



Multilayered Vulnerability Profile for Kaysone Phomvihane, Lao PDR

Climate, Urban, and Biodiversity Dimensions

**Developed under the Resilient Settlements for the Urban Poor
(RISE UP) Programme**





UN-HABITAT

Multilayered Vulnerability Profile: Kaysone Phomvihane, Lao PDR

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Table of contents

Executive summary	9
I. Introduction	10
1. Background and context	12
1.1. <i>Climate change, urbanization, and multilayered vulnerabilities in cities</i>	12
2. Climate change, urbanization and biodiversity in Kaysone Phomvihane City, Lao PDR	14
2.1. <i>Location and geography</i>	14
2.2. <i>History of city development and growth</i>	15
2.3. <i>Demographics</i>	16
2.4. <i>Key economic sectors</i>	16
2.5. <i>Environment, biodiversity and climate</i>	17
2.6. <i>Urbanization trends</i>	18
2.7. <i>Physical and social infrastructure assets</i>	20
2.8. <i>Institutional and policy frameworks</i>	20
II. Methodology	22
1. Approach and methodology	24
2. Geographic scope	26
III. Key Findings	28
1. Urban dimension	30
1.1. <i>Indicators – urban dimension</i>	30
1.2. <i>Urban dimension analysis</i>	34
1.3. <i>Urban future vulnerabilities</i>	35
2. Climate change dimension	36
2.1. <i>Indicators – climate change dimension</i>	36
2.2. <i>Climate change dimension analysis</i>	39

2.3. Climate change future vulnerabilities	39
3. Biodiversity dimension	40
3.1. Indicators – biodiversity dimension	40
3.2. Biodiversity dimension analysis	42
4. Overlapping vulnerabilities	44
4.1. Urban and climate change vulnerabilities	44
4.2. Climate change and biodiversity vulnerabilities	45
4.3 Biodiversity and urban vulnerabilities	46
5. Multilayered vulnerability hotspots	48
6. Conclusion	51
Annexes	52
Annex 1: Community consultation	54
1) Phonsoung village	55
2) Phonsim village	56
3) Houameung-tai village	57
Annex 2: Steps and tools for analyzing urban area growth changes	58
Annex 3: Methodology - green space accessibility	59
Annex 4: Methodology for community vulnerability by road type	61
Annex 5: Raster processing and estimation of land surface temperature and urban heat island: ArcGIS methodology	62
Annex 6: Community consultation questionnaires (English)	68
Section 1: General information	69
Section 2: Climate change theme	69
Section 3: Urban theme	70
Section 4: Biodiversity and environment	70
Section 5: Adaptive capacity and community strength	71

List of figures

FIGURE 1	
RISE-UP objectives [Multilayered vulnerability assessment handbook, 2024]	13
FIGURE 2	
Map of Kaysone Phomvihane City, Lao PDR	14
FIGURE 3	
Aerial view of Kaysone Phomvihane City	15
FIGURE 4	
Population Density in Kaysone City in 2015	16
FIGURE 5	
Location of Savan-Seno Special Economic Zones (A, C, and D) in Kaysone City	16
FIGURE 6	
Flooded areas in Kaysone Phomvihane City (2019)	17
FIGURE 7	
Forest and other land use changes in Kaysone Phomvihane city from 1997 to 2017	18
FIGURE 8	
Growth of built-up areas in Kaysone City over the period of 20 years (1997 - 2007)	19
FIGURE 9	
Kaysone Phomvihane City's master plan (1999)	19
FIGURE 10	
Public park in Kaysone Phomvihane City	20
FIGURE 11	
Schools and health facilities in Kaysone Phomvihane City and nearby districts	21
FIGURE 12	
An overview of MVA approach	25
FIGURE 13	
Kaysone Phomvihane administrative boundary	26
FIGURE 14	
Urban dimension vulnerability	30
FIGURE 15	
Kaysone urban area growth 2004-2025	31
FIGURE 16	
Kaysone population density 2004 (Persons/sq km)	31
FIGURE 17	
Vulnerability based on green space in Kaysone Phomvihane City	32
FIGURE 18	
Road type in Kaysone Phomvihane City	33
FIGURE 19	
Percentage of unpaved road type in Kaysone	33

FIGURE 20	
Land cover in Kaysone Phomvihane City 2024	34
FIGURE 21	
Urban vulnerability hotspots and village location	35
FIGURE 22	
Climate Change Dimension Vulnerability	36
FIGURE 23	
Flood risk area in Kaysone Phomvihane City	37
FIGURE 24	
Drought risk data in Kaysone Phomvihane City	37
FIGURE 25	
Land surface temperature data in Kaysone City	38
FIGURE 26	
Climate change vulnerability hotspots and village location	39
FIGURE 27	
Biodiversity dimension	40
FIGURE 28	
Inverted NDVI 2025 – Kaysone Phomvihane City	41
FIGURE 29	
Burn Area Index (BAI) – Kaysone Phomvihane City	41
FIGURE 30	
Mean Species Abundance (MSA) Index	42
FIGURE 31	
Biodiversity vulnerability hotspots and village locations	43
FIGURE 32	
Forest change from 2000 to 2025 in Kaysone Phomvihane City	43
FIGURE 33	
Bivariate hotspots urban & climate change	44
FIGURE 34	
Bivariate hotspots climate change & biodiversity	45
FIGURE 35	
Bivariate hotspots urban & biodiversity	46
FIGURE 36	
Multilayered vulnerability hotspots	48
FIGURE 37	
Community consultation sites in Kaysone Phomvihane City	54
FIGURE 38	
Sample of the Vector results	59

Abbreviations

ASEAN	Association of Southeast Asian Nations
ASUS	ASEAN Sustainable Urbanisation Strategy
BAI	Burn Area Index
BT	Brightness Temperature
COP28	28th Conference of the Parties to the UNFCCC
GDP	Gross Domestic Product
GIRI	Global Infrastructure Risk Model and Resilience Index
GIS	Geographic Information System
GMS	Greater Mekong Subregion
GRID	Global Resource Information Database
LEDs	Low Emission Development Strategies
LSE	Land Surface Emissivity
LST	Land Surface Temperature
MSA	Mean Species Abundance Index
MVA	Multilayered Vulnerability Assessment
NDVI	Normalized Difference Vegetation Index
NIR	Near-Infrared (satellite band)
PDR	People's Democratic Republic (as in Lao PDR)
PV	Proportion of Vegetation
RED / R	Red Band (satellite band)
RISE UP	Resilient Settlements for the Urban Poor Programme
SEZ	Special Economic Zone
SIDA	Swedish International Development Cooperation Agency
SMEs	Small and Medium Enterprises

TOA	Top of Atmosphere
UHI	Urban Heat Island
UNFCCC	United Nations Framework Convention on Climate Change
UN-Habitat	United Nations Human Settlements Programme
USD	United States Dollar
USGS	United States Geological Survey

Executive summary

This report presents a Multilayered Vulnerability Assessment (MVA) for Kaysone Phomvihane City, Lao PDR, developed under the UN-Habitat's Resilient Settlements for the Urban Poor (RISE UP) programme. This report aims to identify spatial vulnerability hotspots across urban, climate, and biodiversity dimensions to inform evidence-based urban resilience planning and guide future investments under the Urban Resilience Action Plan (URAP).

As the nation's second-largest city and a key node in the Greater Mekong Subregion, Kaysone Phomvihane is experiencing rapid economic growth. However, this expansion has outpaced infrastructure development and environmental safeguards, resulting in increasing and overlapping risks related to urbanisation, climate change, and biodiversity loss.

Methodology

The MVA applies standardized spatial analysis at a 30-metre resolution using a hexagonal grid system. Indicators across three dimensions - Urban, Climate Change, and Biodiversity - were normalised and analysed to identify vulnerability hotspots. The assessment integrates geospatial data with community consultations to validate findings and reflect local realities.

Key findings

- **Rapid urban expansion:** Built-up areas increased from 42.5 km² in 2004 to 105.9 km² in 2025 (approximately 7 per cent annual growth), resulting in unplanned settlements with limited access to infrastructure and basic services.
- **Climate risks:** Several areas face recurrent flooding and rising temperatures, driven by inadequate drainage systems and expansion into flood-prone zones, particularly near the urban streams connected to Mekong rivers.
- **Biodiversity decline:** Biodiversity vulnerability is driven by significant forest loss, with forest cover declining from 325.1 km² in 2000 to 133.5 km² in 2025 (a 54 per cent reduction) - equivalent to approximately 7.6 km² per year. If this trend

continues, the city may lose its remaining forest within the next 18 years. This decline is largely driven by land conversion for agriculture, commercial use, and residential expansion, resulting in habitat degradation and reduced ecosystem resilience.

- **Infrastructure gaps:** While access to basic services is relatively high, critical gaps remain in drainage, waste management, and road infrastructure, especially in peri-urban and newly developed areas.
- **Multilayered vulnerability hotspots:** Several villages experience overlapping urban, climate, and biodiversity risks, significantly increasing exposure and reducing resilience. Community consultations confirm frequent flooding, deteriorating road conditions, and unmanaged waste management systems.

These findings indicate that unplanned urban growth is intensifying exposure to flooding, heat stress, and environmental degradation, particularly among vulnerable and low-income communities. Without intervention, the city risks increasing disaster impacts, declining ecosystem services, and widening inequalities in access to infrastructure and services.

Recommendations and way forward

The findings highlight the need for integrated actions to address multilayered vulnerabilities in Kaysone Phomvihane City. Priority should be given to strengthening urban planning and land-use regulation, upgrading drainage and flood management systems, increasing and protecting green spaces, and improving basic infrastructure and services—particularly in high-risk and peri-urban areas.

The Multilayered Vulnerability Assessment provides a data-driven foundation for the upcoming Urban Resilience Action Plan (URAP) for Kaysone Phomvihane City. In line with the Lao PDR 2030 Vision and the ASEAN Sustainable Urbanisation Strategy, future interventions should transition from diagnostic mapping to the development and implementation of bankable, climate-resilient projects to support coordinated, inclusive, and sustainable urban development.

I. Introduction





01

1. Background and context

The climate emergency is deeply entwined with urbanization, affecting infrastructure, services, housing, and livelihoods in cities - where over 55 per cent of the global population lives, projected to exceed 67 per cent by 2050. Rapid urban growth, poverty, inequality, and biodiversity loss intensify cities' vulnerability to rising temperatures, extreme weather, and sea-level rise. More than 90 per cent of cities overlap with biodiversity hotspots, where unchecked expansion degrades natural habitats and reduces climate resilience. In response, cities are recognizing the value of spatial planning and ecosystem protection to enhance both human wellbeing and biodiversity.

1.1. Climate change, urbanization, and multilayered vulnerabilities in cities

In the context of Lao PDR, the country is undergoing rapid urbanization, with many emerging towns driven by sharp economic growth over the past decade. However, this urban expansion is occurring largely without proper planning or regulation. As one of the most climate-vulnerable countries in the world, Laos faces increasing threats from floods, droughts, and extreme weather events. The lack of coordinated urban planning, basic services, and hazard protection measures in these growing towns is compounding the risks. Without resilient infrastructure and climate-sensitive development strategies, unplanned urban growth in Laos is intensifying the impacts of climate change on both people and the environment.

UN-Habitat's Resilient Settlements for the Urban Poor (RISE UP) programme addresses these challenges through a multidimensional approach, targeting the urban poor living in informal, hazard-prone areas. Projects include mangrove restoration in Cambodia and flood-resilient infrastructure in Southeast Africa, showcasing the interlinkage between climate resilience and biodiversity. Lao PDR become part of the RISE-UP programme in 2024 when two cities Pakse and Kaysone Phomvihane cities have been selected as part of the programme target areas.

To guide interventions, RISE UP developed the Multilayered Vulnerability Assessment tool, which maps the intersections of climate hazards, urban expansion, and biodiversity loss. This approach helps identify vulnerability hotspots and supports evidence-based, inclusive urban resilience planning. Key barriers to effective assessments include fragmented governance, limited data, and lack of community engagement-particularly for the urban poor, who face the highest risks yet have the least voice in decisions.

*With over USD
150 million
mobilized
globally since
2019, RISE
UP supports
infrastructure
development,
green spaces,
and ecosystem
restoration
across 28
countries*

This report contributes to the RISE UP project “Enhancing interregional knowledge exchange and capacities of national and local governments in Lao PDR, Madagascar, Sri Lanka, and South Africa on financing for urban, sustainable, net-zero, climate resilient and nature positive development for the most vulnerable urban communities” supported by the 2030 Agenda for Sustainable Development Sub-Fund under the United Nations Peace and Development Trust Fund (UNPDF). It presents early findings from mapping and analysis, laying the foundation for action planning that strengthens local capacity and informs targeted resilience strategies.

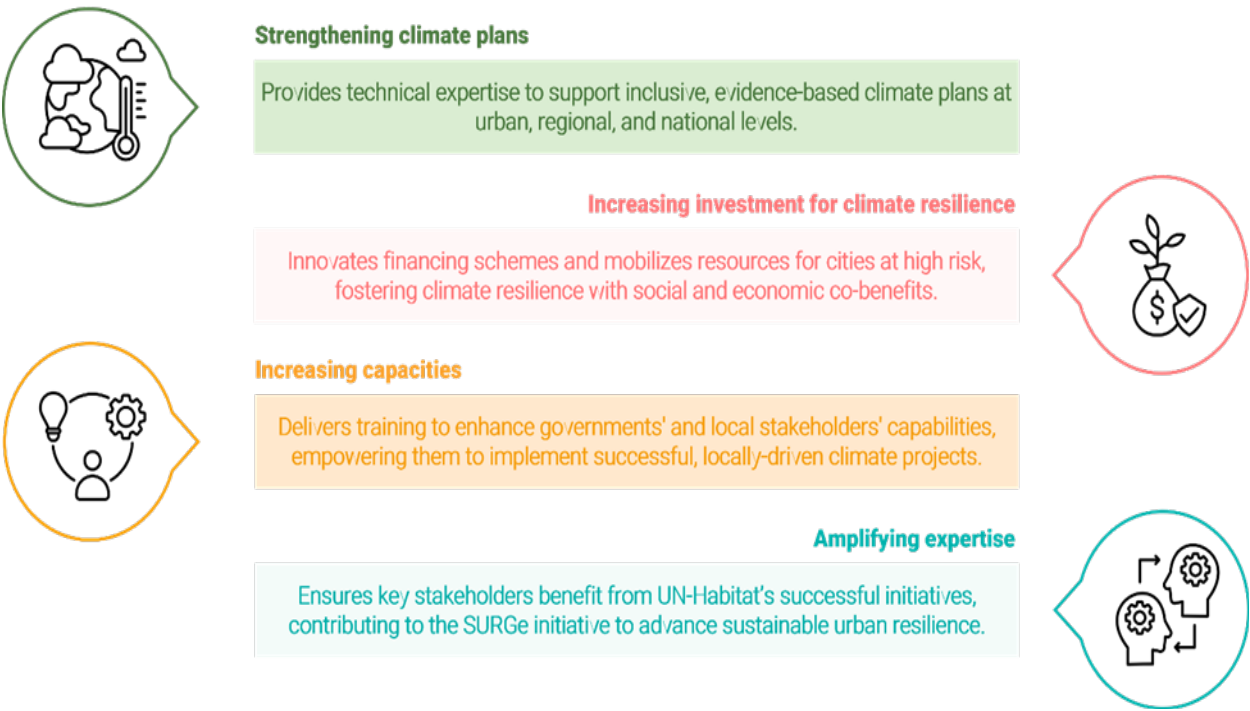


FIGURE 1 RISE-UP objectives [Multilayered vulnerability assessment handbook, 2024]

Source: UN-Habitat, 2024

02

2. Climate change, urbanization and biodiversity in Kaysone Phomvihane City, Lao PDR

2.1. Location and geography

Kaysone Phomvihane City is strategically situated in southern Laos, nestled along the eastern bank of the Mekong River, directly facing Mukdahan, Thailand. This geographical nexus is not merely coincidental; it positions the city as a pivotal hub within the Greater Mekong Subregion (GMS) East-West Economic Corridor. This corridor, designed to enhance connectivity and trade, leverages Kaysone Phomvihane's location as a vital transit point, facilitating the seamless movement of goods and services between Laos, Thailand, and Vietnam. The 2007 Second Thai-Lao Friendship Bridge, a direct physical manifestation of this strategic importance, spans the Mekong, further cementing the city's role as a gateway for cross-border commerce and regional integration.

Encompassing an area of approximately 779.03 km², the city's terrain is predominantly characterized by flat and gently undulating plains. This favorable topography is a significant geographical advantage, making the land highly amenable to various developmental activities. Agriculturally, these fertile lowlands support extensive cultivation, forming a bedrock for the province's food production and agro-processing industries. Furthermore, the relatively flat landscape simplifies urban planning and infrastructure development, contributing to the establishment and expansion of manufacturing zones and commercial centers. This ease of development has been instrumental in driving the city's robust economic growth, particularly in sectors such as agriculture, manufacturing, and the burgeoning cross-border trade facilitated by its prime position.

The Mekong River itself is more than just a natural boundary; it is the lifeblood of Kaysone Phomvihane. Beyond serving as a natural frontier with Thailand,

the river is an indispensable source of freshwater for domestic consumption, agriculture, and local industries. Historically and presently, it functions as a crucial artery for transportation, enabling riverine trade routes that connect the city to other parts of Laos and downstream to Cambodia and Vietnam. This vital waterway supports traditional livelihoods such as fishing and provides an integral ecological corridor, contributing to the region's biodiversity. The interplay of the city's flat topography and its riparian location defines its unique geographical identity, underpinning its historical development and future economic trajectory within the broader Mekong region.



FIGURE 2 Map of Kaysone Phomvihane City, Lao PDR

Source: UN-Habitat Lao PDR, 2021



FIGURE 3 Aerial view of Kaysone Phomvihane City

2.2. History of city development and growth

Kaysone Phomvihane's historical trajectory is inextricably linked to its strategic position on the Mekong River, a vital artery for trade between Laos and Thailand for centuries. During the French colonial era, the city, then known as Savannakhet, flourished as a crucial administrative and commercial hub. Following Laos's independence in 1975, Kaysone Phomvihane embarked on a period of rapid growth, largely driven by significant infrastructure investments. A pivotal development was the Second Thai-Lao Friendship Bridge, completed in 2007. This bridge, connecting Kaysone Phomvihane with Mukdahan, Thailand, acted as a catalyst, dramatically accelerating cross-border trade and tourism and solidifying the city's role as an economic nexus.

Beyond its trade links, Savannakhet province is a powerhouse in the mining sector. The Sepon Mine, located in Vilabuly District, stands as Laos's largest mine, boasting substantial reserves of copper and gold (see Sepon mine site in Figure 2). Since its opening in 2002, Sepon has attracted significant foreign investment. Other notable mining operations in the province (as of 2008) include Wanrong Cement III, Lane Xang Minerals

LTD (Vilabuly District), Lao State Gypsum Mining Co Ltd (Champhone District), and Savan Gypsum Mining Co. (Champhone District). This robust mining industry, with Kaysone Phomvihane city serving as the provincial capital and primary trading center, has been a key driver of the region's rapid economic expansion over the past decades. Furthermore, in the last two decades, the city has diversified its economy, emerging as a major center for manufacturing and agricultural processing. Recent investments in industrial zones have spurred the proliferation of small and medium enterprises (SMEs), further bolstering its economic vitality.

Historically, Savannakhet held considerable strategic importance during the French colonial period (1893–1945), serving as a critical governmental and military stronghold in central and southern Laos. The legacy of this period is still evident in Kaysone Phomvihane's urban planning, with visible traces of colonial-era zoning and architecture in the old city center. However, the period immediately following independence in 1945 saw the country plunge into civil wars, which concluded in 1975. This tumultuous era significantly hampered the city's opportunities for organized development and proper urban planning. Despite subsequent decades of peace and substantial economic advancement, Kaysone city and Savannakhet province continue to grapple with the

absence of a comprehensive master plan. While the Ministry of Public Works and Transport developed its first land use plan in 1999, its effectiveness has been limited. Low public awareness and understanding, coupled with insufficient governmental capacity in this area, have hindered proper law enforcement. The unregulated expansion of new urban areas further exacerbates this challenge. Recognizing these deficiencies, the city and the Ministry initiated an update to the urban plan in 2022, with completion anticipated in 2025.

2.3. Demographics

As of 2021, Kaysone Phomvihane is home to an estimated population of 131,749 people¹⁴, making it the second-largest city in Lao PDR following Vientiane Capital. The majority of the population (73 per cent) resides in urban areas, reflecting the city's ongoing urbanisation. While the city has seen economic growth, 13.4 per cent of the population still lives below the poverty line. This disparity highlights the challenges in achieving inclusive development, as rapid urbanisation often exacerbates inequalities.

