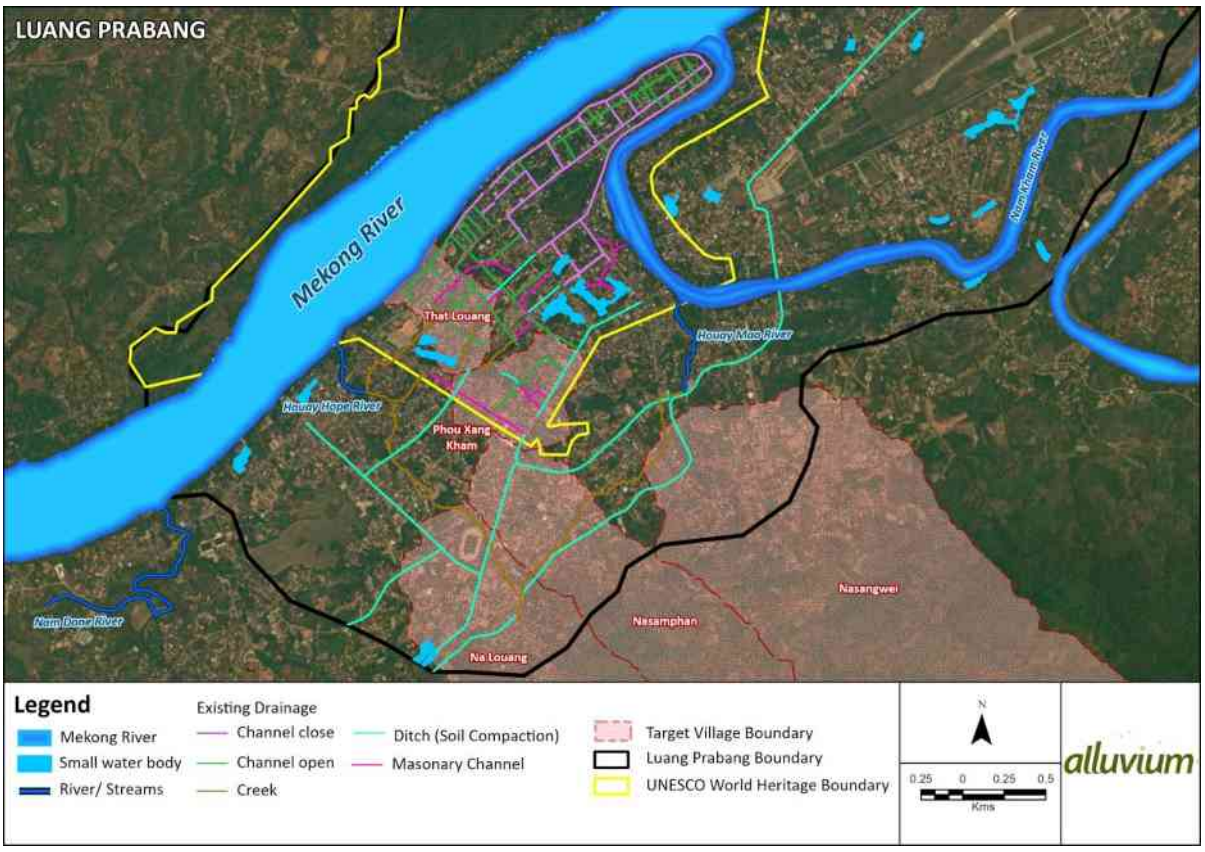


Figure 23. *Existing drainage system in LPC*

2.2.2 *Flood modelling*

Egis (2023c) notes that the World Bank-supported Lao PDR Southeast Asia Disaster Risk Management Project feasibility study highlights the necessity for flood risk reduction measures across five drainage catchments within the Mekong and Nam Khan watersheds. Approved project interventions are planned for the Houay Misay and Houay Khang catchments, as outlined in Table 5. Preliminary hydraulic modelling results from the feasibility study indicate that urban areas in the remaining three catchments—Nam Dong, Houay Hop, and Nam Mao—are expected to flood during a 1-in-20-year rainfall event.

The feasibility study also produced flood maps for the Nam Khan River and select tributaries of the Mekong River, covering six different rainfall return periods (2-, 5-, 10-, 20-, 50-, and 100-year events). These maps indicate that low-lying areas along the main tributaries are particularly susceptible to flooding, with the Nam Dong and Houay Hop catchments being especially vulnerable (Figure 26).

Table 5. *Proposed Flood Risk Reduction Measures (AASCTF 2023b)*

Catchment	Flood Risk Reduction Measures	Funding
Nam Dong	Retention pond, pumping station, flood gate	None
Houay Hop	Retention pond, pumping station, flap gate	None
Houay Misay	1-2.0 m x 3.0 m culvert, flap gate, pumping station, flap gate	World Bank
Houay Khang	1-2.0 m x 1.50 m culvert, flap gate	World Bank
Nam Mao	Retention pond, pumping station, flap gate	None

Figure 24. *1-in-20-Year Rainfall Event Flood Map (AASCTF 2023b)*

GRET (2024b) have prepared 2D pluvial flood maps for parts of LPC using HEC-RAS. The study relied on digital terrain model (12.5m), GIS drainage network and satellite data. The resulting flood maps are presented in Figure 25. GRET also examined the flood retention capacity of LPCs pond network, under:

- Current conditions - assumed 10cm of a flood detention storage per pond.
- Improved conditions - assumed 50cm of a flood detention storage per pond.