The city's demographic profile is relatively young, with a large working-age population. The labour force is concentrated in the services and manufacturing sectors, with agriculture continuing to play a role in the city's periphery. Migration from rural areas and neighbouring

14 http://www.citypopulation.de/en/laos/admin/savannakhet/1301_kaysone_phomvihane/

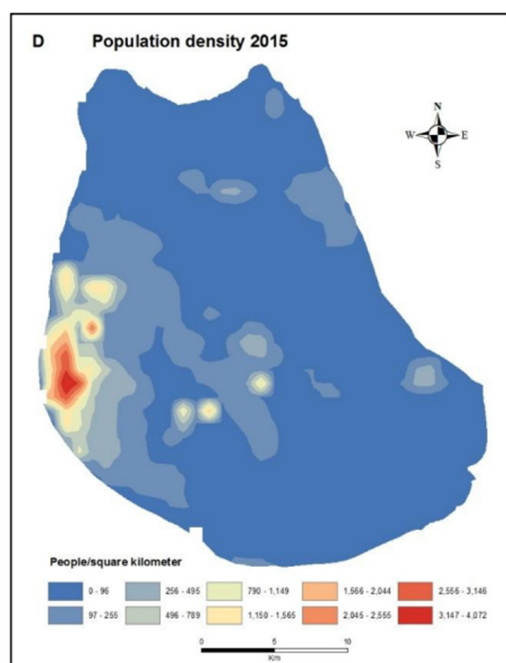


FIGURE 4 Population Density in Kaysone City in 2015

countries has also contributed to population growth, creating both opportunities and pressures on housing and public services.

2.4. Key economic sectors

Savannakhet province is an economic powerhouse for Lao PDR; its economy grew at an average of 10.5 per cent during the period 2006-2010¹⁵. Kaysone City, in particular, has emerged as the focal point for the development of secondary and tertiary industries established within the province. Based on GDP figures between 2007 and 2012, the average economic growth has been gradually increasing from 9.41 per cent in 2007-2008 to 10.89 per cent in 2013-2014¹⁶. Per capita GDP increased from USD 712 in 2006 to USD 1,027 in 2010 and from USD 1,464 in 2014 to USD 2,041 in 2017 (compared to national per capita GDP of USD 1,706). The service, industry and commercial sectors are major sources of employment for local inhabitants in addition to governmental institutions. The service sector has reduced its share of GDP from 46.6 per cent in 2010 to 45.6 per cent in 2014, while the industry-commerce & handicraft sector has increased its share of GDP from 32.9 per cent in 2010 to 35.1 per cent in 2014¹⁷.

15 <https://www.adb.org/sites/default/files/linked-documents/43319-022-lao-oth-06.pdf>

16 ADB, 2017. Lao PDR: Greater Mekong Subregion East-West Economic Corridor Towns Development Project. [online] ADB. Available at: [Accessed 23 October 2020]

17 <https://data.worldbank.org/indicator/NY.GDP.PCAP.KD?locations=LA>

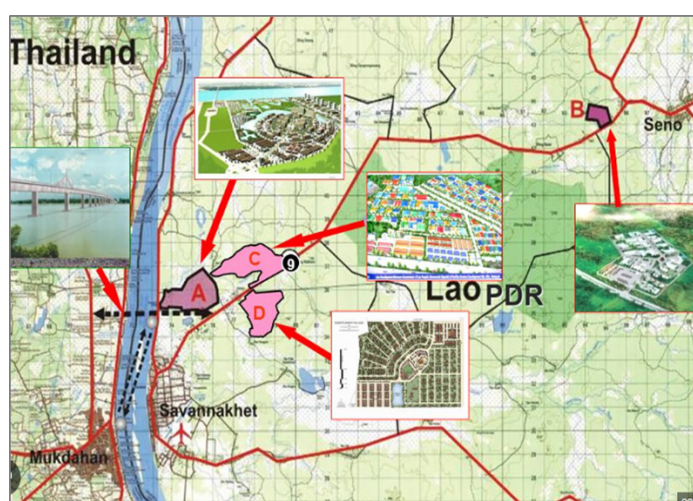


FIGURE 5 Location of Savan-Seno Special Economic Zones (A, C, and D) in Kaysone City

Agriculture, while no longer the dominant sector, remains vital to the city's economy, particularly in agro-processing industries such as rice milling and food production. The city is also an emerging industrial centre, with manufacturing sectors focused on garments, construction materials, and food processing. Special economic zones (SEZs) have been established to attract foreign investment and develop new industries.

2.5. Environment, biodiversity and climate

2.5.1 Kaysone Phomvihane's climate

Kaysone Phomvihane city lies in the tropical zone and experiences two distinct seasons: dry and rainy. The wet season is characterized by oppressive humidity and overcast skies, while the dry season is muggy and partly cloudy. The city remains hot year-round, with temperatures typically ranging from 15°C to 35°C, rarely falling below 12°C or rising above 39°C. Although Laos is landlocked, Kaysone Phomvihane can still be affected by storm remnants that bring heavy rainfall and flooding.

In 2011, Tropical Storm Nokten caused widespread damage and flooding in the city, impacting 318 households and 91 per cent of the rice fields. A subsequent storm in 2013 further devastated infrastructure, homes, and utilities, leaving the city without electricity for over a week. The estimated cost of the damages was USD 220,493¹⁸.

¹⁸ <https://reliefweb.int/disaster/tc-2011-000070-chn>

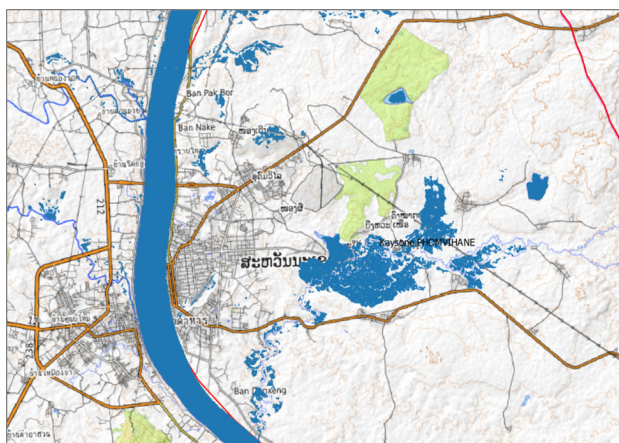


FIGURE 6 Flooded areas in Kaysone Phomvihane City (2019)

A major cause of flooding in Kaysone and the surrounding province is the inadequate capacity of the drainage channels, resulting from a combination of design flaws and insufficient maintenance. Although the city faces periods of heavy rainfall, it also experiences droughts during both the dry and wet seasons.

The city has experienced several droughts, with the most recent occurring in 2010 and 2012. An extreme drought in 2007 saw the average Mekong surface water level drop to 124.84 metres, below the minimum gauge of 125.02 metres. In 2010, the situation worsened, with the average water level recorded even lower at 124.42 metres¹⁹.

The region is vulnerable to environmental degradation due to deforestation, excessive logging, and land conversion for agriculture. These activities have reduced forest cover and threatened biodiversity. Additionally, the city faces significant climate risks, including flooding, drought, and increasing temperatures. Projections indicate that by 2050, rainfall will increase by 10-13 per cent and temperatures by up to 2.2°C²⁰, further stressing the local environment.

2.5.2 Kaysone Phomvihane's environment and biodiversity

Kaysone Phomvihane is located in Savannakhet, a region rich in biodiversity, surrounded by forests and agricultural land. The city is near the Dong Nata Provincial Protected Area, which houses a variety of wildlife, including endangered species like the Eld's deer and silvered leaf monkey. The city's proximity to the Mekong River and other water bodies makes it a habitat for several freshwater fish species, including the giant Mekong catfish.

Forests in the administration boundary of Kaysone City have dramatically decreased. According to a study in 2017²¹, the forest area in Kaysone City dropped from 309 square kilometres in 1997 to 179 square kilometres in 2017 (a 20-year period).

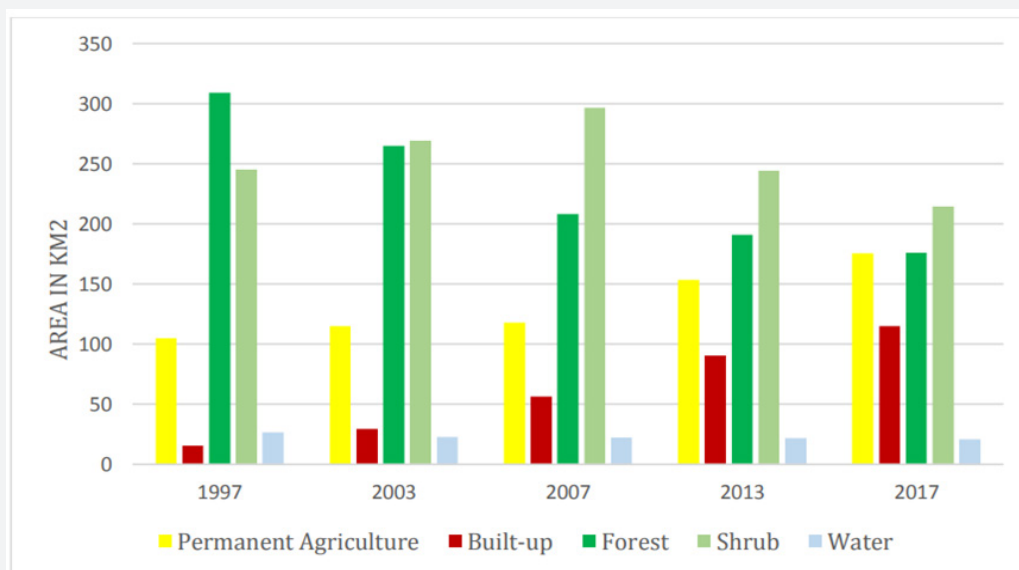
¹⁹ Urban LEDS, City profile for Kaysone Phomvihane City, Savannakhet Province, Lao PDR. 2018

²⁰ https://www.who.int/laos/our-work/protecting-health-amid-a-changing-climate?utm_source=chatgpt.com

²¹ <https://repositorio-aberto.up.pt/bitstream/10216/113114/2/273823.pdf>

FIGURE 7

Forest and other land use changes in Kaysone Phomvihane city from 1997 to 2017



2.6. Urbanization trends

Kaysone Phomvihane, the capital of Savannakhet province in Lao PDR, is experiencing a transformative period of rapid urbanization, largely driven by its strategic location and burgeoning economic potential. This growth is visibly characterized by the poorly managed expansion of residential, commercial, and industrial zones, pushing the city's boundaries outwards in what has become a significant concern regarding urban sprawl.

Evidence of this unchecked growth is stark in the changing land cover of Savannakhet province. Over a mere two decades, from 1997 to 2017, Kaysone Phomvihane's built-up area escalated dramatically from a compact 14 square kilometres to a sprawling 99 square kilometres (Figure 8). This expansion has come at a considerable environmental and agricultural cost. Forest areas, crucial for ecological balance and natural resource provision, have been extensively converted into shrubland, agricultural plots, and ultimately, built-up urban spaces. Simultaneously, prime agricultural lands, traditionally vital for the province's sustenance and economy, are increasingly being paved over for new residential developments and commercial enterprises. This conversion of productive land underscores a broader challenge of balancing economic growth with sustainable land management.

The primary engines of this rapid urbanization are rooted in economic development, particularly the establishment of Special Economic Zones (SEZs) and the burgeoning tourism sector. The Savan-Seno SEZ, for

instance, has attracted significant foreign investment, creating employment opportunities and drawing internal migration to the city. This economic dynamism, while fueling prosperity, concurrently intensifies the demand for housing, services, and infrastructure, often leading to unplanned development. Similarly, the growing tourism industry, leveraging the city's position along the Mekong River and its cultural heritage, has spurred the development of hotels, guesthouses, and related services, further contributing to the city's physical expansion.

However, this swift and economically driven growth is fraught with systemic challenges. The rapid urbanization has outpaced the city's capacity to develop and maintain adequate infrastructure. A critical issue highlighted is the poorly maintained drainage systems, which render the city highly vulnerable to frequent and severe flooding during the rainy season, impacting residents and economic activities alike. This infrastructural deficit points to a broader problem: the weak enforcement of urban planning laws and regulations. Despite the existence of a land use plan, the ability of government agencies to effectively oversee and guide development is low. This limited capacity often results in developers bypassing regulations, contributing to the disorganized and unsustainable nature of the urban sprawl.

Compounding these issues is a general low level of public awareness regarding the importance of proper urban planning and sustainable development practices. Without widespread understanding and engagement from the citizenry, efforts to manage growth, protect environmental assets, or enforce land use policies become inherently more difficult.

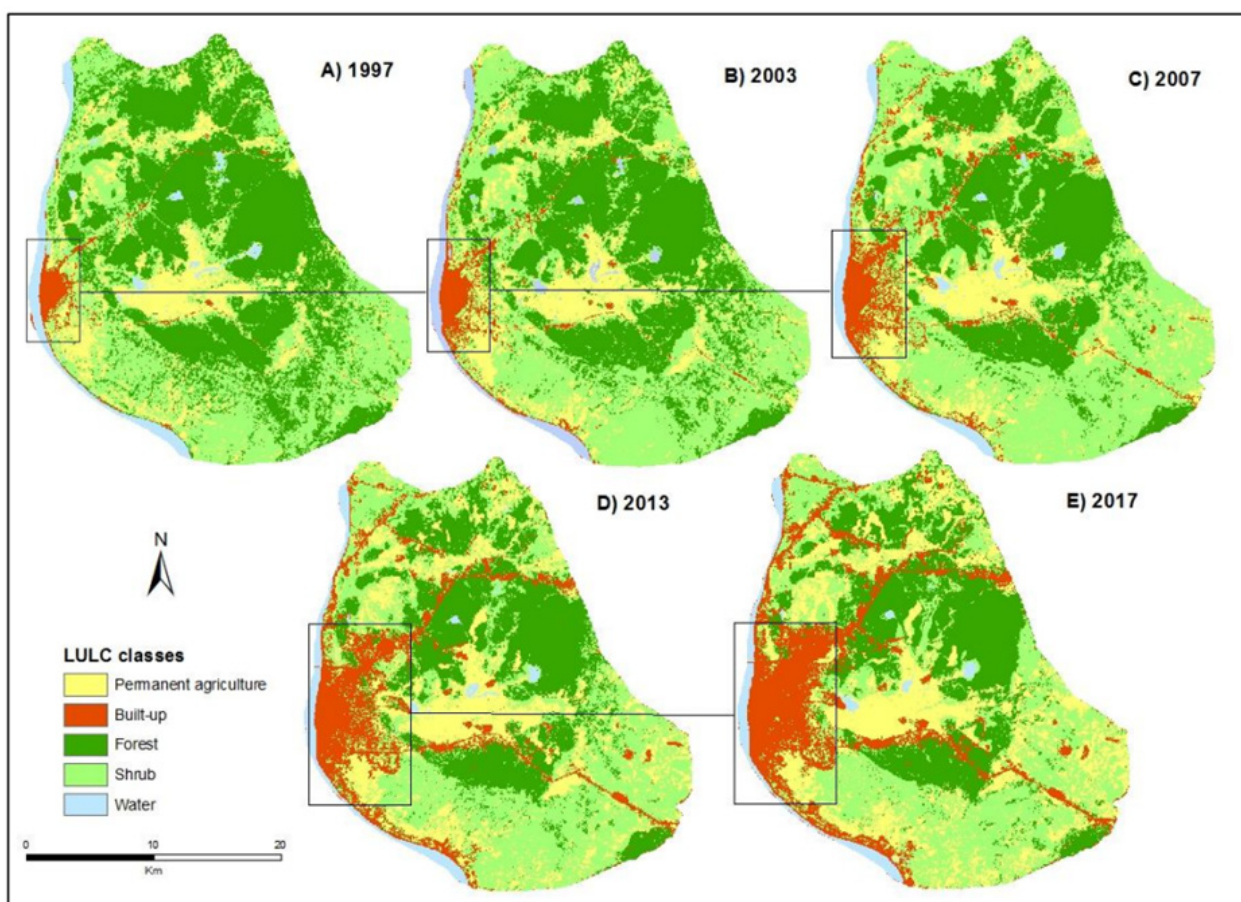


FIGURE 8

Growth of built-up areas in Kaysone City over the period of 20 years (1997 - 2007)

Despite these significant challenges, Kaysone Phomvihane's urbanization is projected to continue its upward trajectory, bolstered by ongoing investments in infrastructure and the expansion of industrial zones. The government's strategic vision to position the city as a crucial node within the East-West Economic Corridor is expected to further accelerate its growth. However, realizing this potential, sustainably, will necessitate a profound shift towards more rigorous and carefully managed urban planning. This requires not only updating existing plans, such as the current effort to revise the land use plan in 2025, but crucially, strengthening the institutional capacity for enforcement, fostering greater public participation, and prioritizing sustainable development to alleviate the mounting pressures on housing, public services, and the environment. Without these concerted efforts, Kaysone Phomvihane risks trading its strategic advantages for the long-term detriments of uncontrolled growth.

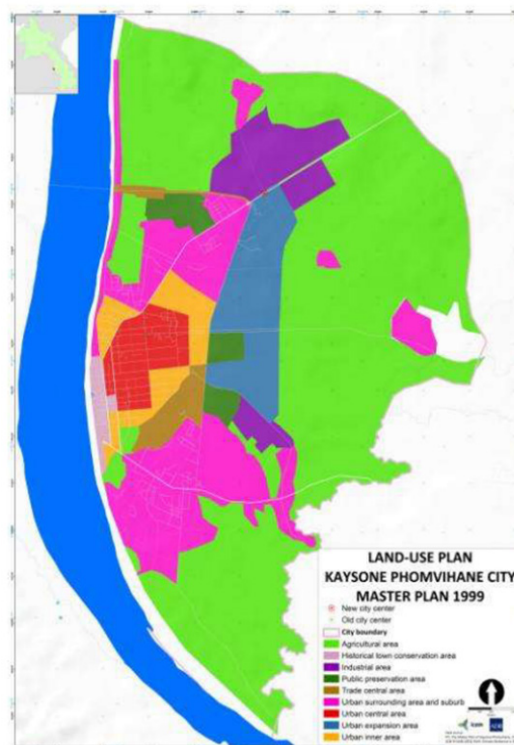


FIGURE 9

Kaysone Phomvihane City's master plan (1999)



FIGURE 10 Public park in Kaysone Phomvihane City

2.7. Physical and social infrastructure assets

Kaysone Phomvihane has made significant investments in infrastructure, particularly in transportation, industrial zones, and public services. The city benefits from its proximity to the Thai border and the Second Thai-Lao Friendship Bridge, which has improved regional connectivity. However, there are still gaps in critical infrastructure, particularly in flood management, waste management, and public health services. The city has improved access to basic services since 2015, according to a World Bank Study: 92.7 per cent of the population has access to improved sanitation; 97 per cent of the population has access to an improved water source; 87.2 per cent are not using firewood as a source of heat for thermal comfort or cooking; 97.7 per cent are using electricity; and 96.4 per cent have access to a phone²². The city's topography is relatively flat, and

²² Kaysone City Diagnostic Report 2021, Accelerating the Implementation of the ASEAN Sustainable Urbanisation Strategy project

drainage capacity is fairly limited. The system consists of roadside drains and open channels where flood water flows through natural streams and creeks that lead to the Mekong River.

The city's physical infrastructure, including roads, bridges, and industrial parks, has been expanded to support economic growth. Social infrastructure, such as education and healthcare services, is also improving, but challenges remain in providing equitable access to these services for all residents, especially those in low-income areas.

2.8. Institutional and policy frameworks

Kaysone's development is guided by a blend of national and international frameworks promoting sustainable urban growth. Recognizing urbanization as a key economic driver, the Lao government has implemented policies to manage urban expansion and mitigate

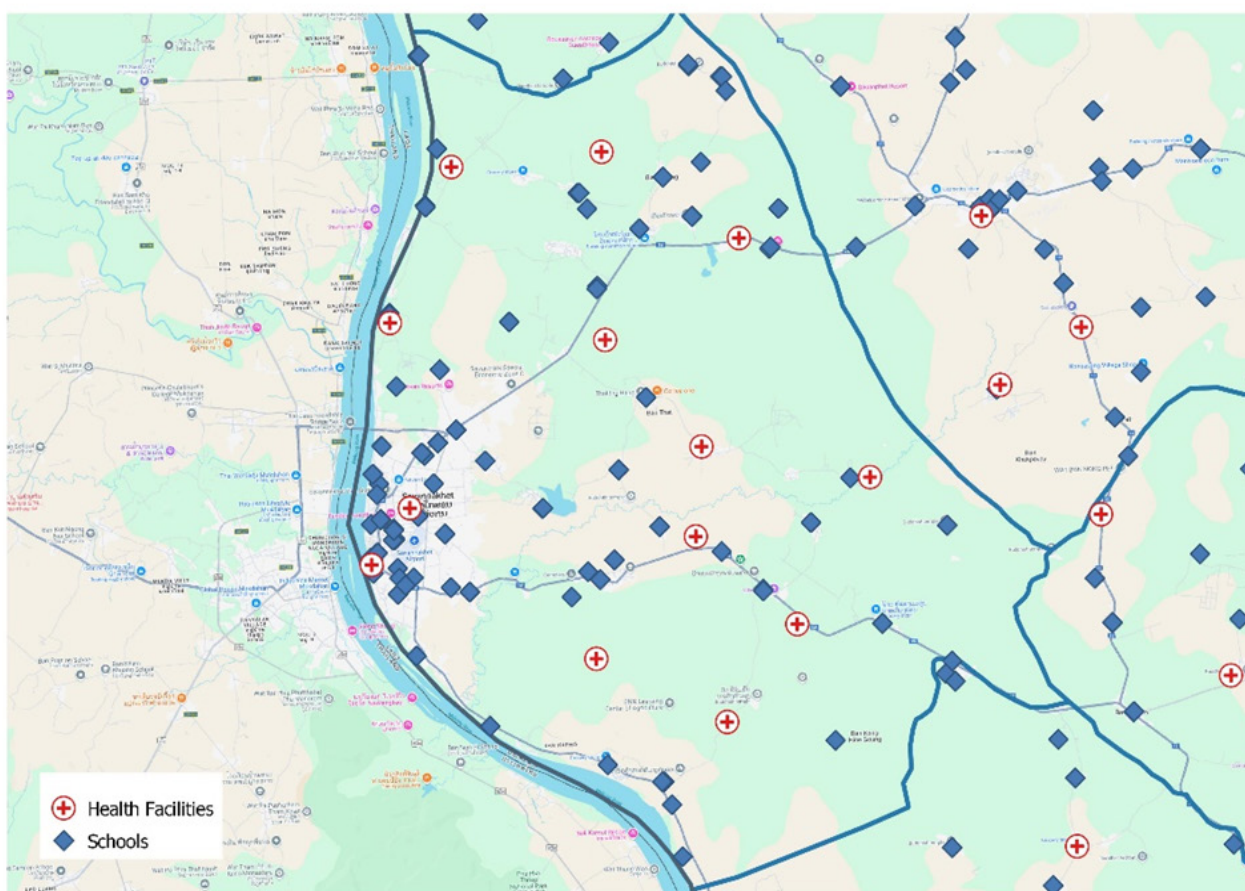


FIGURE 11 Schools and health facilities in Kaysone Phomvihane City and nearby districts

environmental risks. The city's development aligns with the 9th National Socio-Economic Development Plan (2021–2025), focusing on urbanization, biodiversity, and climate change. Key objectives include fostering balanced urban–rural development, protecting natural habitats, advancing sustainable land use, reducing emissions, and enhancing climate resilience across sectors, all while upholding Laos' international environmental commitments. These commitments are reinforced by the Lao PDR's Nationally Determined Contributions (NDCs) under the Paris Agreement, which set national targets for greenhouse gas reduction, climate adaptation, and low-carbon urban development.

The institutional and policy framework governing Kaysone Phomvihane's development is also aligned with national and regional initiatives that promote sustainable urbanisation. The city is actively involved in the ASEAN Sustainable Urbanisation Strategy (ASUS), which helps guide its efforts in managing rapid urban growth and strengthening resilience to climate impacts.

In addition, the city participates in the Urban LEDS II Project, which promotes low-emission urban development. This project has helped Kaysone Phomvihane develop climate action plans and implement pilot projects focused on renewable energy and energy efficiency. These efforts contribute directly to the achievement of Lao PDR's NDC targets and form part of a broader strategy to integrate climate resilience and sustainability into the city's long-term planning.

II. Methodology





01

1. Approach and methodology

The Multilayered Vulnerability Assessment (MVA) tool employs a three-stage methodology designed to help countries, cities, and communities effectively incorporate, adapt, and operationalize the assessment. This structured and phased approach facilitates improved resilience planning and decision-making. Each stage comprises specific steps and activities, outlined as follows:

The MVA uses a simple step-by-step process to map the most vulnerable areas, check the findings with communities, and prepare for practical resilience projects later

Stage 1: Preparation

This stage focuses on establishing the groundwork for the MVA and the framework for the assessment process. Key contributors are identified, and relationships necessary for completing the MVA and analysis are established. This initial phase is crucial for ensuring that the assessment is comprehensive, well-organized, and aligned with the goals and objectives of the organization or community involved. Stage 1 consists of three steps (e.g., Step 1.1: Set up delivery team and steering committee; Step 1.2: Conduct rapid diagnostic of the city or urban area) and eight activities.

Stage 2: Mapping and analysis

This stage involves sourcing and applying data to provide a detailed analysis of vulnerability hotspots within urban areas, examining factors related to climate change, biodiversity, and urban dimensions. The maps produced in this stage are key outputs of the MVA, allowing for the overlaying of outputs to identify and analyze areas of conflicting vulnerabilities and

vulnerability hotspots. Stage 2 is articulated in five steps (e.g., Step 2.2: Data acquisition and collection; Step 2.3: Mapping historic, current, and future vulnerabilities; Step 2.5: Interpretation and analysis of vulnerability hotspots) and encompasses 19 activities.

This multilayered vulnerability assessment was conducted using a spatial resolution of 30 square metres, ensuring consistent and detailed analysis across all indicators. To identify vulnerability hotspots, the data was aggregated into hexagonal units, each with an apothem of 250 metres and an approximate area of 0.216 square kilometres.

The selection of indicators across different dimensions was primarily guided by the feasibility and availability of data. This process involved consultations with local experts and city authorities. While some datasets were available locally, they were excluded from the assessment due to limitations in format or data quality. To supplement the analysis, additional data from online sources and satellite imagery was also utilized. All indicators across dimensions were normalized to a common scale to ensure comparability and consistency in the analysis.

Stage 3: Intervention planning

In this stage, the findings from Stage 2 are transformed into bankable projects aimed at enhancing resilience to current and future climate, urban, and biodiversity shocks and stresses. Collaborating with a diverse range of stakeholders, this stage involves developing 10 to 12 resilience-building actions that are both financially and technically feasible, addressing the intersecting vulnerabilities identified in the MVA. Stage 3 comprises



FIGURE 12 An overview of MVA approach

three steps (e.g., Step 3.1: Visioning and objective setting; Step 3.2: Develop resilience action plans) and includes 12 activities. Please note that this report only cover stage 1 and 2 and the third stage report would come later as a separate one.

Community consultation and validation

In addition to spatial and quantitative analysis, the MVA incorporates community consultation as a complementary methodological component to validate and contextualise the mapping results. Consultations were conducted in selected villages, in coordination with city authorities, to capture local knowledge, lived experiences, and community perceptions of risk related to climate hazards, urban services, and environmental change. These consultations provided qualitative insights on issues such as flooding, drainage, road access, waste management, heat stress, and land-use change,

which were used to cross-check and interpret the spatial vulnerability patterns identified through GIS analysis. While the consultation findings are presented in detail in the annex, their integration into the analytical process strengthened the robustness of the MVA by ensuring that identified vulnerability hotspots reflect on-the-ground realities and local priorities.

The MVA provides a clear, phased methodology that guides countries, cities, and communities through effective resilience planning. The tool's three-stage approach-preparation, mapping and analysis, and intervention planning - provides a clear framework for systematically identifying urban vulnerabilities and transforming insights into actionable, bankable projects. This method ensures that resilience-building actions are well-targeted, feasible, and aligned with local priorities, making it a critical tool for addressing the complex challenges posed by climate change, urbanization, and biodiversity loss.

MVA represents an analytical and diagnostic phase under the RISE UP programme. While the report identifies spatial vulnerability hotspots and integrates community consultation findings, it does not aim to define or prioritise specific investments at this stage. The results of this assessment will be further analysed, prioritised, and translated into targeted, bankable interventions through the upcoming Urban Resilience Action Plan (URAP) for Kaysone Phomvihane City. The URAP will build on the vulnerability hotspots identified in this report, combined with additional stakeholder engagement and feasibility assessments, to ensure that actions are context-specific, socially inclusive, and implementable.

Note: This report covers only Stages 1 and 2. Stage 3 will be presented in a separate report.

02

2. Geographic scope

The scope of this analysis is comprehensive, covering the entire 779.03 square kilometre official administrative boundary of Kaysone Phomvihane city. This includes all 67 villages under city governance, encompassing diverse landscapes such as urban, peri-urban, agricultural, lake, and forest areas. Notably, Kaysone Phomvihane serves as the capital of Savannakhet province, is the province's most urbanized region, and stands as the second-largest city in Lao PDR

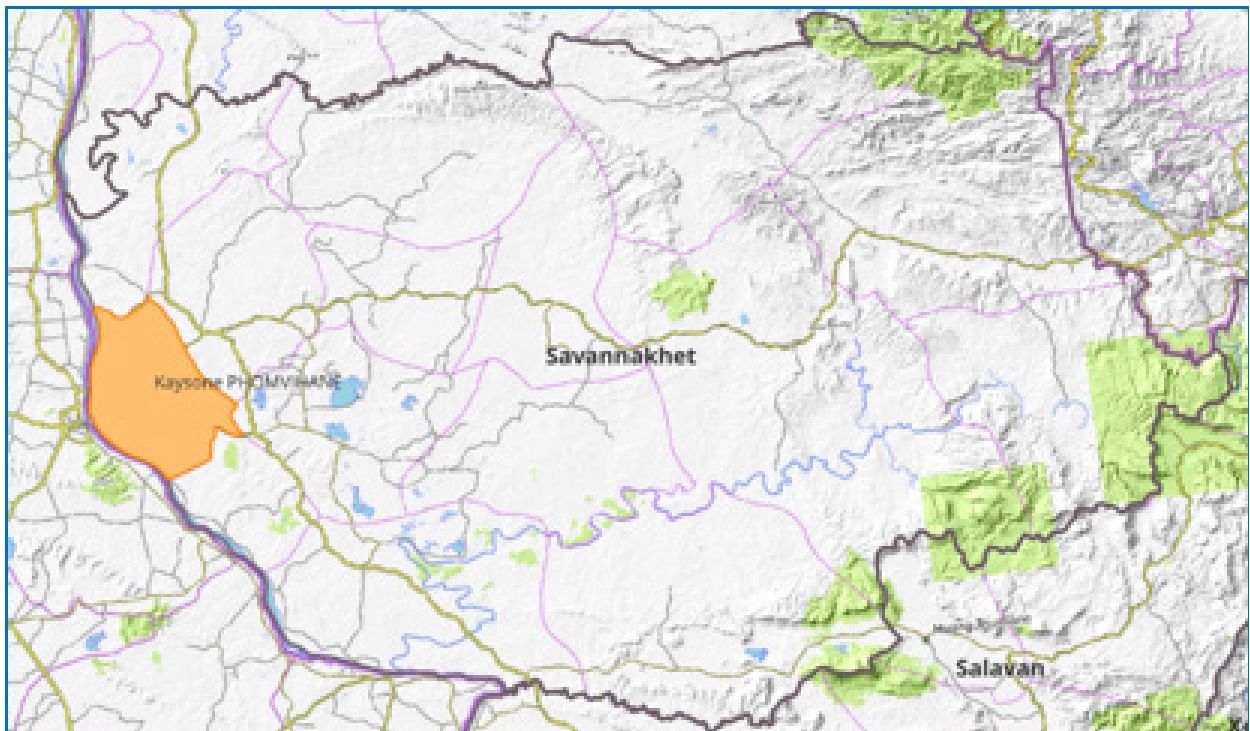
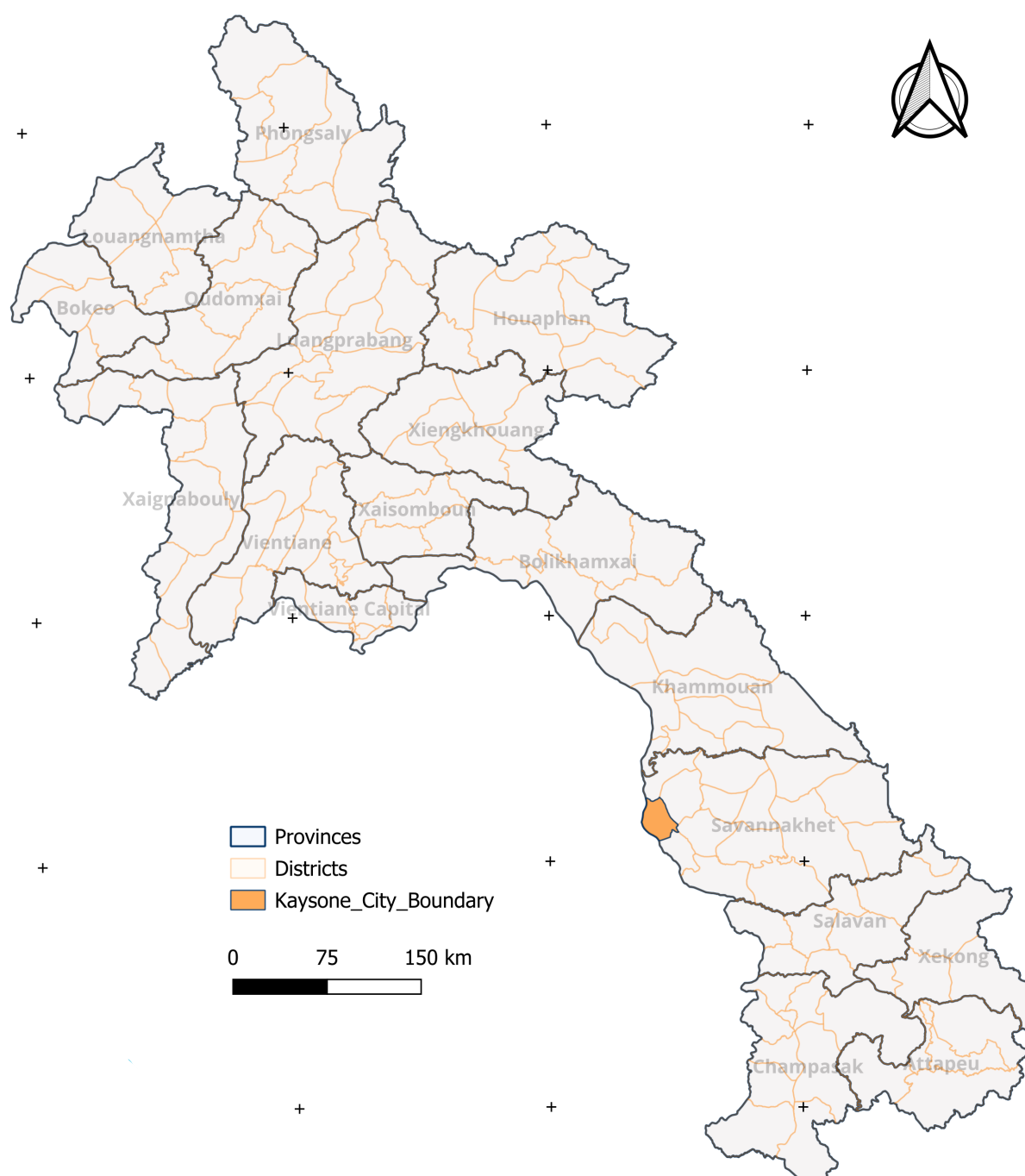


FIGURE 13 Kaysone Phomvihane administrative boundary

Districts and Provinces in Lao PDR



III. Key Findings



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01

1. Urban dimension

Kaysone City, located in Savannakhet Province, Lao PDR, is experiencing rapid urbanisation that remains largely unregulated, leading to several urban management challenges. Weak law enforcement on land use planning and the uncontrolled conversion of agricultural land into urban use have resulted in fragmented development. Basic urban services such as waste management, water supply, and road infrastructure have not kept pace with the growing demands of the expanding population. Most paved roads are concentrated in the old urban core, while newer areas lack adequate infrastructure and public amenities. Although the city's land use remains predominantly agricultural, urban land use is poorly managed, with limited attention given to green space planning, pedestrian infrastructure, and the overall urban landscape. Population density is highest around trade centres and key government offices, increasing pressure on services and mobility. The figure 14 show urban vulnerability across the city categories in 5 classes from light orange to dark orange or from lowest to highest vulnerability. The detail of the analysis will be explained in detail in section 1.2 Urban Dimension Analysis.

Addressing these challenges requires robust policy interventions, such as those outlined in the 2030 Vision and 10-Year Socio-Economic Development Strategy (2016-2025), National Green Growth Strategy of the Lao PDR till 2030 and efforts supported by entities like development partners through initiatives like the ASEAN Sustainable Urbanisation Strategy, and green city Action plan which aim to strengthen urban management, improve infrastructure, and promote sustainable and resilient urban development.

1.1. Indicators – urban dimension

Within the urban dimension, five urban-related indicators are utilized to spatially analyze and identify vulnerability hotspots in Kaysone Phomvihane city. All indicators are equally weighted at 1, and their spatial data scores are normalized to a range between 0 and 1. This analysis is conducted using R and QGIS.

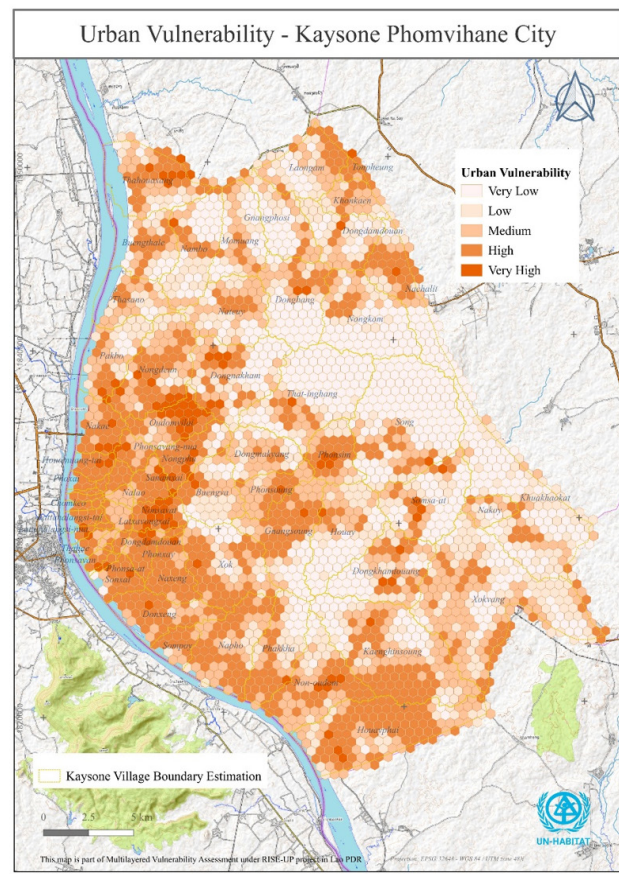


FIGURE 14 Urban dimension vulnerability

1.1.1 Urban Area Growth

This indicator is based on high-resolution imagery data from a study conducted between 2004 and 2025, utilizing Google Earth historical data within Google Earth Pro. Image classification techniques were employed to identify the urban area of Kaysone Phomvihane in both 2004 and 2025. The figure 15 compares the built up area of Kaysone city in 2004 and 2025 in orange and red. Further details on this methodology can be found in the Annex 1.

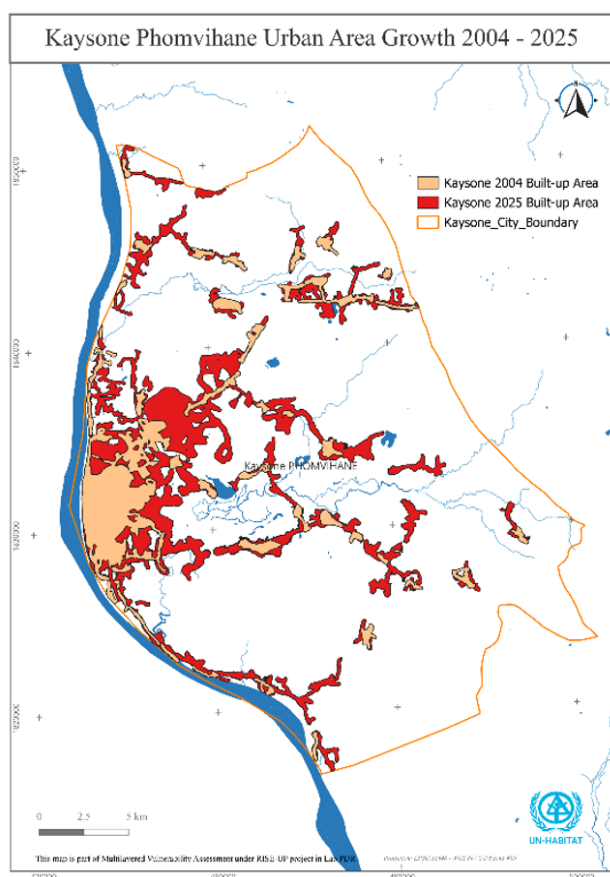


FIGURE 15 Kaysone urban area growth 2004-2025

“From 2004 to 2025, Kaysone’s built-up area grew from 42.5 sq km to 105.9 sq km, growing at an average of 7 per cent annually indicating sustained expansion and conversion of forest and agricultural land into urban uses.”

The analysis reveals that the built-up area was 42.5 sq km in 2004 and expanded to 105.9 sq km in 2025. This represents significant growth, averaging 3.03 sq km per year, or slightly higher than 7 per cent annually over the past 21 years of economic development. At this rate, it indicates that other land types have been converted into residential and commercial areas. Forest and agricultural lands, especially those near trade centers, were among the primary land types converted to built-up areas.