The results indicate that:

- Under **existing conditions** nearly 300m^3/ha of flood detention storage could be provided by the ponds, retaining less than a 1 year return period rain (30minutes duration).
- Under **improved conditions** nearly 1,400m^3/ha of flood detention storage could be provided by the ponds, retaining up to a 5-10 year return period rain event (30minutes duration) in some catchments.

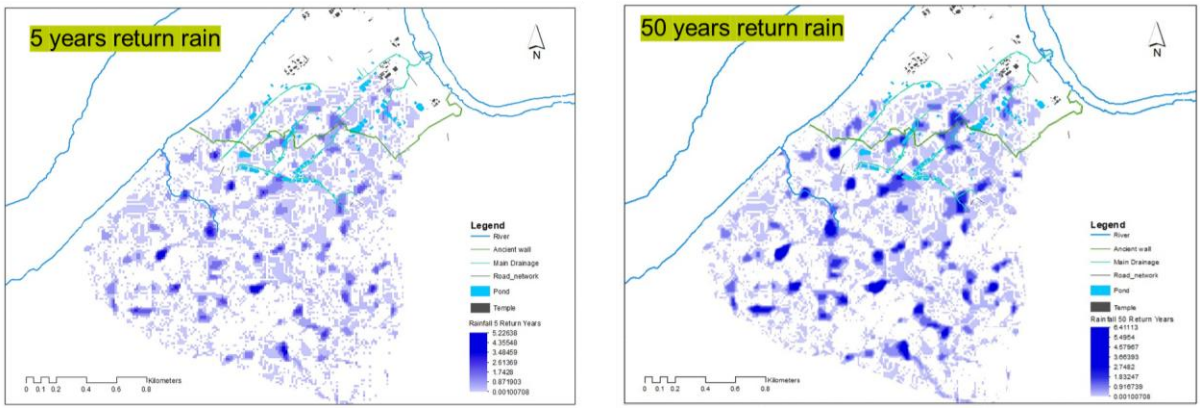


Figure 25. *1-in-5-Year and 1-in-50-Year Rainfall Event Flood Map (GRET, 2024b)*

Despite several projects investigating flooding in LPC in recent years, there appears to be:

- A lack of coordinated storage of data that is used to generate flood models, the flood modelling results and the flood models themselves.
- A lack of a holistic flood model that considers the impacts of fluvial flooding, pluvial flooding, the interactions between pluviaul and fluvual flooding under current and future climate change scenarios.
- A lack of flood modeling that systematically considers diffierent traditional and EbA infrastructure solutions, identifying viable sites and exploring both the costs and benefits of options to support master planning.