The assumption under this indicator is that the old urban area is considered to have low vulnerability because basic services were well-designed to

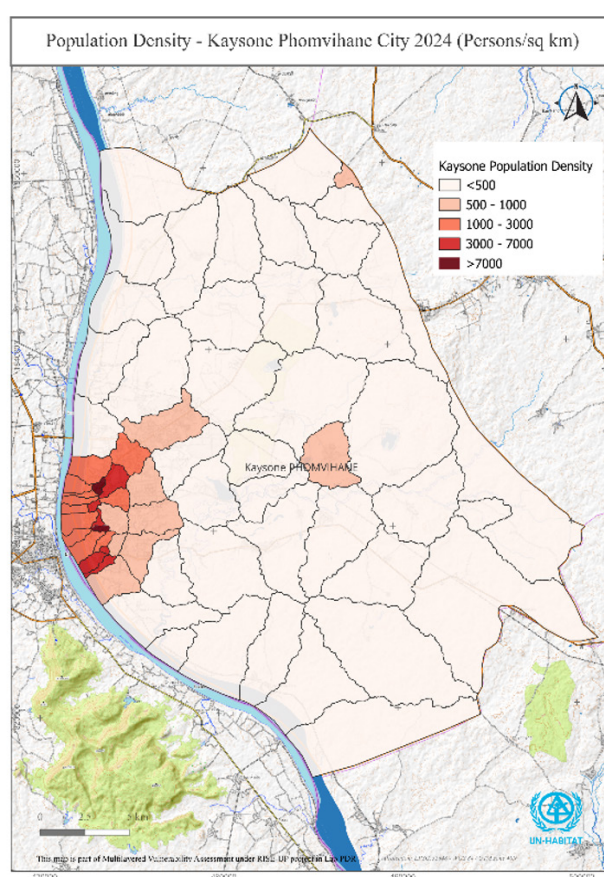


FIGURE 16 Kaysone population density 2004 (Persons/sq km)

support the population’s livelihood. In contrast, newly expanded urban areas, which have grown rapidly and are largely unregulated, mostly lack access to these essential basic services and infrastructure. The population in the urban area tend to be poorer as the land there is also cheaper and they can not afford to live in the old urban area. This is due to the fact that infrastructure and services are not being built quickly enough to keep pace with the growth, making these new built-up areas more vulnerable. The focus of this urban indicator is on this new expansion, which is assigned a vulnerability score of 1, while the remaining areas are not assigned a score.

1.1.2 Population density

According to the Kaysone Administrative Office, the total population of Kaysone City in 2024 is 139,248, with 69,793 women, accounting for roughly 50 per cent of the total. These residents live across 67 villages within the city boundaries, as shown in the map to the right. Most people reside in the old urban area, where trade centres and key government offices are located. Lao PDR has one of the lowest population densities in ASEAN

and globally. In the context of Kaysone City, the average population density is 179 people per square kilometre, which is considered low compared to large global cities, where an average population density is 10,650 people per square kilometre¹⁴. However, in several central urban villages of Kaysone City, the density exceeds 3,000 people per square kilometre. For this indicator, the assumption is that more people living in, or higher density in an area, is considered more vulnerable.

High population density in urban areas contributes to increased vulnerability due to the pressure it places on infrastructure, services, and social systems. Overcrowding can strain essential services such as waste management, water supply, and transport, limiting their ability to operate effectively, especially during disruptions. The lack of sufficient green space and high levels of sealed surfaces also intensify the urban heat island effect, contributing to health risks during periods of extreme heat. Furthermore, dense environments can experience higher rates of crime and reduced social cohesion, which may impede community resilience and emergency response efforts. These issues collectively make densely populated urban areas more susceptible to the impacts of climate hazards such as floods, storms, and heatwaves.

14 <https://demographia.com/db-worlduasizeclass.htm>

Although Kaysone City's average density is low (179 people/km²), some central villages exceed 3,000 people/km², where crowding places put greater pressure on services and increases vulnerability to floods, heat, and other climate hazards

1.1.3 Green space accessibility

In the context of Kaysone Phomvihane City, green areas primarily consist of natural forests located on the outskirts of the city, far from the urban core. While local authorities recognise the importance of green spaces, tree planting along roads remains limited and fragmented, falling significantly short when compared to standards seen in cities of the developed world. During the dry season, urban temperatures can exceed 40°C, making the city environment particularly harsh for pedestrians due to a lack of shade and cooling vegetation. This indicator focuses specifically on the availability and proximity of

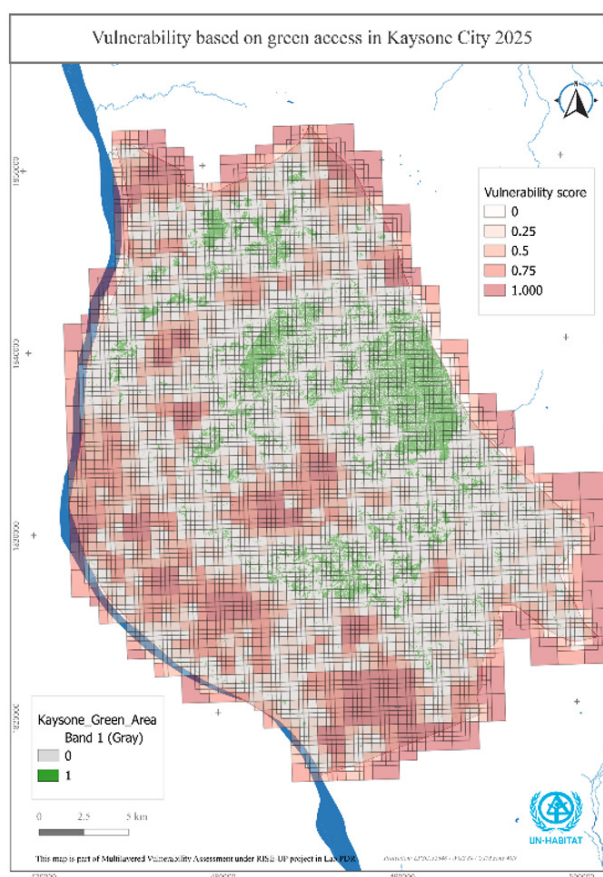


FIGURE 17

Vulnerability based on green space in Kaysone Phomvihane City

green space within the city. The underlying assumption is that communities located closer to green areas benefit from improved air quality, lower ambient temperatures, reduced pollution, better health outcomes, increased longevity, and an overall enhanced urban environment. Consequently, such communities are considered less vulnerable compared to those with limited or no access to green space.

The figure 17 show vulnerability score from lowest to highest based on its distance from the forest area. The green area on the map show tree cover while the dark red show the highest vulnerability score under this indicator. Vulnerability in this approach is calculated based on accessibility to green space, using a scoring system derived from Sentinel-2 satellite imagery and NDVI analysis. Green areas with an NDVI value of 0.475 or higher are identified and overlaid with a series of grids at four spatial resolutions (500×500 m, 750×750 m, 1000×1000 m, and 1500×1500 m) across the city. A green score is assigned to each grid cell depending on its size and the presence of at least 100 m² of green area, with smaller grids (e.g., 500 m) receiving a higher score

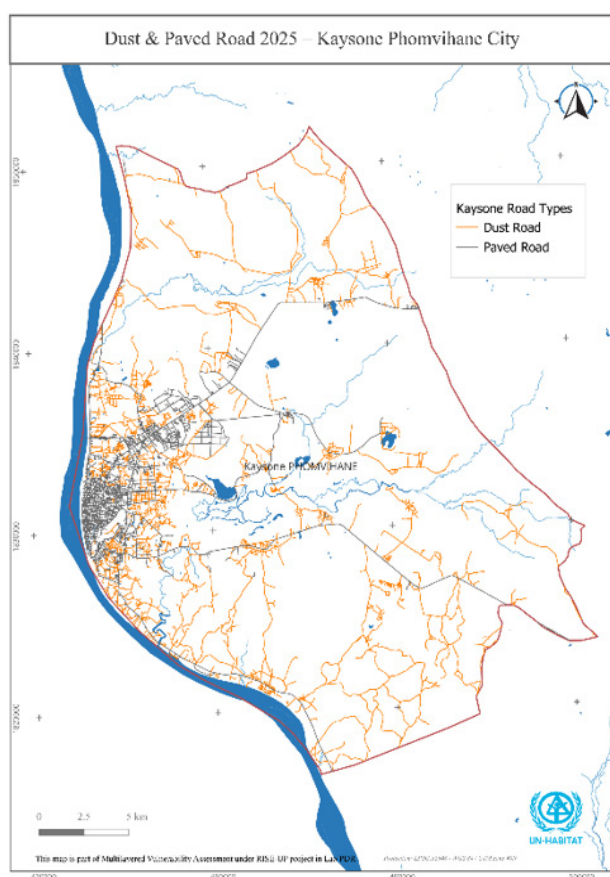


FIGURE 18 Road type in Kaysone Phomvihane City

(1) and larger grids receiving progressively lower scores (0.75, 0.5, and 0.25). These scores are then merged across grid scales using a union process in QGIS and normalized to ensure no overlap in values. The final green accessibility score is then inverted using the formula $Vulnerability = 1 - \text{Green Score}$, meaning areas with less accessible green space are assigned higher vulnerability values. The resulting data is converted into a 30x30 m raster file for further spatial analysis, providing a detailed vulnerability map that highlights areas with limited access to green space and, therefore, greater exposure to heat stress and reduced urban resilience. The detail of this methodology can be found in the Index 2.

1.1.4 Community vulnerability by road types

As urban areas expand rapidly, population growth-driven both by natural increase and rural-to-urban migration is also accelerating. However, the annual budget for infrastructure development, particularly for roads, remains limited and is unable to keep pace with rising demand. Unplanned settlements and weak land use regulation further complicate efficient infrastructure

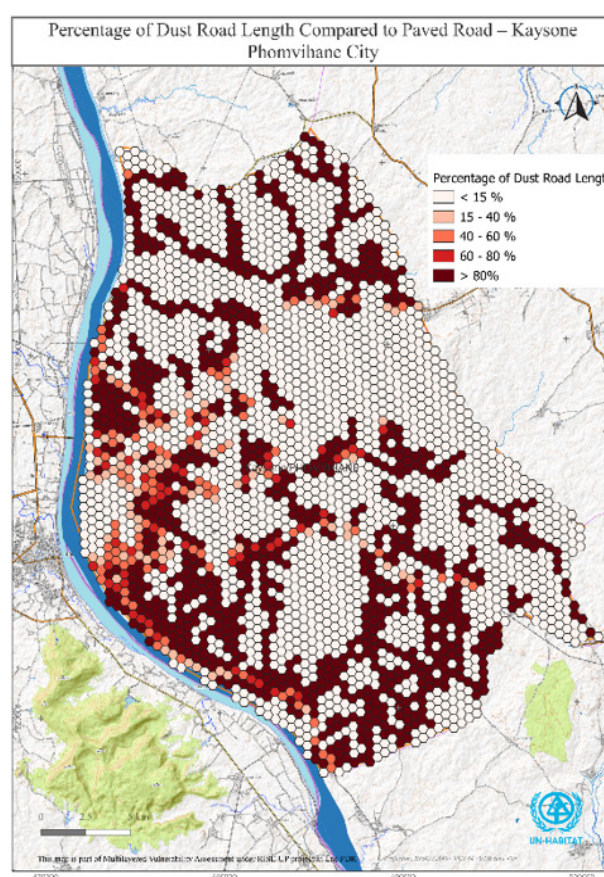


FIGURE 19 Percentage of unpaved road type in Kaysone

investment, as new residential areas are scattered across former paddy fields and agricultural zones, making service delivery and connectivity more costly and less effective. To address these challenges, city authorities require stronger support from the central government. As shown in the figure 18, the paved roads (represent in grey color) are mostly in the old urban center and in the main roads. While dust roads (represent in orange) are those for emerging communities expanded from the city area. In major cities like Luang Prabang, Kaysone, and Pakse, essential infrastructure projects such as road construction, landfills, and water treatment facilities have relied on international financing, including loans from the Asian Development Bank (ADB) through initiatives like the Livable Cities Project¹⁵ and Urban Improvement projects¹⁶.

This urban indicator focuses on capturing vulnerability based on road type, using the per centage of unpaved road length as a proxy. The result from this indicator analysis is shown in figure 19 where darker red represent higher per centage of dust road. The underlying

¹⁵ <https://cdia.asia/project/lao-pdr-livable-cities/>

¹⁶ <https://www.adb.org/projects/43316-012/main>

assumption is that communities with dirt roads have reduced access to essential services such as waste collection, schools, and hospitals, particularly during the rainy season when road conditions deteriorate. For example, Kaysone City waste collection trucks only service villages in the urban center due to accessibility challenges, leading to significant waste management issues—one of the key concerns raised during the consultation workshop for the RISE-UP project. Additionally, communities with a higher proportion of unpaved roads tend to be poorer, as limited access to services and lower land prices make these areas more affordable for low-income residents. Methodology of this indicator can be found in the annex 3.

1.1.5. Land cover

This land cover indicator represents directly different types of land use within the city boundary. The data for this indicator is generated using Sentinel 2 satellite imagery. This is a global dataset available online¹⁷. The figure 20 show 5 main landuse types within the city in different color. The use of land cover data from satellite imagery is preferred because the official land use plan available in the city does not accurately represent actual land use on the ground. This discrepancy is largely due to weak enforcement of land use regulations, resulting in a plan that does not reflect reality. In contrast, land cover derived from satellite data provides a more accurate and up-to-date representation of how land is being used across the city, making it more suitable for analysis.

The underlying assumption is that different land use types correspond to different levels of vulnerability. For example, urban areas are considered more vulnerable than forested areas, where few or no people reside. The scoring system for land use types in this analysis follows the recommendations outlined in the Geospatial Workflow Guideline developed by UNOSAT.

1.2. Urban dimension analysis

High vulnerability is observed in the peri-urban areas surrounding the city centre, primarily due to low accessibility to basic services, higher poverty levels, a greater proportion of unpaved roads, and the emergence of new urban growth areas. These factors collectively contribute to higher vulnerability scores in these zones. Although informal settlement is not familiar in Laos as the concept here differs from that in other countries. In Laos, informal settlements are often defined by the socioeconomic conditions of households rather than high-density slum development. Given that Laos has one

¹⁷ <https://livingatlas.arcgis.com/landcoverexplorer/>

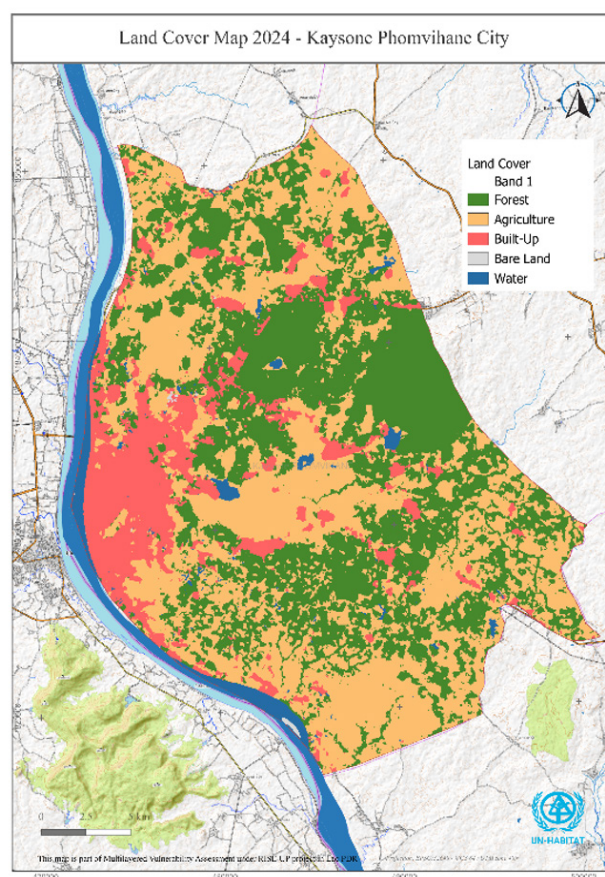


FIGURE 20 Land cover in Kaysone Phomvihane City 2024

of the lowest population densities in the world, cities like Kaysone Phomvihane do not have crowded slums, but instead have poorer communities with limited access to basic services such as clean water, proper roads, sanitation facilities, and waste collection. This spatial pattern is consistent with findings from community consultations in Phonsoung and Houameung-tai Villages, where residents reported poor road conditions, limited waste collection services, and difficulties accessing basic services during the rainy season. In Phonsoung Village, community members noted that waste collection trucks cannot reach parts of the village due to unpaved roads, reinforcing the vulnerability identified in the road-type indicator (Details of community consultation can be found in Annex 1).

Vulnerability hotspots are also found within communities located in the urban center. The main reason for their high vulnerability is limited access to green spaces. Since most green areas are situated far from the urban core, residents in these central communities receive fewer environmental benefits such as improved air quality, lower ambient temperatures, reduced pollution,

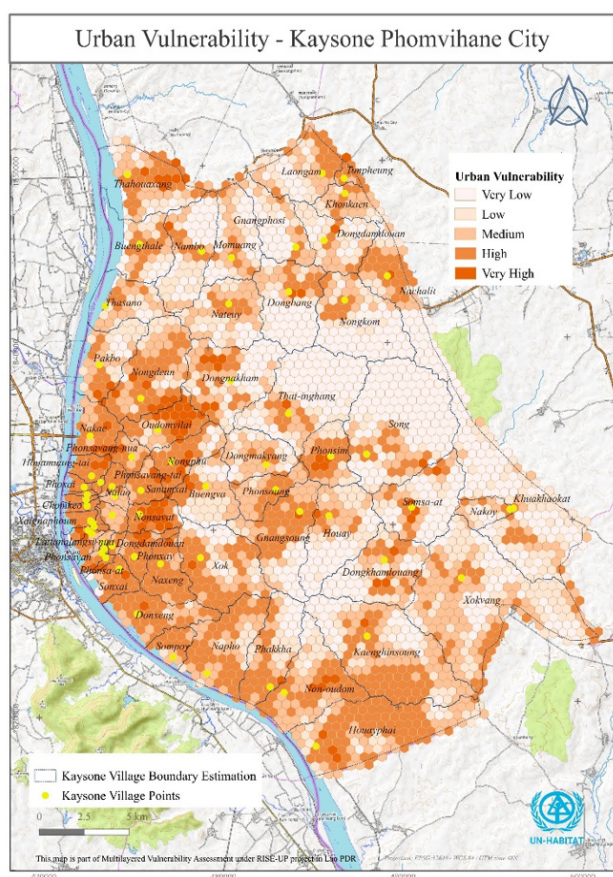


FIGURE 21 Urban vulnerability hotspots and village location

better health outcomes, and increased longevity-all of which contribute to a lower quality of urban life. During consultations, residents highlighted the lack of trees and shaded public spaces, noting increased heat discomfort during the dry season, which aligns with the green space accessibility analysis.

The very highly vulnerable communities in the urban dimension of Kaysone City include Oudomvilai, Nongphu, Nonsavath, Phonsim, Phonsa-at, Houameung-tai, Nakae, Phonsoung, Dongmakham and others (See Figure 21).

“Waste is a major issue in our village. The priority support needed in our village is waste management, along with capacity building and awareness-raising activities for the community.”

“There is no proper drainage system along the roads. During heavy rainfall, flooding becomes a major issue in our community.”

— Ms. Souksamai, Village Authority. Huameungtai, Kaysone Phomvihane city, Savannakhet Lao PDR

1.3. Urban future vulnerabilities

While there is no trend data available to analyse future urban vulnerability, it is likely that vulnerability will remain the same or even worsen without proper investment in basic service improvements. As the population grows, vulnerable areas are expected to expand, particularly in peri-urban zones and outer villages. Based on urban growth projections, the city is expected to expand by approximately 3 square kilometres per year, or around 7 per cent of its total area. This growth will likely exacerbate existing vulnerabilities if not properly managed.

Community consultations reinforce this projection. Residents in Houameung-tai and Phonsoung Villages expressed concern that recent settlement growth has not been matched by improvements in roads, drainage, or waste management, suggesting that future urban expansion may further increase vulnerability in these areas.

Given the large size of Kaysone City and its low-density, scattered population, substantial investment is required to improve basic services such as water supply, road infrastructure, wastewater treatment, landfill management, healthcare, education, public transport, and urban green spaces.

Equally important is a long-term capacity-building program targeting government offices and raising public awareness. These efforts must go hand-in-hand with physical infrastructure investments to effectively reduce future vulnerability.

Moreover, interventions should be coordinated across all sectors and led by urban planning authorities, with strong enforcement of laws to ensure long-term effectiveness.

02

2. Climate change dimension

Kaysone City is situated in lowland areas along the Mekong River and is frequently affected by climate change-related hazards, particularly heavy rainfall and flooding. Floods in Kaysone mainly impact agricultural zones along natural streams in the central and northern parts of the city, which are at a lower elevation than the built-up urban areas. Urban flooding also occurs during intense rainfall events, affecting communities within the city. These floods are typically short in duration, often lasting less than a day, due to the absence of a systematic drainage system and poor water management practices, which still heavily rely on natural streams. Additionally, buildings and human activities, especially the improper disposal of waste, often obstruct waterways, further impeding flood drainage. The figure 22 represent vulnerability under climate change across the city area, from light blue to dark blue (lowest to highest level). The detail of the analysis can be found in section 2.2 Climate Change Dimension Analysis.

Despite national efforts such as the National Strategy on Disaster Risk Reduction (2021-2030)¹⁴, the implementation at the city level remains challenging. Both local and central governments face limitations in funding, technical capacity, and the absence of early warning systems, all of which exacerbate the city's vulnerability to climate hazards.

This climate risk assessment also considers drought and surface temperature using secondary data and satellite imagery. However, these factors currently have less direct impact on the Kaysone community compared to flooding. To reflect their relative significance, flooding is assigned a higher weight of 1.5 in the overall risk analysis, while drought and land surface temperature are each assigned a weight of 0.5.

¹⁴ <https://faolex.fao.org/docs/pdf/lao215507eng.pdf>

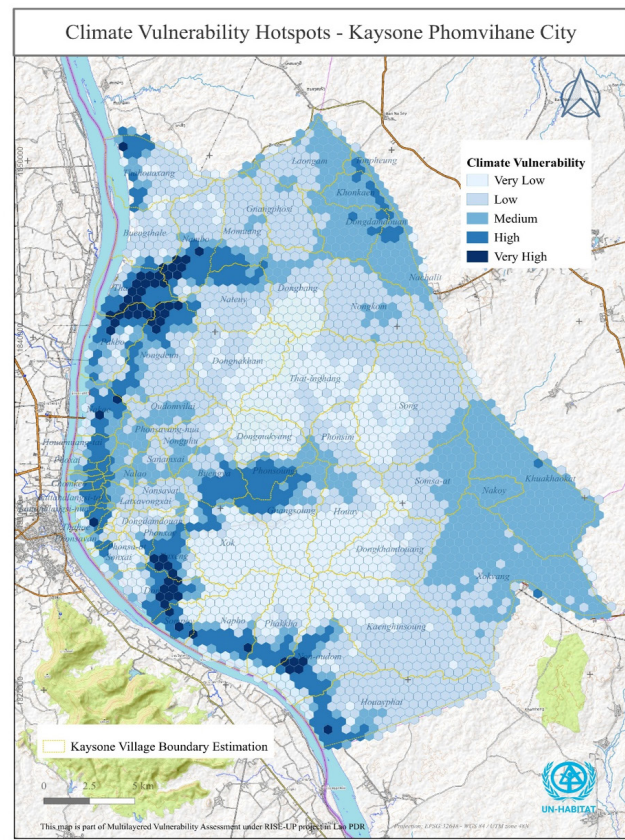


FIGURE 22 Climate Change Dimension Vulnerability

2.1. Indicators – climate change dimension

2.1.1 Floods

This indicator assesses the areas at risk of flooding. The data for this analysis is derived from the global flood risk statistics dataset (Giri dataset)¹⁵, which represents a 100-year return period (up to 2016), and is available online. The data was cropped to the city boundary and normalized to a 0-1 scale, consistent

¹⁵ <https://giri.unepgrid.ch/>

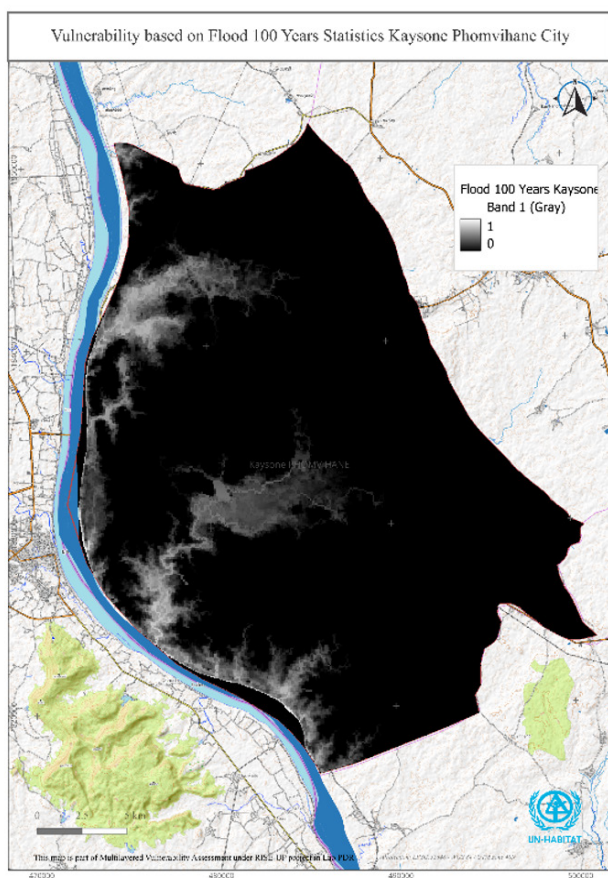


FIGURE 23 Flood risk area in Kaysone Phomvihane City

with other indicators. As shown in Figure 23, flood risk is displayed on a greyscale from black to white, where lighter (whiter) areas indicate higher levels of vulnerability, while black indicates the lowest level of vulnerability under this indicator.

The analysis shows that flood risk areas are typically located near the Mekong River and along the natural streams connected to the Mekong. The majority of these areas are agricultural land. As the impacts of flooding are more evident and severe compared to other hazards-and because it is the primary hazard affecting citizens-this indicator is assigned a weight of 1.5, which is higher than the other climate change indicators.

Flood risk in Kaysone Phomvihane is highest along the Mekong River and connected streams, mainly affecting low-lying agricultural areas vulnerable to river overflow

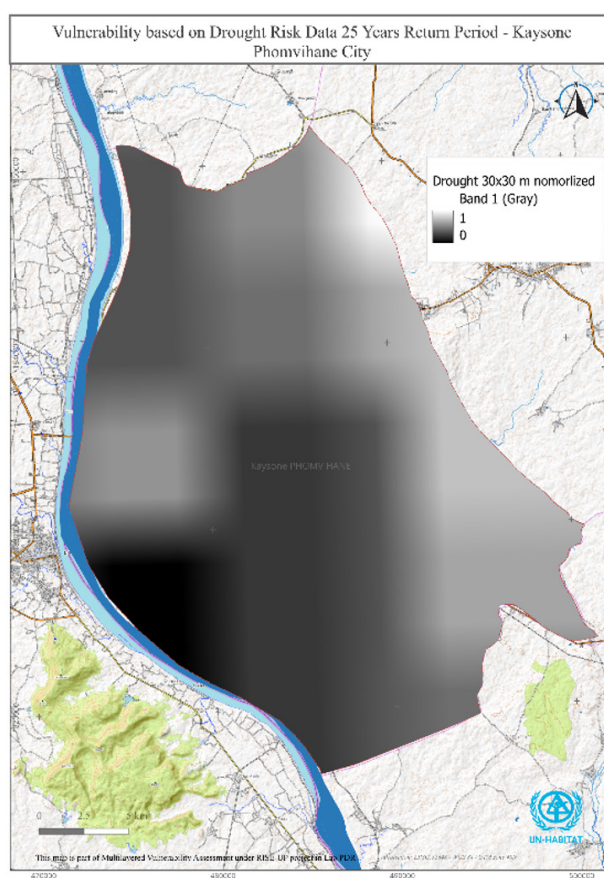


FIGURE 24 Drought risk data in Kaysone Phomvihane City

2.1.2. Drought

The drought indicator is derived from the global dataset available at GIRI (Global Infrastructure Risk Model and Resilience Index) – giri.unepgrid.ch. The map of drought risk (Figure 24) is displayed on a greyscale from black to white, where lighter (whiter) areas indicate higher levels of vulnerability, while black indicates the lowest level of vulnerability under this indicator. Kaysone Phomvihane, situated on the Savannakhet Plain - the largest plain in Laos along the Mekong River - is susceptible to periodic droughts. The drought risk pattern shows higher vulnerability in the east, northeast, and southeast, mainly in agricultural areas and in the urban residential areas of Kaysone, where there is little or no tree cover.

Drought is another recurring hazard, particularly affecting agricultural and urban residential areas in the east, northeast, and southeast, where limited vegetation cover increases vulnerability

Although drought impacts are generally less severe than flooding, they still pose considerable risks to local communities, infrastructure, and biodiversity. Prolonged dry periods can reduce agricultural productivity, threaten water supply for domestic and industrial use, degrade soil quality, and increase pressure on rural livelihoods. Drought also stresses ecosystems, leading to the loss of vegetation cover, reduced habitat quality, and declining resilience of local biodiversity. Therefore, drought is included as an indicator in the analysis, though assigned a lower weight of 0.5 compared to flooding.

2.1.3 Land surface temperature

This indicator was generated using Landsat 9 imagery obtained from USGS EarthExplorer¹⁶. The methodology follows the approach used in the study “Impact of Urbanization on Urban Heat Island in Arkana City, Sindh, Pakistan”. Detailed steps of this methodology are provided in the Annex 4.

Figure 25 shows land surface temperature in a normalised greyscale from 0 to 1; lighter (whiter) areas indicate higher temperatures, while black areas indicate lower temperatures. The underlying assumption of this indicator is that areas with higher surface temperatures are more vulnerable due to the increased risk of heatwaves and urban heat island effects, which can significantly impact the health of people working outdoors, both in urban and agricultural environments. Similar to the drought indicator, it is weighed 0.5 as this factor is considered less impactful on people compared to the flood indicator.

¹⁶ <https://earthexplorer.usgs.gov/>

The highest surface temperatures in Kaysone Phomvihane are observed in bare agricultural lands and dense urban areas with minimal tree cover, increasing vulnerability to heat stress and urban heat island effects.

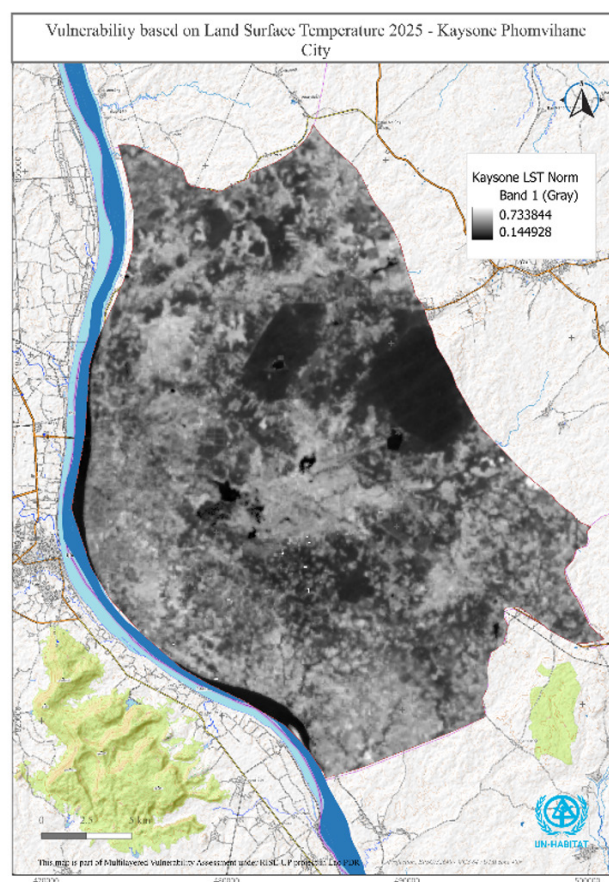


FIGURE 25 Land surface temperature data in Kaysone City

“Our village often experiences flooding, especially in the lower-lying agricultural areas.”

“Our village is facing problems with forest loss, as much of the forest land has been converted into residential land for sale.”

— Mr. Noy Vilay, Phonsim Village Chief, Kaysone Phomvihane City

2.2. Climate change dimension analysis

Highly vulnerable hotspots are concentrated in low-lying areas near natural streams and the Mekong River, which are prone to frequent flooding. Some of these areas also exhibit high surface temperatures due to bare land with little or no tree cover. Notably, the hotspots primarily cover agricultural areas and partially overlap with community settlements. As shown in the Figure 22 & 26, the villages of Thasano, Nambo, Pakbo, Nongdeun, Nakae, Donxeng, Sompoy, Naxeng and Thanae are identified as highly vulnerable to climate change due to a combination of factors, including flooding, high surface temperatures, and drought conditions. High vulnerability is also found in Phonsoung, Beungva, Houameung-tai, and other villages in the urban areas such as Viengsavang, Thameung, Lattanalangsi-tai, Huameungneue, Xaiyamounkhoun and Thahae. These findings are strongly supported by community consultations. In Phonsoung Village, residents reported recurrent flooding during heavy rains, with floodwaters affecting houses and agricultural plots. In Houameung-tai Village, community members described how blocked drains and waste disposal along waterways worsen flood impacts, validating the mapped flood-risk hotspots.

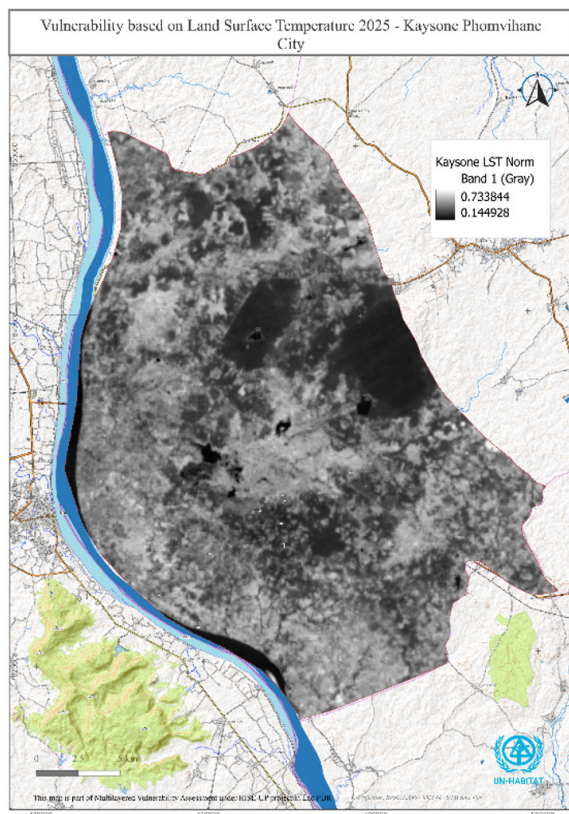


FIGURE 26 Climate change vulnerability hotspots and village location

2.3. Climate change future vulnerabilities

Data from the Climate Change Knowledge Portal indicate that average annual precipitation in Savannakhet Province is projected to slightly decrease by 2100, from approximately 1,962 mm to 1,912 mm, compared with the 1991–2020 baseline. This trend suggests an increasing risk of drought conditions across the city and province. At the same time, the number of extremely hot days is expected to rise sharply: by 2100, days with temperatures exceeding 35°C could increase to around 124 days per year, compared with an observed average of 14 days annually during the 1995–2014 period.

Despite relatively modest changes in total annual rainfall, the number of people exposed to climate-related hazards is expected to increase due to rapid urban expansion driven by population growth and rural-to-urban migration. This trend disproportionately affects marginalised and low-income groups, who often have limited housing options and are compelled to settle on cheaper, hazard-prone land without full awareness of the associated risks. Without stronger integration of land-use planning and stricter enforcement of development regulations, exposure to climate hazards is likely to intensify, particularly in high-risk areas.

There is also a critical need for substantial investment in systematic urban drainage infrastructure. While overall rainfall totals may remain relatively stable, changing rainfall patterns—especially the increasing frequency and intensity of short, heavy downpours—are placing growing pressure on existing drainage systems. Targeted investments in upgrading natural streams, drainage channels, and flood pathways are essential to improve water conveyance and reduce future urban flooding.

Community members in Phonsoung and Phonsim Villages noted that flood events have become more frequent and disruptive in recent years, raising concerns that future climate impacts will increasingly affect housing safety, mobility, and access to services if no preventive measures are implemented.

03

3. Biodiversity dimension

Kaysone Phomvihane, located in Savannakhet Province, is a region rich in biodiversity, surrounded by forests and agricultural land. The city lies close to the Dong Nata Provincial Protected Area, which is home to various wildlife species, including endangered animals such as the Eld's deer and silvered leaf monkey. However, rapid urbanization and economic growth over recent decades have driven the expansion of agricultural activities, particularly rubber, cassava, and corn plantations. This has resulted in significant forest loss, raising major concerns for biodiversity conservation as large areas of forest have been converted to farmland.

Despite efforts from government agencies, supported by NGOs and development partners, challenges remain due to limited budgets, insufficient human resources, and inadequate capacity for effective planning and law enforcement. Furthermore, data on biodiversity within the province and city is limited. To address this gap, global datasets and satellite imagery are used for analysis, employing indicators such as the Normalized Difference Vegetation Index (NDVI), Burn Area Index (BAI), and Mean Species Abundance (MSA) index which all indicators are weighed equally. The Figure 27 is the combined indicator vulnerability under biodiversity dimension where darker green indicator higher vulnerability and lighter green indicate lower indicator. The detail analysis is explain in the section 3.2 Biodiversity Dimension Analysis.

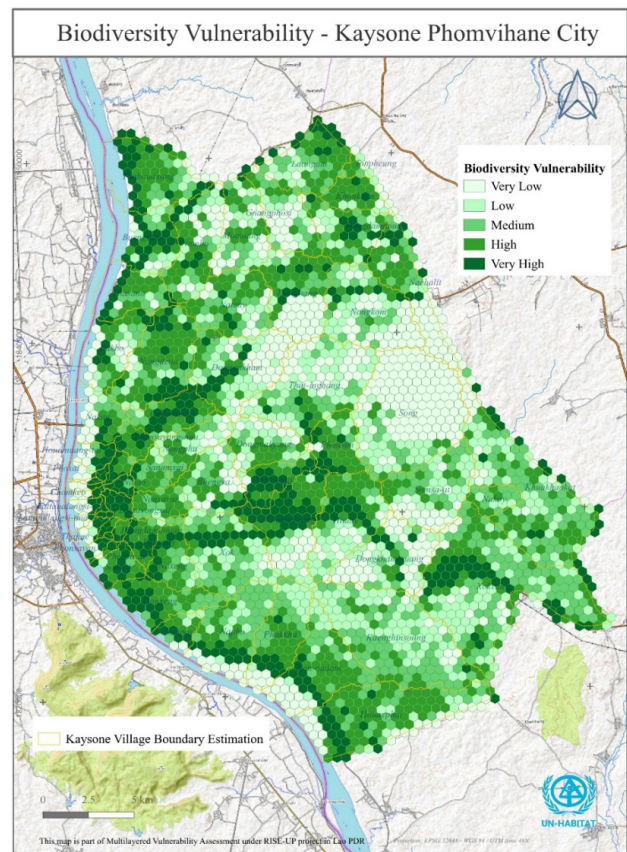


FIGURE 27 Biodiversity dimension

3.1. Indicators – biodiversity dimension

3.1.1 Normalised Difference Vegetation Index (NDVI)

This indicator focuses on the abundance of biodiversity within the boundary of Kaysone Phomvihane city. The **Normalised Difference Vegetation Index (NDVI)** is widely used as a proxy for biodiversity abundance because it reflects the health, density, and productivity of vegetation,

The biodiversity assessment in Kaysone Phomvihane shows that areas with low vegetation cover - mainly urban, agricultural, and bare land - have higher vulnerability due to limited green space and habitat quality

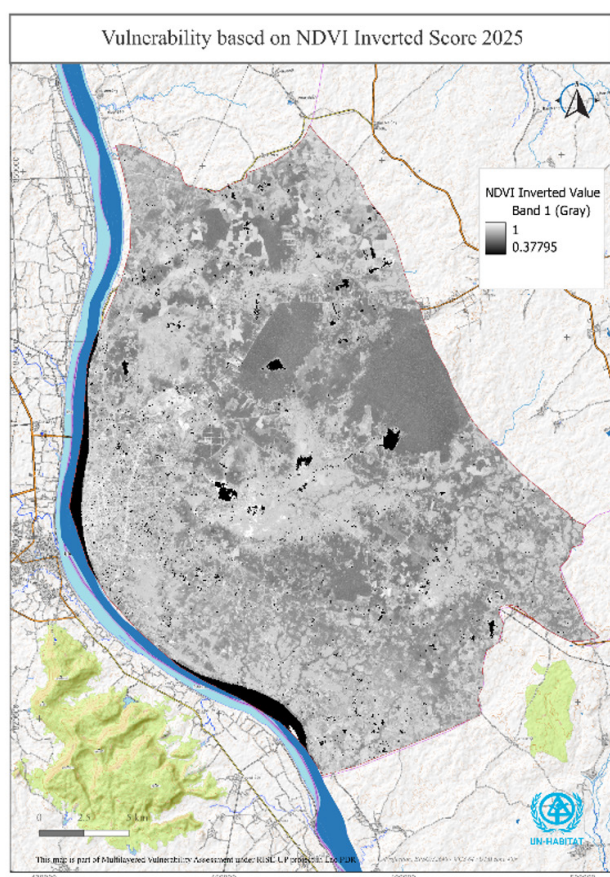


FIGURE 28 Inverted NDVI 2025 – Kaysone Phomvihane City

which are key components of habitat quality and species richness. NDVI is calculated from satellite imagery using the difference between near-infrared (NIR) and red (R) reflectance values:

$$NDVI = (NIR - R) / (NIR + R)$$

NDVI in this case is generated from Sentinel 2 data in February 2025 using Red and Near Infrared bands. The results from NDVI were inverted ($1 - NDVI$) to create a vulnerability index, ensuring that areas with lower vegetation cover are represented with higher vulnerability scores. The analysis map in Figure 28 is displayed in greyscale, where lighter (whiter) areas indicate higher vulnerability and darker areas indicate lower vulnerability. The most vulnerable (lightest) areas are mainly located in urban, agricultural, and bare-land zones where tree cover is limited or absent.