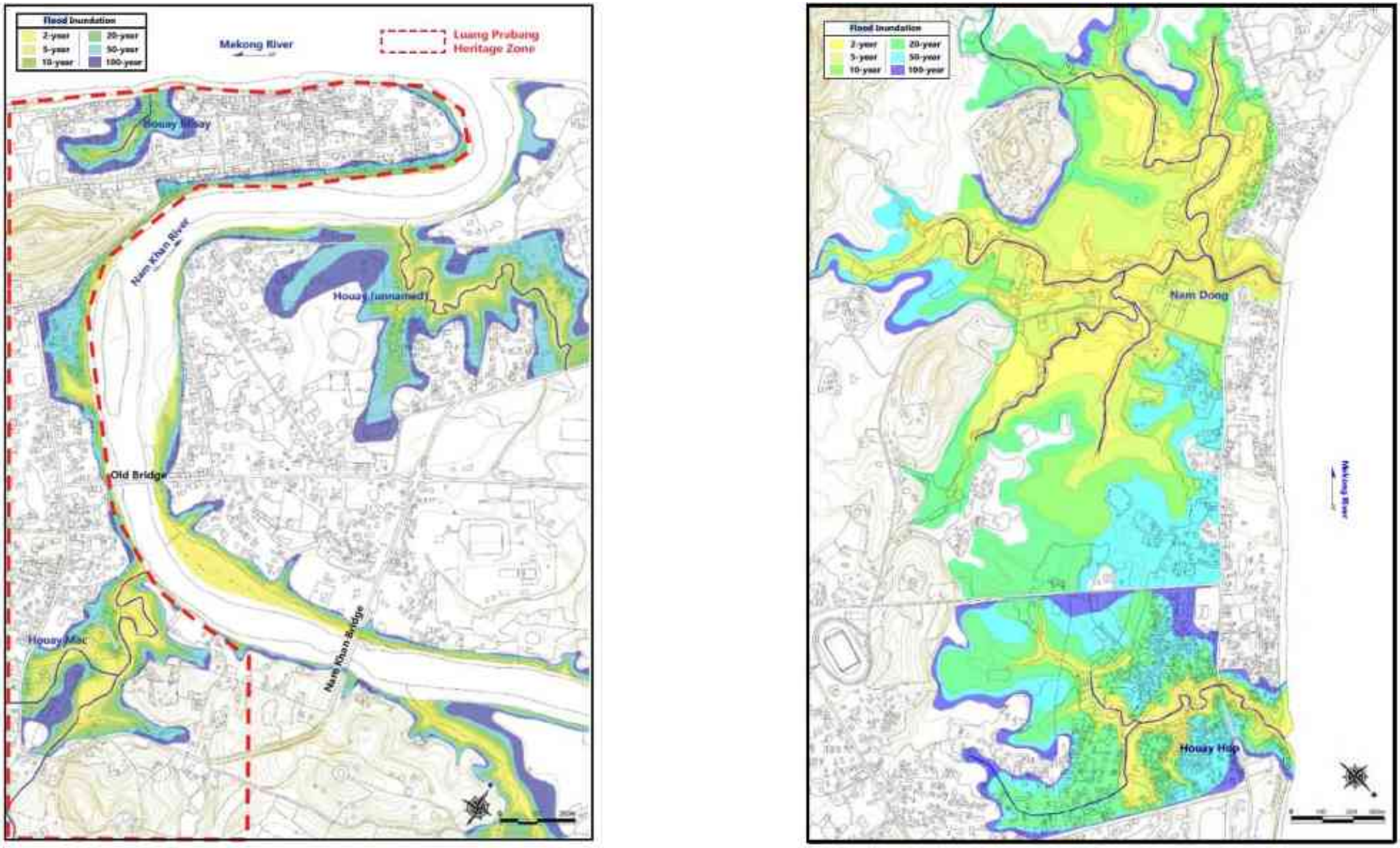


Figure 26. *Flood Map for Nam Khan River and its Tributaries (left) and Nam Dong and Houay Hop Catchments (right) (AASCTF 2023b)*

2.2.3 Flood forecasting and warning

The flood forecasting and warning systems in Luang Prabang Province follows a structure similar to other provinces in Lao PDR, as illustrated in Figure 27. The Department of Meteorology and Hydrology (DMH) under the Ministry of Natural Resources and Environment (MoNRE) in Vientiane serves as the national centre for forecasting and warnings in Lao PDR. DMH is responsible for collecting, analysing, and distributing data on key hydrometeorological parameters, including rainfall, evaporation, river water levels, and flow. Its monitoring and observation systems include observation stations, data transmission and telecommunications networks, data processing and storage systems, and comprehensive data management facilities.

At the provincial level, the Water Resources and Meteorology and Hydrology divisions within the Provincial Office of Natural Resources and Environment (PoNRE) are tasked with collecting daily weather and water level data from each river and providing this information to DMH in Vientiane. At the district level, the District Office of Natural Resources and Environment (DoNRE) compiles daily water level and rainfall data from local stations, reporting twice per day, or more frequently during emergencies, depending on the situation. Notably, the responsibility for hydrometeorological data collection largely resides with central agencies, while provincial and district agencies monitor and gather raw data from the field, but don't process or analyse the data for forecasting.

PoNRE's Meteorology and Hydrology division is also responsible for receiving weather forecasts from DMH and distributing this information to relevant provincial and district agencies, including the Provincial Flood and Drought Steering Committee and other key agencies such as DoNRE. DoNRE then relays the information to the District Governor, district agencies, and village communities, often by phone. Warnings reach villagers through megaphones or other available resources. Routine weather forecasts from DMH are sent daily to Provincial Meteorology and Hydrology at 11 a.m. During emergencies, DMH issues updates every 6–12 hours, depending on conditions. Weather forecasts typically reach villages within 24 hours; however, remote communities with limited telecommunications access may experience delays.