3.1.2 Burn Area Index (BAI)

This indicator looks at the burn area in the past few years, 2023 – 2025, using satellite imagery from Sentinel

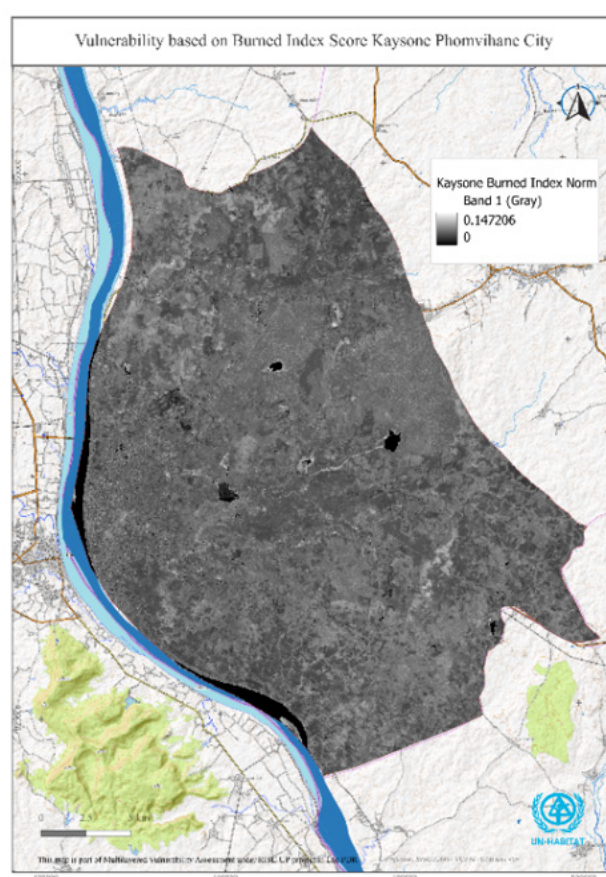


FIGURE 29 Burn Area Index (BAI) – Kaysone Phomvihane City

2 data. The idea behind this assumption is that the Burn Area Index (BAI) can indicate levels of biodiversity damage from forest fires because it highlights areas where vegetation has been burned, which directly affects habitat quality, species abundance, and ecosystem structure. BAI is derived from satellite imagery and is sensitive to changes in surface reflectance caused by burning, such as the loss of green vegetation and the presence of charred soil and ash. The Burn Area Index (BAI) is calculated from satellite imagery using the near-infrared (NIR) and red (R) reflectance bands. Its formula is:

$$BAI = \frac{1}{(0.1 - R)^2 + (0.06 - NIR)^2}$$

The analysis map (Figure 29) is shown in greyscale, where lighter (whiter) areas represent higher levels of burning and therefore greater vulnerability, while darker (black) areas indicate lower vulnerability. The map shows that most burned areas are located in agricultural land and forest areas, which is closely linked to agricultural activities during the dry season.

3.1.3 Mean Species Abundance (MSA) index

This indicator uses a global dataset sourced from the Global Biodiversity website. The study, released in 2020, is based on data collected in 2015. The MSA values range from 0 to 1, which aligns with the scale of other indicators used in the analysis. Within the biodiversity index, the Mean Species Abundance (MSA) indicator is assigned an equal weight of 1.

The MSA Index is a key measure of biodiversity, representing the average abundance of original species in a given area relative to their abundance in undisturbed ecosystems. A value of 1 (100 per cent) indicates a fully intact ecosystem with no human disturbance, whereas a value of 0 reflects the complete loss of the original species. For this analysis, the index was inverted so that higher values indicate greater vulnerability, corresponding to a lower presence of native species.

The analysis is shown in greyscale (see Figure 30), where lighter (whiter) areas indicate higher vulnerability under this indicator. The map shows that high-risk areas are mainly concentrated in urban zones, concrete infrastructure, and agricultural land, which are also associated with lower biodiversity richness.

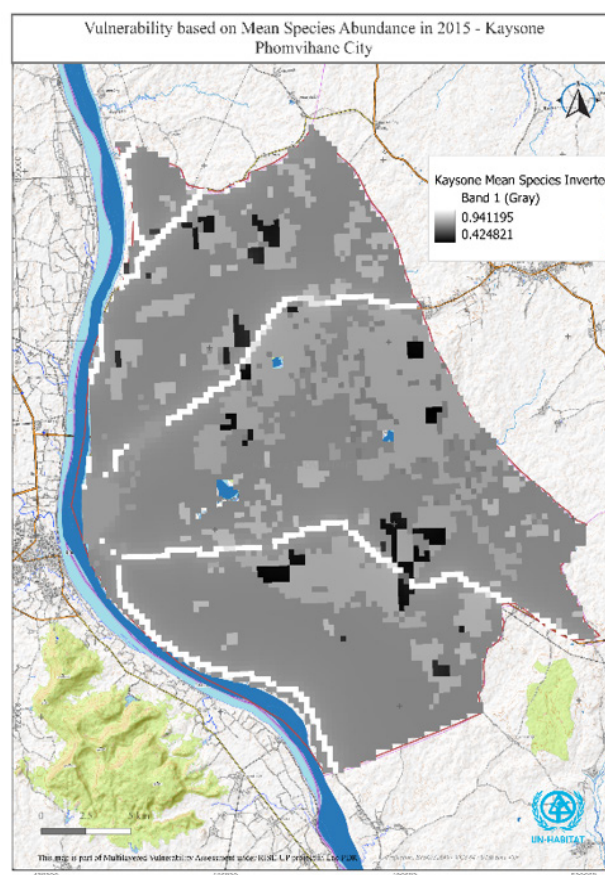


FIGURE 30 Mean Species Abundance (MSA) Index

3.2. Biodiversity dimension analysis

The lowest species abundance and highest vulnerability is found in urban, infrastructure, and agricultural areas where human activity has significantly reduced natural biodiversity

Highly vulnerable biodiversity hotspots have been identified in built-up areas within the urban core and in most peri-urban centers of the city, where these areas receive high vulnerability scores from NDVI and the Mean Species Abundance (MSA) index. These locations have little to no tree cover, making them unable to support healthy ecosystems or sustain biodiversity. Hotspots are also concentrated in agricultural zones, particularly open paddy fields, where the absence of trees and the conversion of forests to farmland have resulted in significant biodiversity loss. In some forested areas, high hotspot scores are linked to burn activities detected by the Burn Area Index (BAI). Such fires often occur during the dry season near agricultural areas, where farmers burn fields to improve soil fertility, but the fires frequently spread to nearby forests, causing damage to wildlife and ecosystems. These patterns align with observations from Phonsim Village, where residents reported visible forest and land clearing for residential and commercial expansion. Community members also noted fewer wildlife sightings and reduced tree cover, reinforcing NDVI and MSA findings.

Many villages have been identified as very highly vulnerable in the biodiversity dimension; in the urban core area such as: Nalao, Lattanalangsi-nua, Lattanalangsi-tai, Houamuang-nua, Latxavongxai, Xaignamoungkhoun, Thahae, Saphan-nua, Phonsavan, Dongdamdouan, Phonxay, Dongnakham, Phonsavang-nua, Phonsavang-tai, Phonsa-at, Oudomvilai, Phoxai, Xaignaphoum, Houameung-tai, Viengsavan, Chomkeo, Thamuang;

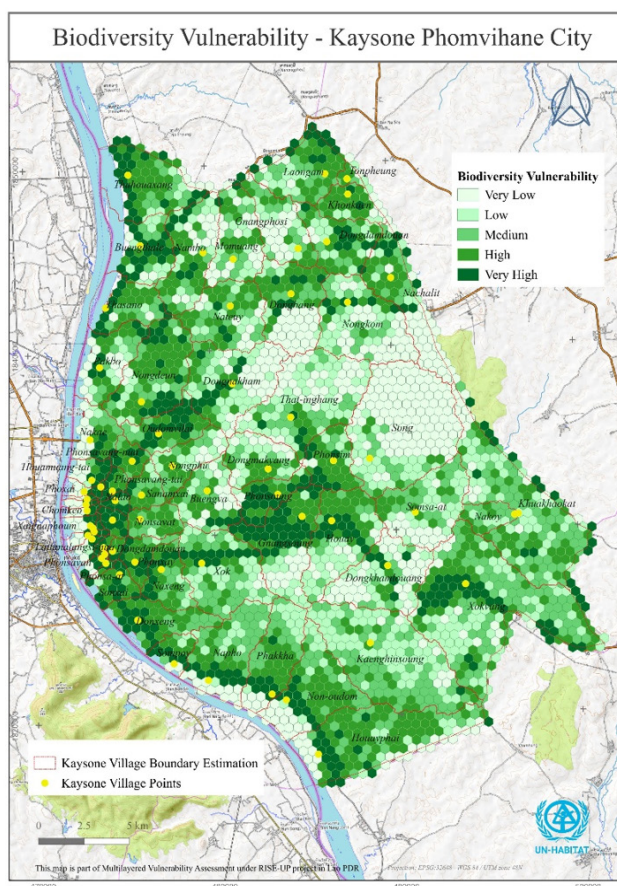


FIGURE 31 Biodiversity vulnerability hotspots and village locations

and outside of urban core areas: Thahouaxang, Buengthale, Non-oudom, Sonxai, Naxeng, Phonsim, Sompoy, Phonsoung, Gngangsoung, Napho, Nongdeun, Donxeng, Houay, Phakkha, Xokvang (See Figure 31).

3.3. Biodiversity future vulnerabilities

The future vulnerability under the biodiversity dimension is expected to become more widespread than the current hotspot pattern if no interventions are implemented to conserve existing forests and expand forest cover and ecosystem areas within urban environments. Further analysis of forest change using Landsat and Sentinel imagery shows that forest area declined from 325.1 km² in 2000 to 133.5 km² in 2025 - a 54 per cent reduction - within just 25 years of economic development (See Figure 32 below) or roughly 7.6 km² per year. If the current rate of forest reduction continues without intervention, Kaysone Phomvihane City may lose all its remaining forest within the next 18 years. Urgent action is needed to raise awareness and strengthen commitments to prevent land conversion, particularly from forests

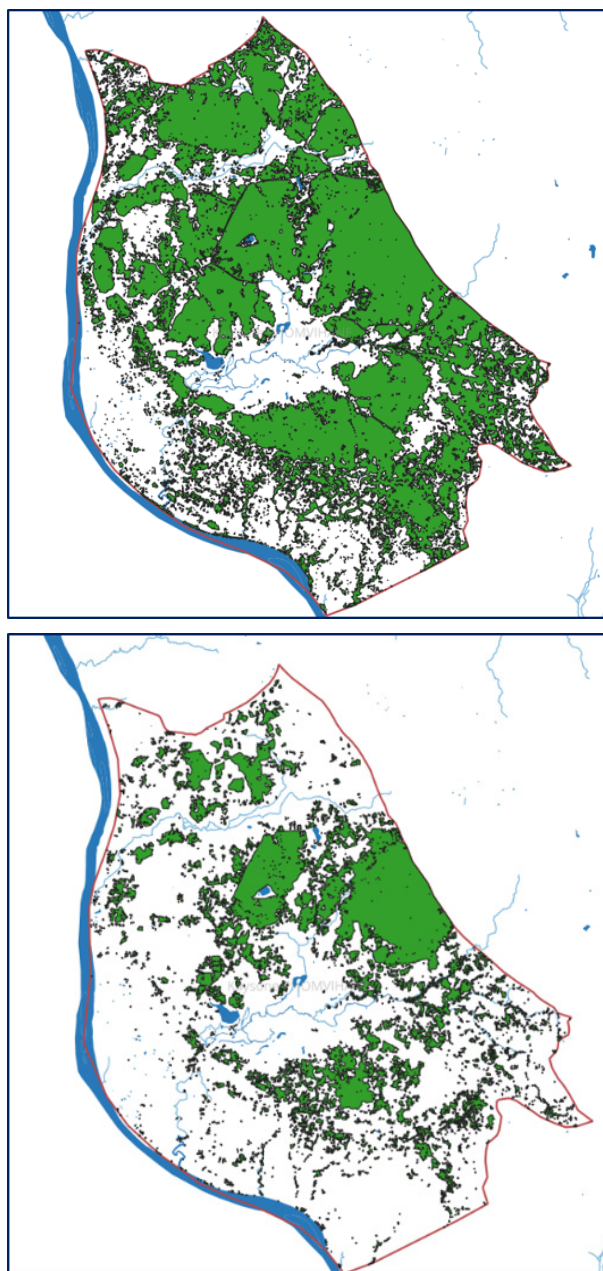


FIGURE 32 Forest change from 2000 to 2025 in Kaysone Phomvihane City

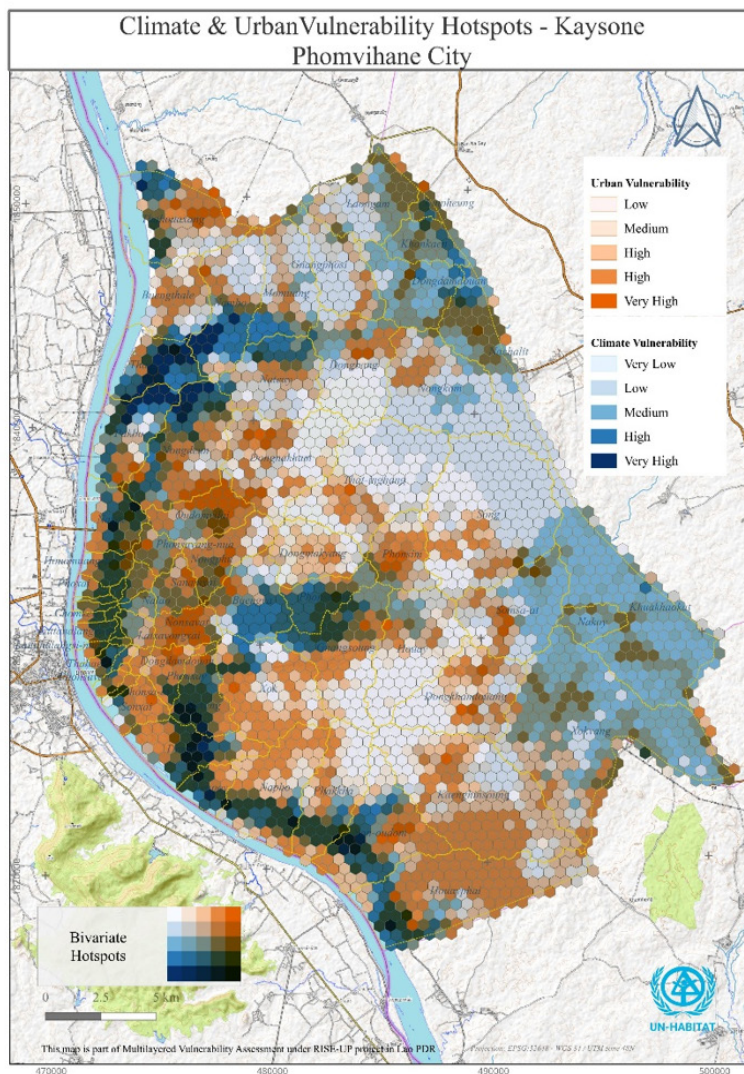
to agricultural and commercial areas. Community consultations in Phonsim Village revealed growing concerns about ongoing land clearing associated with residential expansion. Private companies are purchasing large parcels of land—some of which were previously forested—clearing the vegetation and subdividing the land into smaller plots for residential sale. Similar patterns were reported in neighbouring villages, and this process has been identified as a key driver of forest cover decline in Kaysone Phomvihane City. More detail can be found in Annex 1.2.

04

4. Overlapping vulnerabilities

4.1. Urban and climate change vulnerabilities

Based on the spatial analysis of vulnerability in Kaysone Phomvihane City, the villages have been identified as very high vulnerable under both the urban and climate change dimensions are Thahae, Nakae, Non-oudom, Houameung-tai, Donxeng and Naxeng due to their dual exposure to urban development pressures and environmental hazards.



Hotspots of compounded vulnerabilities in Kaysone Phomvihane City are identified in villages such as Thahae, Nakae, Non-oudom, Houameung-tai, Donxeng, and Naxeng, where overlapping urban pressures and climate-related risks significantly heighten overall vulnerability.

FIGURE 33 Bivariate hotspots urban & climate change

The overlapping layers of vulnerabilities between the urban and climate dimensions are shown in Figure 33, where darker orange represents higher urban vulnerability and darker blue represents higher climate vulnerability.

Rapid and unregulated urban expansion has led to poor infrastructure, limited access to basic services, and low green space coverage, particularly in peri-urban and newly developed areas where many of these villages are located. A key driver of residential expansion into these high-risk zones—often near natural streams and the Mekong River—is the affordability of land, which attracts low-income families, new settlers, and young households seeking cheaper housing options closer to urban job centres. These areas offer proximity to the city for work while avoiding the high land prices of the old urban core. However, their low-lying location makes them especially prone to flooding, and the absence of adequate drainage, paved roads, and public services exacerbates vulnerability. Surface sealing and sparse vegetation also contribute to elevated land surface temperatures and increased heat stress. High population density in these communities further intensifies the strain on already limited infrastructure, weakening their adaptive capacity. The convergence of socio-economic vulnerability, urban planning deficiencies, and climate-related risks highlights the urgent need for integrated interventions that combine resilient urban infrastructure, flood management, and inclusive land-use planning to reduce long-term exposure and build community resilience.

Community consultations confirm these findings. In Phonsoung Village, residents reported recurrent flooding during heavy rainfall, which is worsened by poor drainage and waste accumulation along natural waterways. In Houameung-tai Village, participants noted that unpaved roads become muddy and impassable during floods, restricting access to markets, schools, and health facilities. These examples illustrate how urban infrastructure deficits intensify climate-related risks and contribute to compounded vulnerability.

4.2. Climate change and biodiversity vulnerabilities

The several villages identified as highly vulnerable in both the climate change and biodiversity dimensions—such as Thasano, Nambo, Pakbo, Nongdeun, Nakae, Donxeng and others—are located in low-lying and rapidly urbanizing areas near natural streams and the Mekong River.

Part of these locations, especially their agricultural areas, are highly exposed to recurrent flooding due to their proximity to waterways and the absence of systematic drainage infrastructure, compounded by poor waste management and unregulated urban expansion. The overlapping layers of vulnerabilities between the biodiversity and climate dimensions are shown in Figure 34, where darker green represents higher biodiversity vulnerability and darker blue represents higher climate vulnerability.

The combination of intense rainfall events and unplanned settlement patterns—driven by the affordability of land and proximity to urban job centres has increased the climate risk for these communities. Simultaneously, these same areas are experiencing significant biodiversity loss, as urban sprawl and agricultural expansion (especially rubber and cassava farming) continue to convert forested land into built-up zones and monoculture plantations. Satellite-based indicators such as NDVI, BAI, and the MSA index show that these villages lack sufficient

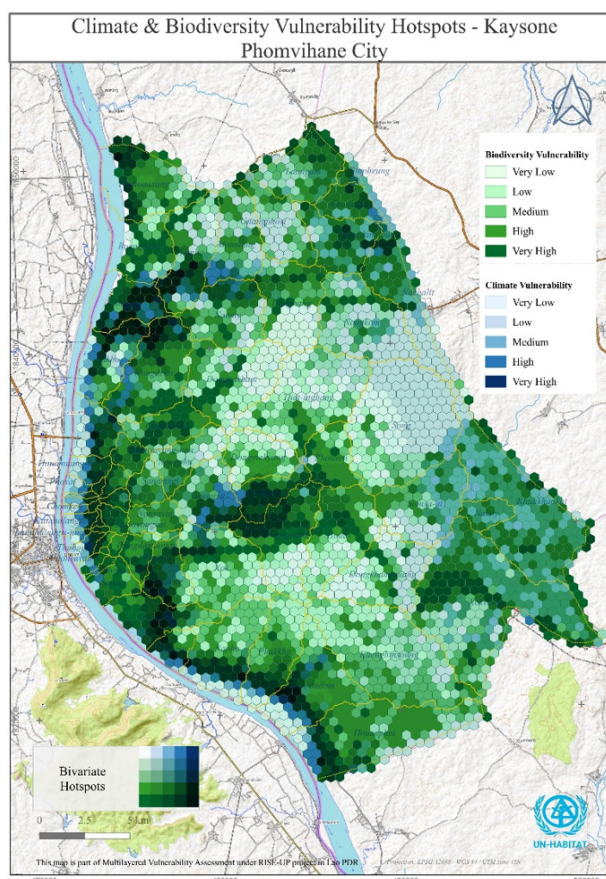


FIGURE 34 Bivariate hotspots climate change & biodiversity

vegetation cover, have experienced recent burn activities, and are situated in degraded ecosystems with diminished species abundance. The overlap of climate-induced hazards (flooding, heat stress, and drought) with ecological degradation (deforestation, fires, and habitat fragmentation) intensifies the vulnerability of both the human population and the local biodiversity. Without urgent intervention to regulate land use, restore vegetation, and improve climate resilience infrastructure, these villages face escalating risks to both ecological integrity and community well-being.