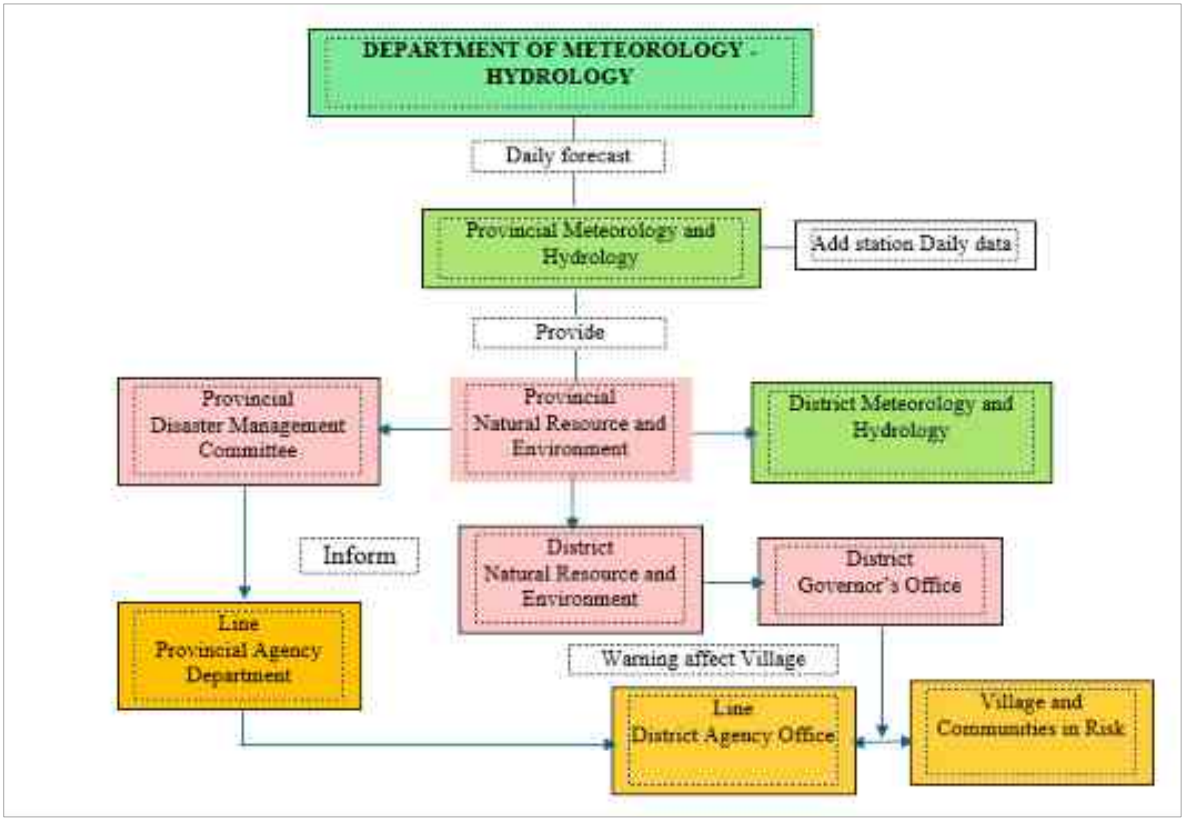


Figure 27. *The system of forecasting and warning for flood in LPC*

2.2.4 Hydrometeorological infrastructure

Hydrometeorological data collection is essential for accurate flood forecasting. The national Department of Meteorology and Hydrology has been making continuous efforts to expand its hydrometeorological network to cover all affected areas and gather more data to support forecasting. Despite these efforts, there is still insufficient infrastructure in Luang Prabang province. Currently, there is an automatic meteorological station established in 1975 by the National Meteorology and Hydrology Centre, operating at Luang Prabang Airport in Phousangkham village. Additionally, there are four rain gauge stations surrounding the city, located in Saenkhalok (established in 1988), That Luang (established in 2014), Phousangkham (relocated from an old station in 2015), and Xiangman villages (established in early 2022 through cooperation with China).

LPC is located on the Mekong and Nam Khan rivers and several water level gauges are installed along both waterways to monitor water levels. Currently, three gauges are positioned along the Mekong River, located at the villages of Pakham, Xiangman and Sanghai. Further gauges are installed on the Nam Khan River at Mixay village and the Nampa River at Kookvan village, with all gauges situated close to LPC.

In addition to government-operated gauges used for flood warnings and forecasting, several automatic water level gauges have been installed along the Nam Ou and Nam Khan rivers by hydroelectric project operators to support their infrastructure. Details of the hydrometeorological infrastructure in LPC are provided in Table 6.

Table 6. *List of meteorology and hydrology station in LPC*

No	Station name	Location			Coordination		Installed Year
		Village	District	Province	Latitude	Logitude	
I	**Meteorology station**	Phousangkham	Luangprabang	Luangprabang	19.908984	102.178208	DMH 1975
II	**Rainfall stations**						
	Seankhalok	Seankhalok	Luangprabang	Luangprabang	19.702333	101.895424	DMH 1988
	Thatluang	Thatluang	Luangprabang	Luangprabang	19.882135	102.128706	PMH 2014
	Xiangman	Xiangman	Chomphet	Luangprabang	19.896090	102.131643	China 2022
	Phousangkham	Phousangkham	Luangprabang	Luangprabang	19.908984	102.178208	DMH 2015
III	**Water level stations**						
	Mekong River	Pakham	Luangprabang	Luangprabang	19.892660	102.133890	MRC 1992
	Mekong River	Sanghai	Luangprabang	Luangprabang			LPB HP 2022
	Mekong River	Xiangman	Chomphet	Luangprabang	19.896090	102.131643	China 2022
	Nampa	Kookvan	Luangprabang	Luangprabang	19.956511	102.296815	DMH 1995
	Namkhan	Mixay	Xiangnguen	Luangprabang	19.786151	102.183172	MRC 1993

2.2.5 Early warning systems

Early warning systems (EWS) play a vital role in protecting communities and building resilience against floods; however, these systems remain underdeveloped at the provincial and district levels across Lao PDR. Current early warning messages are often too generalized, covering large geographic areas without clear, accessible language regarding expected timelines, potential impacts, or recommended actions for communities.

In LPC, flood warnings are primarily issued by DoNRE through the Water Resources and Meteorology and Hydrology sections. In emergencies, especially when hydroelectric power projects on the Nam Khan and Nam Ou rivers need to release water downstream, the project operators also provide advance warnings. These notifications are typically issued through official letters to relevant agencies one to two days prior to water releases, especially during storm events or when river levels are already elevated.

Generally, early warnings are communicated via mobile networks or official documents from responsible agencies. These warnings are often sent by the DoNRE to Disaster Management Committees, which then inform at-risk villages and communities. Despite government and project efforts to improve early warning communication systems, challenges remain due to difficult limited telecommunications access and terrain in some areas. Specific gaps in the current early warning system, highlighted in Table 7, need to be addressed to

enhance the effectiveness of flood risk management and ensure the safety and resilience of vulnerable communities.

Table 7. *Gaps in LPC Early Warning System (EWS) for flood hazards*

Component of EWS	Gaps
Risk Knowledge	• Communities have limited understanding of flood risks and appropriate response measures. • Inadequate assessment of flood-prone areas. • Misunderstandings and limited access to official bulletins issued by responsible agencies.
Monitoring and Warning Service	• Flood warnings are generally broad weather forecasts and lack the specificity needed for early warnings in particular areas. • Warnings are primarily cautionary and do not provide clear actions to be taken. • Information and data supporting warnings are not unified within a single responsible sector. • Insufficient hydrological data for effective flood forecasting. • Hydrometeorological equipment is outdated. • Monitoring responsibilities are fragmented across central, provincial, and district levels, primarily managed by DMH. • Limited trained staff for data collection and analysis (forecasting) and a constrained budget for equipment maintenance. • Village leaders lack understanding of the importance of hydrometeorological monitoring and play a minimal role in data collection and infrastructure maintenance.
Dissemination and Communication	• Forecast and warning messages are often too technical for many users, particularly community representatives. • Insufficient trained staff at the provincial and district levels to interpret forecasts and warnings effectively. • Limited public access to flood forecasting data and information. • Lack of clarity regarding the coverage and reach of forecast and warning messages at the district level; early warning information is not widely known among locals. • No system to verify that warnings have been received and communicated effectively at the village level. • Limited understanding within communities regarding the specific roles of technical agencies in issuing early warning alerts and messages.
Response Capability	• No standardised procedures at the village level for responding to floods (or landslides, and droughts). • Limited awareness and preparedness for flood emergencies in some villages. • While some flood-prone villages have experience in flood response and adaptation, others lack necessary resources (e.g., evacuation zones, shelters, emergency supplies). • Limited capacity among district officials and village leaders to enhance flood resilience through improved land use planning, infrastructure, and building practices.

3 Action Plan 2025-2029

3.1 Goal

A 5-year Action Plan (2025-2029) is proposed for LPC to strengthen the climate resilience of communities to flood risks.

3.2 Objectives and actions

The Action Plan will achieve this goal by implementing actions under four objectives:

1. **Raise awareness and understanding of flood risks**, including improved capacity within government and increased community involvement, preparedness and capability to respond
2. **Integrate stormwater and land use planning**, including increased enforcement of new and existing laws.
3. **Improve the city's drainage system**, including renewal, upgrade and creation of drainage infrastructure (including retention and detention capacity and integration of EbA approaches) supported by an enhanced maintenance program.
4. **Protect, restore and manage ecosystem functions and services**, including headwater catchments, waterway buffers and heritage listed ponds/wetlands.

Table 8 (p22) provides a description of each objective together with an estimated budget for actions under each objective over a 5-year horizon in the district. The proposed actions under each objective are also detailed in Table 9 (p23).

The proposed actions and budget for this 5-year Action Plan build on the existing projects (EPs) identified in the Luang Prabang Smart and Integrated Urban Strategy (LPSIUS) (AASCTF 2023a). Several existing projects from the strategy have been included in the ICFMS Action Plan (denoted by grey text) as they directly relate to the management and funding of flood risk reduction activities in LPC. The ICFMS actions have been designed to build on and enhance these existing projects.

The funding estimates in the Action Plan do not cover personnel costs within the lead organizations which have been nominated to be responsible for delivering the actions. It is assumed that this delivery function is covered within existing resources and staffing of the lead organisations.

Table 8. *Action Plan objectives and estimated budget for 2025-2029*

Objectives	Estimated budget (USD)		
	Existing Actions	ICFMS Actions	Total
Objective 1: Raise awareness and understanding of flood risks	$750,000	$195,000	**$945,000**
Objective 2: Integrate stormwater and land use planning	$500,000	$170,000	**$670,000**
Objective 3: Improve the cities drainage system	$4,350,000	$1,120,000	**$5,470,000**
Objective 4: Protect, restore and manage ecosystem functions and services	$0	$575,000	**$575,000**
Total	$5,600,000	$2,060,000	**$7,660,000**

Table 9. *LPC Action Plan*

No.	Theme	Action	Responsibility	Implementation timeline 2025-2029					Estimated budget (USD)
				Y1	Y2	Y3	Y4	Y5	
Objective 1: Raise awareness and understanding of flood risks									
EP15	Social Inclusion Study	i) Conduct a Social Inclusion Study as part of the program to ensure that flood resilience measures are adapted to support vulnerable groups. ii) Targets to mainstream Gender Equality, Disability and Social Inclusion (GEDSI) considerations to be included.	DLSW	Near Term (2024-2026): Requires "High Level Hazard and Risk Assessment" to be completed first.					(200,000)*
EP16	Smart Early Flood Response System	i) Smart early warning systems with real-time data capture can be developed based on the results of the existing flood maps to ensure that communities are equipped to respond to flood events in a timely manner.[5] ii) Empowering communities to act for local flood resilience measures. For example, social media can be used to increase and improve the flood awareness and self-efficacy of citizens and organizations.[6] iii) Involving community groups (e.g., citizens, farmers, business, schools) in flood resilience measures and flood action plans.[5] iv) Disaster management governance to be developed, including identifying departments with clear roles and responsibilities, articulation of workflows and processes.[7]	DLSW	Near Term (2024-2026): Requires "High Level Hazard and Risk Assessment" to be completed first.					(500,000)*
EP4	Heritage Disaster Risk Management (DRM) Policy and Plans	i) Review International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM)'s Disaster Risk Management manual (currently being updated to provide a strong foundation on aspects of risk preparedness for World Heritage Sites, be it from disasters or climate change impacts) and other relevant literature.	DICT	Near to Medium Term (2024-2028)					(50,000)*

[5] It is recommended this includes establishing a collaborative platform for flood management, enabling agencies and stakeholders to share data, models, forecasts, and lessons learned. This platform will support integrated flood modelling, forecasting, and warning systems, as well as coordinate traditional and ecosystem-based adaptation infrastructure investments and maintenance to enhance urban flood resilience. To be supported by MoNRE.