Community consultations in Phonsim Village highlighted visible land clearing for urban and commercial development, with residents reporting fewer trees and reduced wildlife presence. Participants also noted that the loss of vegetation has contributed to higher temperatures and reduced shade during the dry season, consistent with mapped land surface temperature and NDVI indicators. In Houameung-tai Village, residents reported erosion along natural streams following heavy rainfall, further demonstrating how biodiversity degradation reduces ecosystem resilience to climate impacts.

4.3 Biodiversity and urban vulnerabilities

In Kaysone Phomvihane City, Several villages, including Oudomvilai, Houamueng-tai, Phonsim, Nakae -are identified as very high vulnerability in both urban and biodiversity dimensions. The overlapping layers of vulnerabilities between the urban and biodiversity dimensions are shown in Figure 35, where darker orange represents higher urban vulnerability and darker green represents higher biodiversity vulnerability.

This dual vulnerability is the result of compounded pressures from rapid, unregulated urban expansion and extensive biodiversity degradation. On the urban side, these villages are located either in newly developed peri-urban zones or near expanding trade centers, where infrastructure has not kept pace with growth. As a result, residents face limited access to essential services such as paved roads, water supply, and waste management. Most of these communities are connected by dirt roads, making them less accessible and more exposed to service disruption, especially during the rainy season. Additionally, high population densities in these areas exacerbate strain on already weak services and amplify health risks through the urban heat island effect, due to the lack of green spaces.

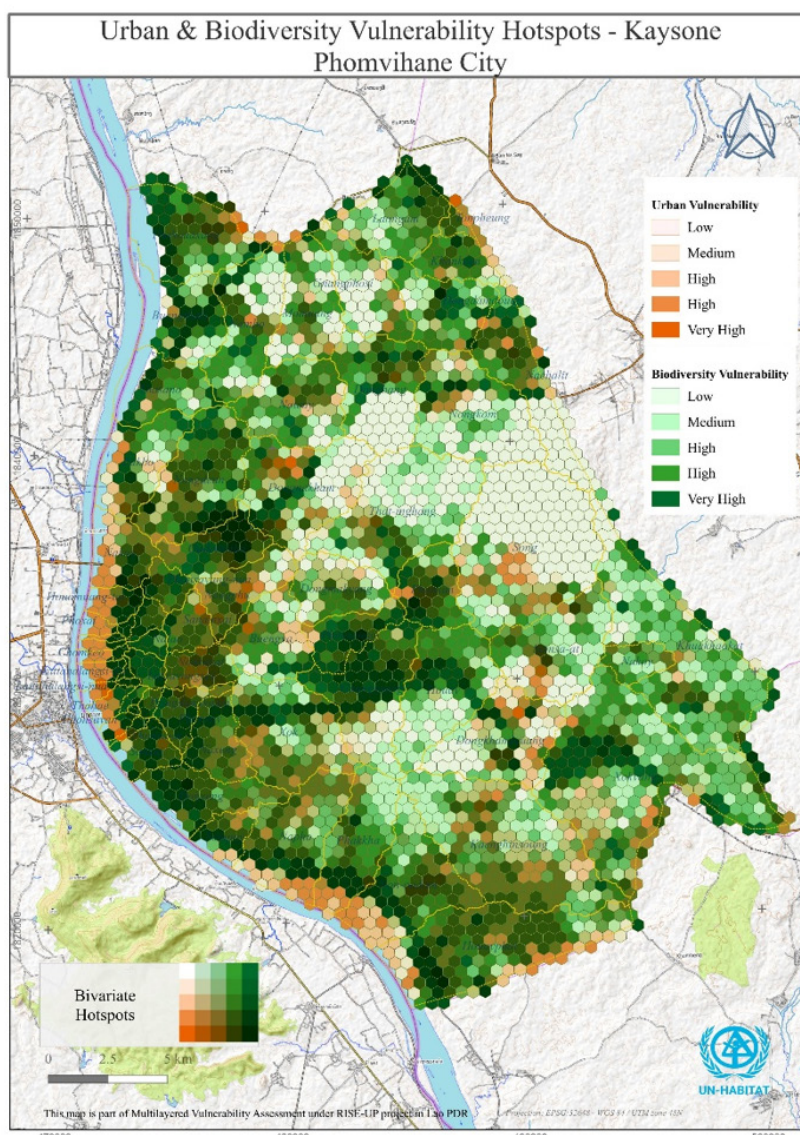


FIGURE 35 Bivariate hotspots urban & biodiversity

From a biodiversity perspective, these same areas also exhibit low vegetation cover, frequent fire disturbance, and declining species abundance, as evidenced by high vulnerability scores in NDVI, Burn Area Index (BAI), and Mean Species Abundance (MSA) indicators. Forests near these communities have been heavily converted into agricultural land, particularly for crops like rubber and cassava. The absence of tree cover in both urban and rural settings has degraded habitat quality and disrupted ecosystem services. This situation is further intensified by the increasing frequency of fires during the dry season, often linked to slash-and-burn practices, which damage surrounding forest ecosystems. The overlapping vulnerabilities in these villages highlight a critical need for integrated planning efforts that simultaneously address urban infrastructure deficiencies and biodiversity conservation. Strengthening enforcement of land-use policies, restoring forested buffers, enhancing access to green space, and investing in basic urban services are essential to build resilience in these high-risk communities.

Consultation findings support this analysis. In Phonsim Village, residents expressed concern about the reduction of nearby forested areas and the decline in wildlife, while in Phonsoung Village, community members linked limited green space and tree cover to increased heat and reduced environmental quality. These observations illustrate how biodiversity loss compounds urban vulnerability by diminishing the natural systems that support liveability and resilience.

Hotspots of combined urban and biodiversity vulnerability are found in Oudomvilai, Houamueng-Tai, Phonsim, and Nakae

“Our village always experiences flooding during the rainy season, especially affecting roads and agriculture. The most recent flood event this year occurred from 27 to 30 September 2025.”

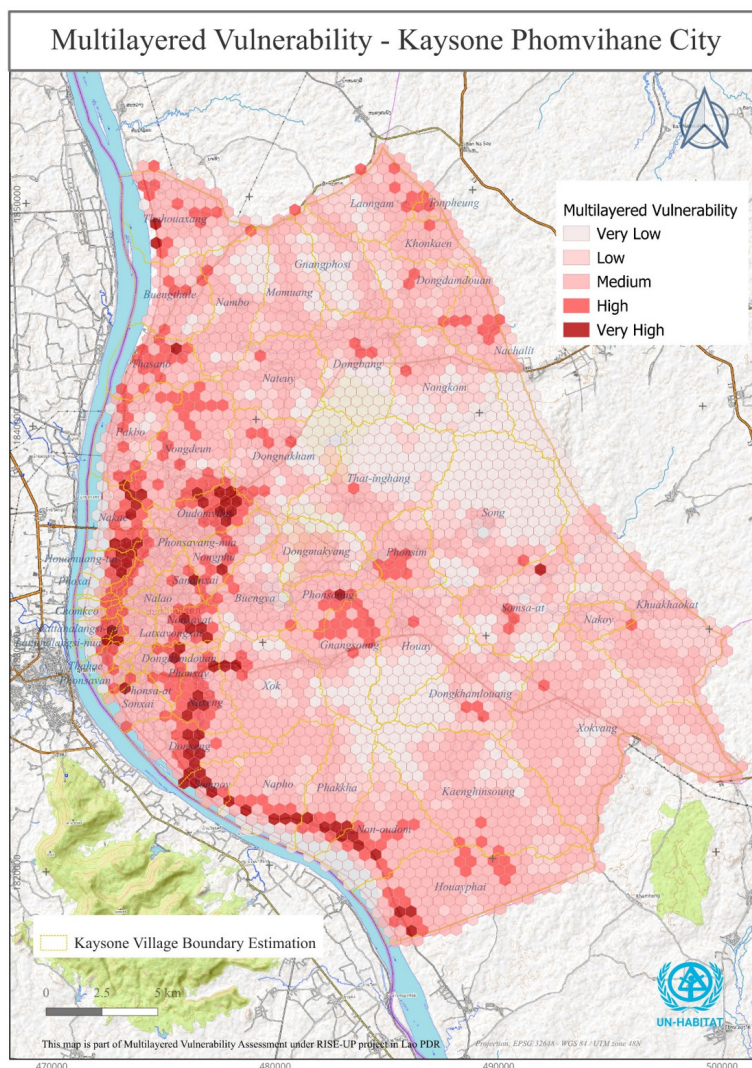
“Every time flooding occurs, we cannot access the roads, which makes it very difficult for us.”

— Mr. Phouvong Xaysana, Village Chief of Phonsoung Village, Kaysone Phomvihane City

05

5. Multilayered vulnerability hotspots

The spatial analysis identifies several areas in Kaysone Phomvihane City (Such as Thahouaxang, Sanamxai, Lattanalangsi-nua, Lattanalangsi-tai, Xok, Non-oudom, Houayphai, Xaignamoungkhoun, Thahae, Phonxay, Naxeng, Sompoy, Phonsoung, Napho, Nonsavath, Nongdeun, Phonsavang-nua, Nongphu, Phonsa-at, Donxeng, Phakkha, Oudomvilai, Xaignaphoum, Nakae, Houameung-tai) where high vulnerability scores across urban, climate change, and biodiversity dimensions overlap to form multilayered vulnerability hotspots. These hotspots are primarily located in peri-urban expansion areas and low-lying zones that are exposed to flooding and environmental degradation. Findings



Villages such as Thahouaxang, Sanamxai, Lattanalangsi, Xok, Non-Oudom, Houayphai, and Phonsoung represent priority hotspots where compounded urban, climate, and biodiversity risks are most severe

FIGURE 36 Multilayered vulnerability hotspots

from community consultations strongly reinforce these spatial patterns, providing concrete examples of how multiple vulnerabilities converge at the village and household levels.

The multilayered analysis, based on an average of combined all three dimensions, is shown in the Figure 36 using red scale, where darker red indicate higher multi vulnerability score.

In peri-urban hotspot areas, multilayered vulnerabilities are particularly evident. In Phonsoung Village, the combination of unpaved roads, inadequate drainage, unmanaged waste, and frequent flooding demonstrates how urban infrastructure gaps interact with climate hazards and environmental stress. Residents explained that stormwater often carries waste into natural waterways, clogging drainage paths and increasing flood severity, which simultaneously affects housing safety, mobility, and environmental quality.

In Phonsim Village, overlapping vulnerabilities are driven by rapid land conversion and limited green space within expanding settlement areas. Community members reported ongoing land clearing for residential and commercial development, reduced tree cover, and fewer wildlife sightings, which have contributed to increased heat exposure and declining environmental conditions. These observations align with the mapped biodiversity and land surface temperature indicators.

Similarly, Houameung-tai Village faces converging pressures linked to seasonal flooding, erosion along natural streams, and poor road access. Residents noted that heavy rainfall frequently leads to flooding of nearby areas and damages unpaved roads, limiting access to essential services and increasing vulnerability for households located near waterways. This demonstrates how climate exposure, urban infrastructure limitations, and ecosystem degradation reinforce one another.

Together, the spatial analysis and community consultation findings confirm that multilayered vulnerability hotspots in Kaysone Phomvihane City are not merely theoretical risk zones, but places where climate stressors, infrastructure gaps, environmental degradation, and social pressures are already shaping everyday life. As shown in the common issues identified through community consultations (Common Issues table below), hotspot villages experience overlapping challenges—such as poor drainage and road conditions, limited waste collection access, recurrent flooding and heat stress, forest and vegetation loss, and unequal impacts on low-income households, youth, the elderly, and people with limited mobility.

These findings highlight that future vulnerability will not be driven by a single factor, but by the interaction of urban growth patterns, weak basic services, climate hazards, ecosystem decline, and social inequality. They therefore underscore the need for integrated, cross-sectoral interventions that go beyond addressing isolated problems, and instead simultaneously strengthen urban services, climate resilience, ecosystem protection, and social inclusion—particularly in peri-urban hotspot communities where multiple risks converge.

Notably, multilayered vulnerability hotspots can disproportionately affect women, youth, elderly residents, low-income households, and people with disabilities. Women reported increased caregiving responsibilities during flood events and difficulties accessing services when roads become impassable. Youth highlighted disruptions to schooling and limited access to safe recreational spaces during periods of heavy rainfall. Elderly residents and people with disabilities face heightened risks in flood-prone areas due to limited mobility and challenges in evacuating or reaching health services. Low-income households are particularly vulnerable, as recurrent flooding, heat stress, and environmental degradation place additional financial pressure on families with limited capacity to repair homes or adapt to repeated shocks. These insights underscore the need for inclusive, gender-responsive, and socially targeted resilience interventions in hotspot areas.

Common issues identified in community consultations

Theme	Phonsoung Village	Phonsim Village	Houameung-tai Village
Urban Vulnerabilities	• High proportion of unpaved roads • Limited access for waste collection trucks • Poor drainage infrastructure	• Rapid settlement and commercial expansion • Limited green space within built-up areas • Increasing pressure on local services • Limited access for waste collection trucks	• Poor road conditions in peri-urban areas • Limited connectivity during rainy season • Restricted access to services during floods
Climate Change Vulnerabilities	• Recurrent flooding during heavy rainfall • Floodwater affecting houses and livelihoods	• Increased heat stress during dry season • Reduced shade in residential areas	• Seasonal flooding near natural streams • Erosion and water overflow during storms
Biodiversity / Environmental Issues	• Waste accumulation in waterways affecting environmental quality	• Forest and land clearing for residential and commercial development • Reduced tree cover and wildlife sightings	• Degradation of natural drainage channels • Declining vegetation cover along streams
Social & Livelihood Impacts	• Flooding disrupts daily activities and mobility • Low-income households more exposed to damage	• Heat and environmental degradation affecting living conditions • Youth report fewer safe outdoor spaces	• Flooding limits access to schools and health services • Elderly and people with limited mobility more affected

06

6. Conclusion

This MVA has provided a comprehensive understanding of how urbanisation, climate change, and biodiversity loss interact to shape vulnerability in Kaysone Phomvihane City. By combining spatial analysis across urban, climate, and biodiversity dimensions with community-based evidence (presented in the annex 1), the assessment offers a picture of current and emerging risks.

A key strength and a major success of this MVA is the effective integration of technical analysis with community consultation. Spatial mapping identified vulnerability hotspots using geospatial indicators, while consultations in selected villages confirmed that these mapped risks reflect real lived experiences. Issues such as frequent flooding, poor drainage, unpaved roads, limited waste collection, rising heat, and rapid land clearing were repeatedly raised by communities and directly matched the patterns shown in the vulnerability maps. This alignment between data and community voices strengthens the credibility of the assessment and ensures that it is not only technically sound but also socially grounded.

The findings show that rapid and largely unregulated urban expansion has created significant stress on infrastructure, services, and the natural environment. Peri-urban and newly developed areas are particularly vulnerable due to poor road access, limited drainage, weak waste management, and low access to green space. At the same time, low-lying areas near rivers and natural streams face high flood risk, while rising temperatures and declining vegetation are intensifying heat stress and environmental degradation. Biodiversity loss, driven by land clearing, burning, and forest conversion also further weakens natural protection against climate hazards.

Another major outcome of this MVA is the identification of multilayered vulnerability hotspots, where risks from all three dimensions overlap. These areas face compounding pressures: high exposure to climate hazards, weak urban services, and declining ecosystem health. The fact that communities in these areas also reported the greatest daily challenges demonstrates that the hotspot approach is both analytically valid and practically relevant.

This assessment does not aim to prescribe specific investments at this stage. Rather, it serves as a diagnostic and evidence-building exercise under the RISE UP programme. The next step is to work with the project steering committee and city officials to identify priority actions based on the specific context of the city. This will ensure that a proposal can be developed to attract investment from donors to help address the challenges identified and prioritised through the MVA process.

Annexes





Annex 1: Community consultation

To validate the spatial analysis and ensure that the MVA integrates lived experiences from affected communities, a three-day consultation was conducted in Kaysone Phomvihane City from 17-19 November 2025. Engagement was semi-structured and included interviews, focus groups, and on-site observations facilitated by the Kaysone Phomvihane Agriculture and Environment Office.

The selection of the villages for community consultation is based on both consultation with city officials and vulnerability analysis results. As time and budget constraint, we try to cover all key challenges in the city such as urban flood, green space reduction and waste management issues.

List of communities, we have consulted with:

Date	Agenda	Team
17 Nov 2025	Data collection in Ban Phonsoung (Case study focus on regula flood impact)	Kaysone City
18 Nov 2025	Data collection in Ban Phonsim (Case study focus on forest and biodiversity reduction)	Kaysone City
19 Nov 2025	Data collection in Ban Houameung-tai (Case study focus on urban flood, waste-management and access to green space issues)	Kaysone City

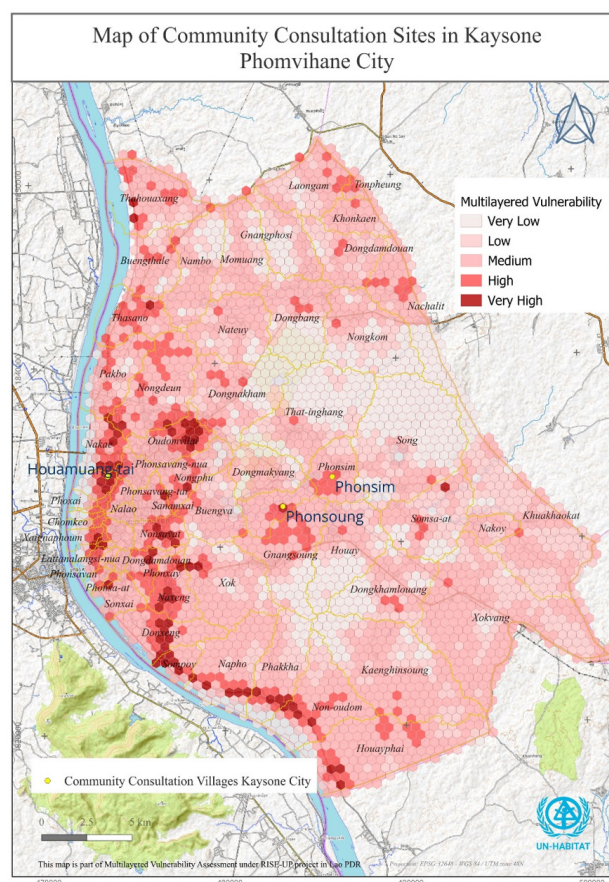


FIGURE 37 Community consultation sites in Kaysone Phomvihane City

1) Phonsoung village

Primary issues: Roads frequently damaged by flooding, Lack of waste collection; burning and burying common, No green space accessible, Agriculture disrupted by floods, declining fish and forest resources.

Climate change

Flood hazards occur once every year; floods damage roads and make transportation difficult.

Urban issues

Roads partially good but frequently damaged; no formal waste service; clean water access needs improvement.

Biodiversity

Fish decreasing; deforestation, burning, and agricultural expansion observed.

Local capacity

Community works well together; receives meteorology-based hazard information.

Support needed

- Road raising and reconstruction
- Water drainage expansion
- Irrigation and clean water support
- Flood response and emergency training
- Sustainable agriculture/livestock training
- Waste management solutions



Phonsoung flood in 2025

2) Phonsim village

Primary issues: Deforestation and loss of wildlife, Frequent climate hazards damaging crops and causing disease, and Lack of waste collection (burning/burying common)

Climate change

Hazards (floods, droughts, heatwaves, storms) occur every 2 years; water-borne diseases increase after flooding.

Urban issues

Burning waste common; roads partially good; no waste collection service.

Biodiversity

Protected forest and lake nearby; wildlife such as

squirrels, flying squirrels, and tree shrews declining; deforestation and burning frequent.

Local capacity

Community groups exist and help each other; warnings from meteorology office; strong awareness of forest issues.

Support needed

- Reforestation and forest protection
- Tree-planting campaigns
- Drainage canal improvements
- Green space development
- Sustainable farming, fishing, and land-use training
- Support for drought and flood preparedness



Interview Phonsim village authorities

3) Houameung-tai village

Primary issues: Poor drainage causing temporary flooding, Waste collection is limited; some households not covered, No community green space, Households lack proper waste bins. Water supply only partially reliable.

Climate change

Flooding from poor drainage; frequent storms, droughts, and heatwaves every two years.

Urban issues

No green space nearby; incomplete waste collection; need for household bins; moderate road condition.