[6] It is recommended this includes i) Implementing a comprehensive community flood awareness campaign to educate residents on flood risks, warning systems, and safety measures in vulnerable areas through workshops in schools and community centres. ii) Conducting regular emergency response drills and simulation exercises for communities in flood-prone areas to improve response capabilities and foster engagement. iii) Establishing and operating a network of volunteers and the private sector to support early warning dissemination and communication. To be supported by MoNRE, MoLSW, NDMC and MoICT.

[7] It is recommended this includes setting up clear mandates, roles, responsibilities and coordination mechanisms for all stakeholders involved in hydrometeorological data collection and dissemination of forecasts and hazard warnings (including a feedback mechanism for two-way community engagement and real time reporting to the national-level warning authorities). Supported by DMH, MTC, MoNRE and MoLSW.

No.	Theme	Action	Responsibility	Implementation timeline 2025-2029					Estimated budget (USD)
				Y1	Y2	Y3	Y4	Y5	
		ii) Informed by the ICCROM manual and others, and in coordination with agencies involved in overall DRM planning for Luang Prabang, undertake DRM planning and policy development particularly focusing on protection of all assets expressing OUV from disasters. iii) Implement measures and smart technologies to detect, report and trigger rapid responses to threats or actual immediate risks such as fires or floods and to monitor sites to deter and catch thieves. iv) Build capacity on DRM for heritage attributes, O&M of the smart technologies, including sustainable financing.							
1	Increased public awareness	Raise public awareness on flood risks, and the impacts of litter and wastewater cross-connections on the drainage network. Promotion via television, radio, YouTube, schools and other media channels.	MoNRE			X	X	X	10000
2	Effective early warning services	Undertake a study to assess the coverage and reach of flood warning systems within LPC, identifying recommendations for improvements.	PoNRE		X				15,000
3	Effective early warning services	Develop and disseminate simplified standard early warnings messages for the community, especially vulnerable and high risk community members.	MoNRE			X	X		15,000
4	Effective early warning services	Increase the maintenance of early warning system infrastructure (starting immediately) and gradually upgrade or supply new warning equipment/tools (e.g. including Information Communication and Technology (ICT) infrastructure, public loudspeakers, etc.).	MoNRE, MTC, PoNRE	X	X	X	X	X	100,000
5	Institutional capacity building	Collate key data, information, models and outputs from all existing and underway flood assessments conducted in LPC. Identify relevant gaps and use to support related ICFMS actions.	MoNRE	X					10,000
6	Institutional capacity building	Build the capacity of municipal staff to support a greater understanding of hydrometeorological monitoring and data collection, and improve the transfer of forecasts and warning messages from central agencies.	MoNRE, DMH				X	X	10,000
7	ICFMS implementation & community capacity building	Provide annual training for Target Village Taskforce members at the start of the rainy season to support their contribution to flood management in LPC (refer to Section 3.3 Implementation mechanism).	MoNRE	X	X	X	X	X	25,000

No.	Theme	Action	Responsibility	Implementation timeline 2025-2029					Estimated budget (USD)
				Y1	Y2	Y3	Y4	Y5	
8	ICFMS implementation	Develop and implement a Coordination Team and a Working Group to deliver the ICFMS (refer to Section 3.3 Implementation mechanism).	PoNRE	X	X	X	X	X	10,000
Objective 2: Integrate stormwater and land use planning									
EP13	Flood Risk Zoning	i) Produce flood-proof spatial plans and design, e.g., avoid locating critical infrastructure in in flood-prone areas. ii) Develop land use processes to guide new developments and upgrading of existing developments in flood-prone areas. iii) Prepare clear building regulations, considering high water levels to eliminate downstream flooding impact. iv) Prepare clear action plans to relocate existing critical infrastructure and developments in flood-prone areas.	DPWT	Near Term. Requires "High Level Hazard and Risk Assessment" to be completed first.					(500,000)*
9	Enhanced planning approvals process	Review and strengthen the development approvals process to limit (i) development in flood prone areas, (i) development in forested areas or riparian corridors, (iii) loss or damage to heritage wetlands/ponds.	PoNRE		X	X			50,000
10	Preservation of forest and agricultural land use preservation	Conduct a comprehensive review of current laws and regulations governing urban development in agricultural and forested areas. Identify regulatory gaps and develop new zoning policies to protect these areas, including enforcement measures to prevent unauthorized development increasing downstream flood risk.	PAFO	X	X	X			25,000
11	Preservation of riparian corridors	Conduct a comprehensive review of current laws and regulations governing urban development in riparian corridors. Identify regulatory gaps, develop and refine zoning policies, offsets and buffers to protect these areas, including enforcement measures to prevent encroachment and degradation.	PAFO		X	X	X		25,000
12	Onsite detention	Investigate the merit of mandating the installation of rainwater tanks on new developments to provide onsite detention (reserved storage) and water reuse (operational storage).	PoNRE				X	X	10,000
13	Wetland participatory planning	Conduct participatory wetland land-use planning workshops with local community members to map and designate conservation zones. Collaborate with local leaders and stakeholders to prioritize areas for ecosystem protection and restoration based on biodiversity and flood resilience needs.	MoNRE	X	X				30,000

No.	Theme	Action	Responsibility	Implementation timeline 2025-2029					Estimated budget (USD)
				Y1	Y2	Y3	Y4	Y5	
14	Institutional capacity building	Build the capacity of municipal staff to support and implement existing and amended planning provisions that support flood risk reduction.	MoNRE	X		X		X	30,000
Objective 3: Improve the cities drainage system									
EP12	Hazard and Risk Assessment[8]	i) An integrated climate resilience program will start with a High Level Hazard and Risk Assessment to review the key hazards present in Luang Prabang, ascertain the risks posed to the city, and inform the subsequent studies in the program. ii) Identify high risk areas, e.g., flood inundation areas by developing and calibrating relevant models. iii) Produce hazard maps, e.g., flood maps, to serve as foundation for resilience strategies development. iv) Update risk assessment if any climate change forecast data has been updated. v) Define GEDSI indicators and incorporate consultation with GEDSI stakeholders.	DPWT	Near Term (2024-2026): This can be started in the near term as it is a desktop study followed by stakeholder engagement.					(1,000,000)*
EP14	Flood Defense Mechanisms[9]	i) Flood defense through risk mitigation and adaptation focuses on measures that prevent stormwater from inundating urbanized areas, through implementation of infrastructure such as dikes or nature-based solutions. ii) Detention volume can also be added through implementation of detention ponds or widening of drains or rivers. iii) For example, the installation of GPTs can offer surface runoff pre-treatment and filter out the debris to prevent the drainage system from blocking, hence, runoff could enter the drainage and flow out of the site without obstruction.	DPWT	Near Term (2024-2026): Requires "High Level Hazard and Risk Assessment" to be completed first.					(3,000,000)*
EP9	Gross Pollutant Traps (GPTs)	i) Incorporate GPTs in the drainage system to capture sediments to allow treated effluent to flow through to the drain.	PWTO, USO	Immediate. To be implemented as a pilot project.					(350,000)*

[8] It is recommended that this includes modelling of both fluvial and pluvial flooding (including their interaction) under current and future climate conditions.
[9] It is recommended that this includes: i) an assessment of a range of traditional and EbA measures to address flooding in high-risk areas, including the Target Villages and flood hotspots identified in the LPC Optioneering Report (Alluvium and Hydrotech Consulting, 2024a). ii) Identification of sites where solutions can be implemented, modelling to evaluate the effectiveness of the proposed interventions, prioritisation based on based on costs, benefits and stakeholder input, selection of preferred interventions that proceed to detailed design and implementation.

No.	Theme	Action	Responsibility	Implementation timeline 2025-2029					Estimated budget (USD)
				Y1	Y2	Y3	Y4	Y5	
		ii) Install a sensor into the GPTs to provide a real-time alert to the Public Works and Transport Office (PWTO) when the waste sump is full.							
15	Urban Drainage Masterplan	Create a new and updated Urban Drainage Masterplan to guide development planning, enforce land-use policies, and assess flood impacts. In preparing the masterplan, develop an updated inventory of drainage assets, including survey and mapping of drainage networks.	PoNRE	X	X	X			500,000
16	Drainage Maintenance Plan	Develop and fund the implementation of a Drainage Maintenance Plan to prioritise the repair and regular maintenance of the drainage network to ensure infrastructure remains functional and in good condition. This includes targeted maintenance prior to each rainy season.	PoNRE	X	X	X	X	X	500,000
17	Project monitoring	The National Committee from central agencies to monitor project implementation with local taskforces on a quarterly and annual basis.	PoNRE				X	X	20,000
18	Institutional capacity building	Implement a comprehensive training and mentorship program for municipal staff focused on improved drainage network planning, design, and maintenance. This multi-year program will include workshops on flood modelling, climate-resilient infrastructure, and ecosystem-based drainage solutions, coupled with ongoing mentorship from experienced urban water management professionals. Staff will gain skills to design, optimise, and maintain effective, sustainable drainage networks.	MoNRE	X	X	X	X	X	100,000
Objective 4: Protect, restore and manage ecosystem functions and services									
19	Wetland Restoration Strategy	Develop a Wetland Restoration Strategy for the city. Consider opportunities to (a) Retrofit of existing ponds to increase their retention capacity (e.g. via desludging and hydraulic modifications), (b) By-passing the existing drainage network and creating additional detention volume in the landscape and (c) Improving sanitation systems and pond water quality (including ecosystem-based adaptions and decentralised solutions) (e) work with the community, (f) leverage the work undertaken by Group For Research and Technology Exchanges (GRET) and the Resilient Urban Centres and Surrounds (RUCaS).	MoNRE		X	X	x		250,000
20	Riparian buffer zones	Establish and protect riparian buffer zones along all key rivers and streams to reduce flood impact and enhance ecosystem services (initially focus on the Huai Mao and Phou Xang He	PAFO	x	x	x			100,000

No.	Theme	Action	Responsibility	Implementation timeline 2025-2029					Estimated budget (USD)
				Y1	Y2	Y3	Y4	Y5	
		rivers). Install markers and signage along waterways to alert the community of the regulations and consequences.							
21	Restore headwater catchments and buffer zones	Protect and restore ecosystems that provide natural flood mitigation services, including headwater catchments and buffer zones.	DoNRE			X	X	X	100,000
22	Restore natural floodplains	Restore natural floodplains to improve water absorption, reduce urban flood risks, and support biodiversity.	MoNRE			X	X	X	50,000
23	Monitor and maintain	Monitor and maintain restored vegetation to ensure long-term success.	DoNRE			X	X	X	15,000
24	Institutional capacity building	Build the capacity of municipal staff to support and implement ecosystem-based adaptation interventions and ecosystem restoration to support flood risk reduction.	MoNRE	X		X		X	30,000
25	Community exchange and study tour	Develop a community exchange and study tour program for local leaders focused on flood risk management. This program will facilitate knowledge sharing on effective socio-economic and cultural practices that support basin conservation, incorporating lessons on sustainable water management, flood-resistant infrastructure, and the role of natural ecosystems in reducing flood impacts.	MoNRE				X		30,000

3.3 Implementation mechanisms

The LPC ICFMS sets out actions for the district to strengthen the climate resilience of communities to flood risks. Implementing these actions will require leadership and cooperation from Lao PDR Ministries at the central, provincial and district level.

MoNRE is responsible for multiple sectors related to the ICFMS including water resources, flood protection, hydrological monitoring and early warning, and environmental and land use planning. Therefore the success of the ICFMS rests on how effective MoNRE is in convening, engaging and coordinating all government and non-government stakeholders in the design, delivery and reporting on the proposed actions.

To avoid the risk of poor sectoral integration and coordination, a two-tiered coordination framework is proposed to provide the basis of coordination during the implementation of the ICFMS (Figure 28):

- A **Coordination Team** comprising representatives of central line agencies to provide high-level strategic oversight and advice to MoNRE.
- A **Working Group** comprising government stakeholders and non-government stakeholders in LPC and target districts.

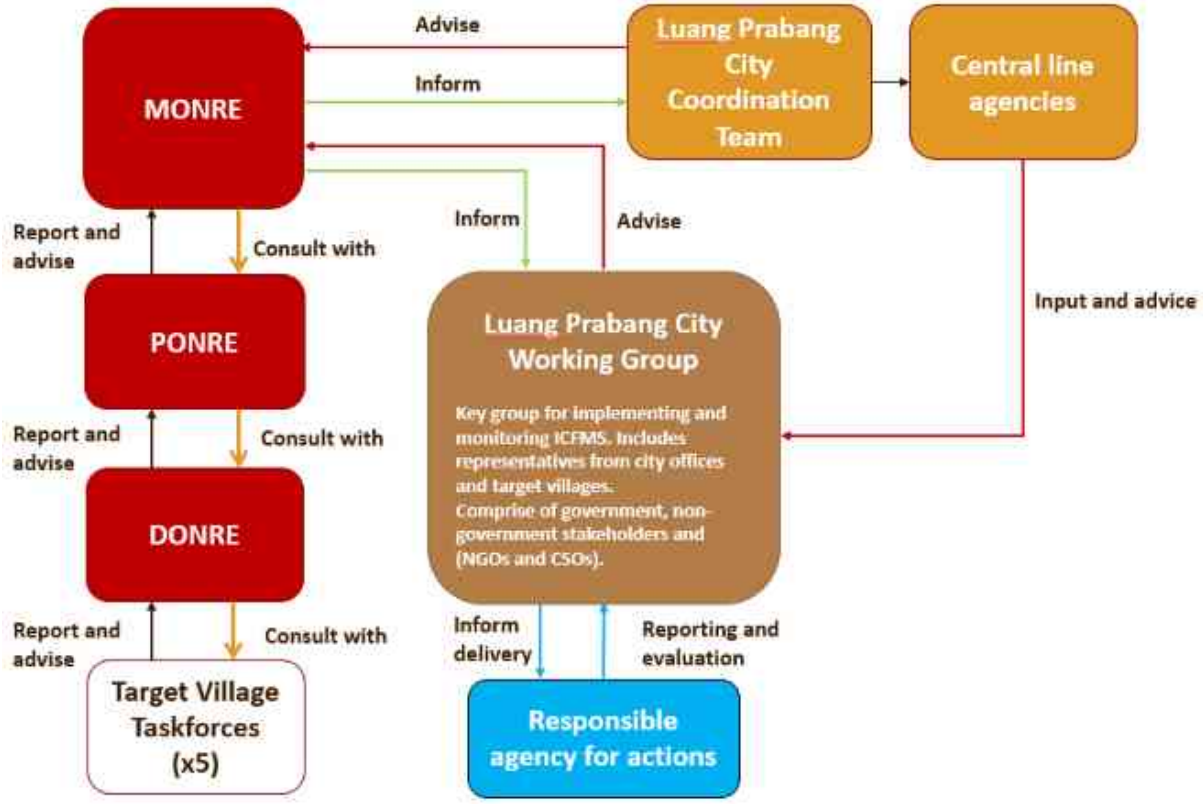


Figure 28. *Governance arrangement*

Coordination Team: The purpose of the coordination team is to involve other water-related sectors in the decision-making and implementation processes of the ICFMS. It is chaired by MoNRE and includes representatives from the central levels of water management and relevant line agencies (e.g. Ministry of Agriculture and Forestry, Ministry of Labour and Social Welfare, National Disaster Management Committee, Ministry of Technology and Communications, Ministry of Information, Culture and Tourism, and Ministry of Public Works and Transport). The Coordination Team makes decisions by consensus related to the implementation of the ICFMS.

Working Group: The purpose of the LPC Working Group is to coordinate the on-ground activities, studies and analyses, and stakeholder collaboration which are needed to implement the Action Plan. This would include

sharing of data, review of analysis and brainstorming discussion of implementation challenges. The Working Group is chaired by PoNRE and would involve technical managers from relevant agencies (e.g. provincial agencies responsible for agriculture, forestry, water resources, public works, disaster management, and communications). The Working Group can be used as the main forum for reporting and evaluating the success of implementation for the Action Plan.

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