Biodiversity

Mekong River and Khyllamung Stream nearby; some deforestation and pollution reported.

Local capacity

No local hazard group; occasional awareness campaigns; strong communal support.

Support needed

- Drainage and sewage system upgrades
- Road improvements
- Installation of waste bins in multiple points
- Regular, full-coverage waste collection
- Training on waste management
- River and stream conservation



Interview Houameung-tai Vice Village Chief

Annex 2: Steps and tools for analyzing urban area growth changes

Tools and data required:

- QGIS
- Google Earth Pro
- Adobe Photoshop

Steps:

1. Download high-resolution images (2004 and 2025):

- Use Google Earth Pro to download high-resolution images for the years 2004 and 2025.
- Mark at least four georeferenced points per scene to ensure accurate alignment.
- Save all downloaded scenes in the same folder.
- Open the scenes in QGIS and perform georeferencing using the previously marked control points.
- Merge all georeferenced scenes into a single mosaic image.

2. Image classification:

- To improve classification accuracy, focus only on built-up areas.
- Use Photoshop to manually highlight built-up areas in the 2004 and 2025 images using a distinct color (e.g., red, green, or blue).
- Export the painted maps with grid lines so they can be re-imported into QGIS for georeferencing.
- Open the painted images in QGIS and georeference them again.
- Use the Raster Calculator to extract the highlighted built-up areas by selecting pixel values (e.g., ≥ 245 in the red band if red was used for painting).
- Perform a subtraction operation (2025 built-up area minus 2004 built-up area) to determine urban growth between 2004 and 2025.

Annex 3: Methodology - green space accessibility

Data for processing:

- Sentinel 2 Satellite imagery (Red and Near Infrared Band) – Feb 2025
- Green Area Data – NDVI (Value ≥ 0.475) – processed from Sentinel 2

- The assessor creates 4 grids with different resolutions (500x500 sq m, 750x750 sq m, 1000x1000 sq m and 1500x1500 sqm) covering the administrative boundary of Kaysone and Pakse city.

Criteria for measurement:

Green Score is assigned to the following:



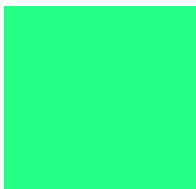
If the area in the 500x500 sq m grid (250,000 sq m) has a green area of more than 100 sq metres. This box is assigned 1. green score. The box without this condition is assigned 0 score



Outside of the green 500x500 cell, if the area in the 750x750 sq m grid has a green area of more than 100 sq m. This box is assigned 0.75 green score. The box without this condition is assigned 0 score



Outside the green 500x500 and 750x750 cells, if the area in the 1000x1000 sq m grid has a green area of more than 100 sq m. This box is assigned 0.5 green score. The box without this condition is assigned 0 score



Outside of the 3 green cells, if the area in the 1500x1500 sq m grid has a green area of more than 100 sq m. This box is assigned 0.25 green score. The box without this condition is assigned 0 score.

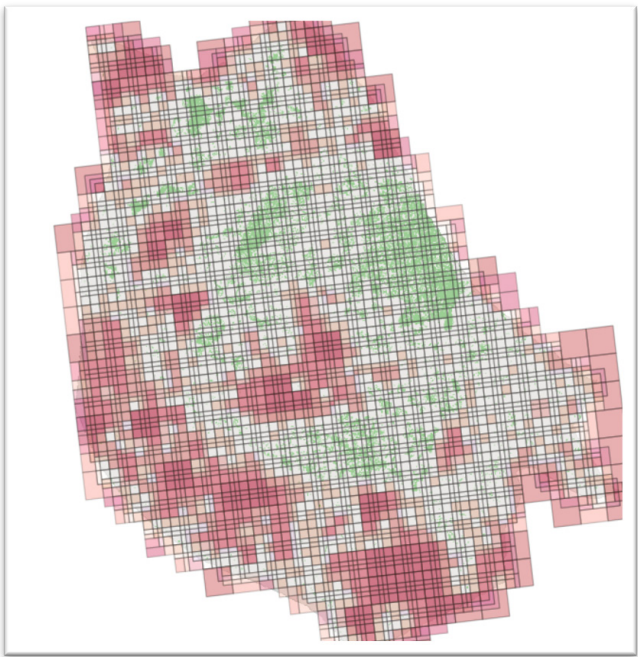


FIGURE 38 Sample of the Vector results

The final score will be inverted using $(1-x)$ to be the vulnerability score (normalised) of this indicator of green space accessibility. The result will be converted into raster file (30mx30m) resolution. Projection to be used

Step: how to do:

1. Make NDVI using the Raster calculator in QGIS using sentinel red and infrared band
2. Export Green Areas with the NDVI value ≥ 0.47
3. Create a grid box of four sizes (500x500 sq m, 750x750 sq m, 1000x1000 sq m and 1500x1500 sqm)
4. Use the function **Zonal Statistics** to extract data from the green area raster for each of the different sizes (use **-Sum** method)
5. Assigned a green score to each of the grids. (Remember the Sentinel 2 resolution is 10mx10m) If the sum field is ≥ 10 means that the green area is 100 sq m, then assign a green score to each grid polygon based on the criteria set earlier. Using the field calculator.

For example, for a grid 1500 m, you can use this condition.

```
CASE
WHEN "_sum" >= 10 THEN 0.25
ELSE 0
END
```

6. Use UNION in QGIS to combine all the grids;
- **UNION: Grid 1500 + 1000;** then fix the value of the union polygon the result of this value should be 0, 0.25 and 0.5;

You may use this:

```
CASE
WHEN "G_Score 1" + "G_Score 2" = 0 THEN 0
WHEN "G_Score 1" + "G_Score 2" = 0.25 THEN 0.25
ELSE 0.25
END
```

Make sure you fix NULL value to 0
You can call the result as **GRID_UNION_12**
(Grid 1500 + 1000)

- **UNION: GRID_UNION_12 + Green 750;** then fix the value of the union polygon, the result of this value should be 0, 0.25 and 0.5, 0.75

You may use this:

```
CASE
WHEN "G_Score 1_2" + "V_Score_3" = 0 THEN 0
WHEN "G_Score 1_2" + "G_Score 3" = 0.25 THEN 0.25
WHEN "G_Score 1_2" + "G_Score 3" = 0.5 THEN 0.5
ELSE 0.75
END
```

Make sure you fix NULL value to 0
You can call the result as **GRID_UNION_123**
(Grid 1500 + 1000 + 750)

- **UNION: GRID_UNION_123 + Grid 500;** then fix the value of the union polygon, the result of this value should be 0, 0.25 and 0.5, 0.75

You may use this:

```
CASE
WHEN "G_Score 1_2_3" + "V_Score_4" = 0 THEN 0
WHEN "G_Score 1_2_3" + "G_Score 4" = 0.25 THEN 0.25
WHEN "G_Score 1_2_3" + "G_Score 4" = 0.5 THEN 0.5
WHEN "G_Score 1_2_3" + "G_Score 4" = 0.75 THEN 0.75
ELSE 1
END
```

Make sure you fix NULL value to 0
You can call the result as **GRID_UNION_1234**
(Grid 1500 + 1000 + 750+500)

The GRID_UNION_1234 (G_Score 1_2_3_4 field)
will be inverted

Vulnerability = 1 - G_Score 1_2_3_4

Then convert to Raster
Projection to be used

Annex 4: Methodology for community vulnerability by road type

Data used:

- OpenStreetMap: Road lines
- Google Earth Imagery – Latest 2025
- The boundary of Pakse and Kaysone city
- Grid 500m (Hexagon)

Criteria:

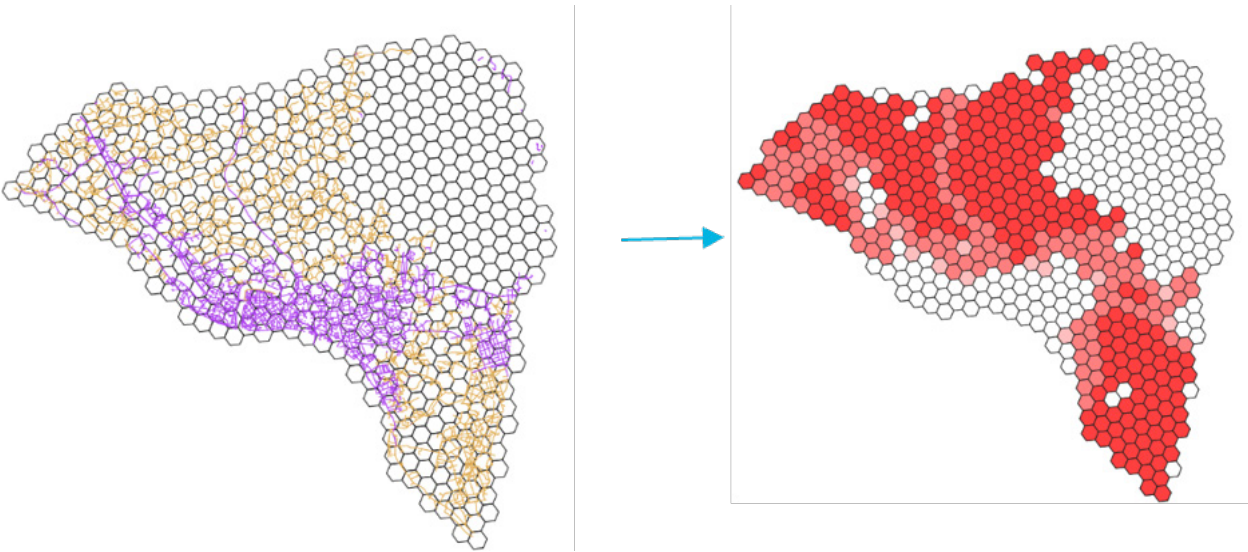
Communities with unpaved roads are generally more vulnerable than those with paved roads, as they tend to be poorer and have limited access to basic services such as solid waste collection.

1. Download road network data from OpenStreetMap
2. Digitize missing road segments using 2024 Google Earth imagery.
3. Classify each road segment as either dirt (dust) or paved.
4. Create a 500m hexagonal grid covering the study area.

5. Intersect the road layer with the grid to split road segments along grid boundaries.
6. Calculate the length of each road segment within each grid cell.
7. Filter for dirt roads and sum the lengths within each grid cell to obtain total dirt road length.
8. Filter for paved roads and sum the lengths within each grid cell to obtain total paved road length (store in a separate field in the same grid).
9. Calculate total road length (dirt + paved) per grid cell, and then compute the proportion of dirt road length:

Proportion of Dirt Road= $\frac{\text{Dirt Road Length}}{\text{Total Road Length}}$
 $\text{Proportion of Dirt Road} = \frac{\text{Dirt Road Length}}{\text{Total Road Length}}$
 (No need to multiply by 100, as the value will be normalized between 0 and 1 for vulnerability assessment.)

10. Convert the final grid data to a 30m x 30m raster format.



Annex 5: Raster processing and estimation of land surface temperature and urban heat island: ArcGIS methodology

Prepared by Sammy Muinde:

Part 1: Raster processing

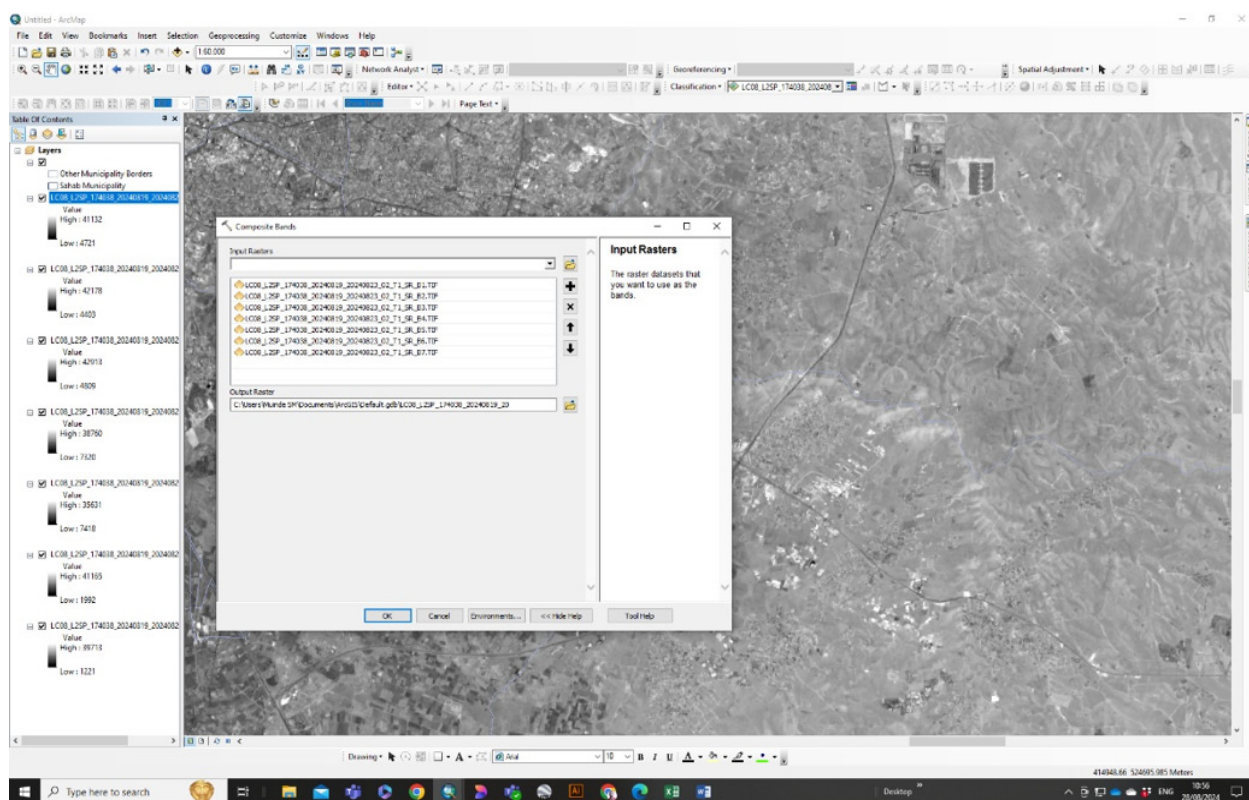
Downloading

- Download Landsat 8 from USGS Earth Explorer: <https://earthexplorer.usgs.gov/>
- Create account and Log in.
- Enter search criteria:
- Locate area of interest and Create polygon
- Set data range (timeline)
- Set cloud cover to 30 per cent
- Data sets: Select your datasets
- Select Landsat

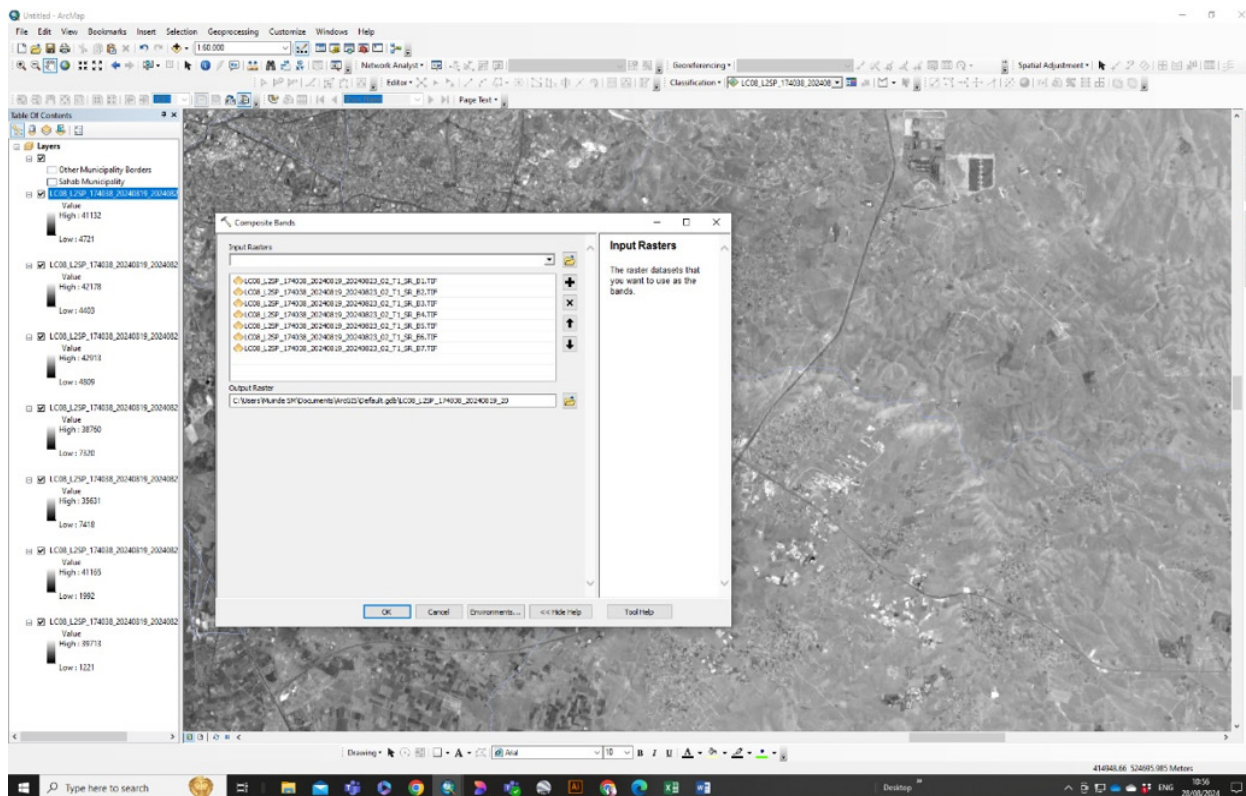
- Select Landsat collection 2 Level- 2
- Select Landsat 8-9 OLI/TIRS C2 L2
- Additional Criteria (Optional)
- Search Results
- Select image footprint to download
- Download one by one:
- **MTL.txt**
- **B1-B7.TIF (7files)**

Processing

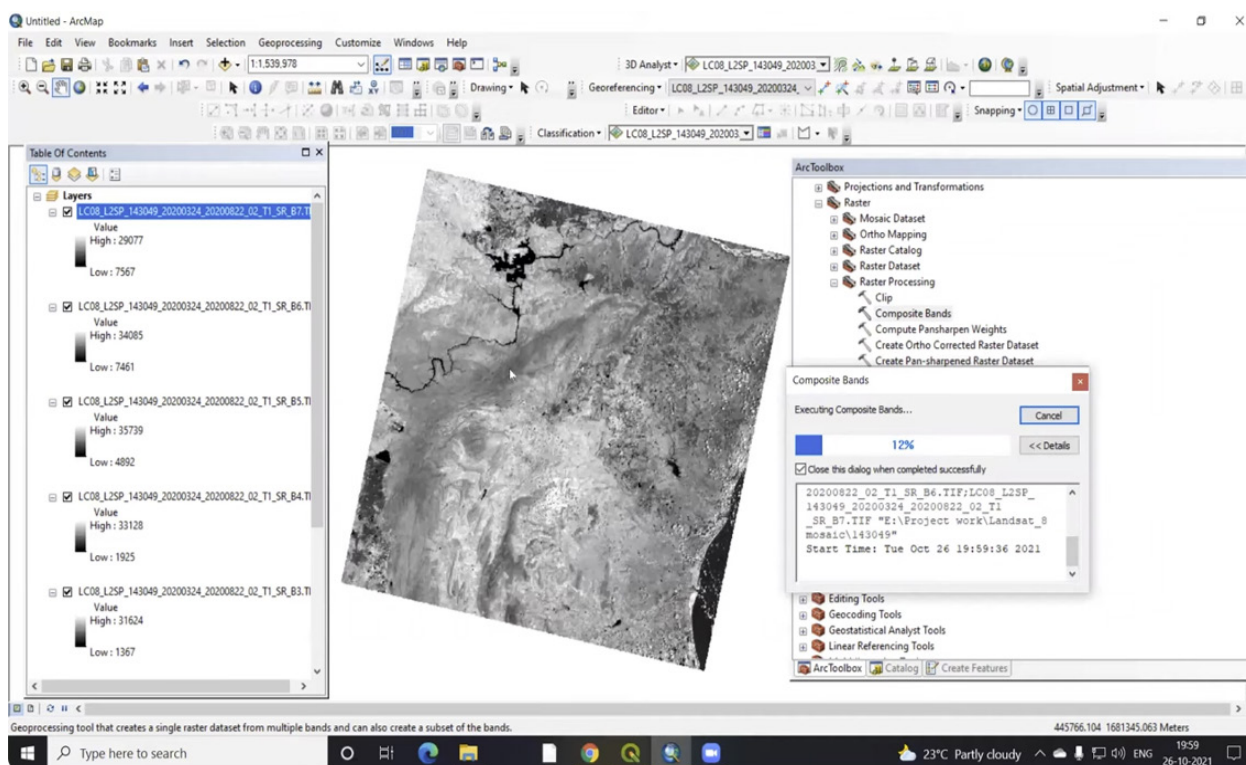
- Load the 7 different image bands on ArcGIS as layers
- Open ArcToolbox > Data Management tools> Raster> Raster Processing > **Composite Bands**



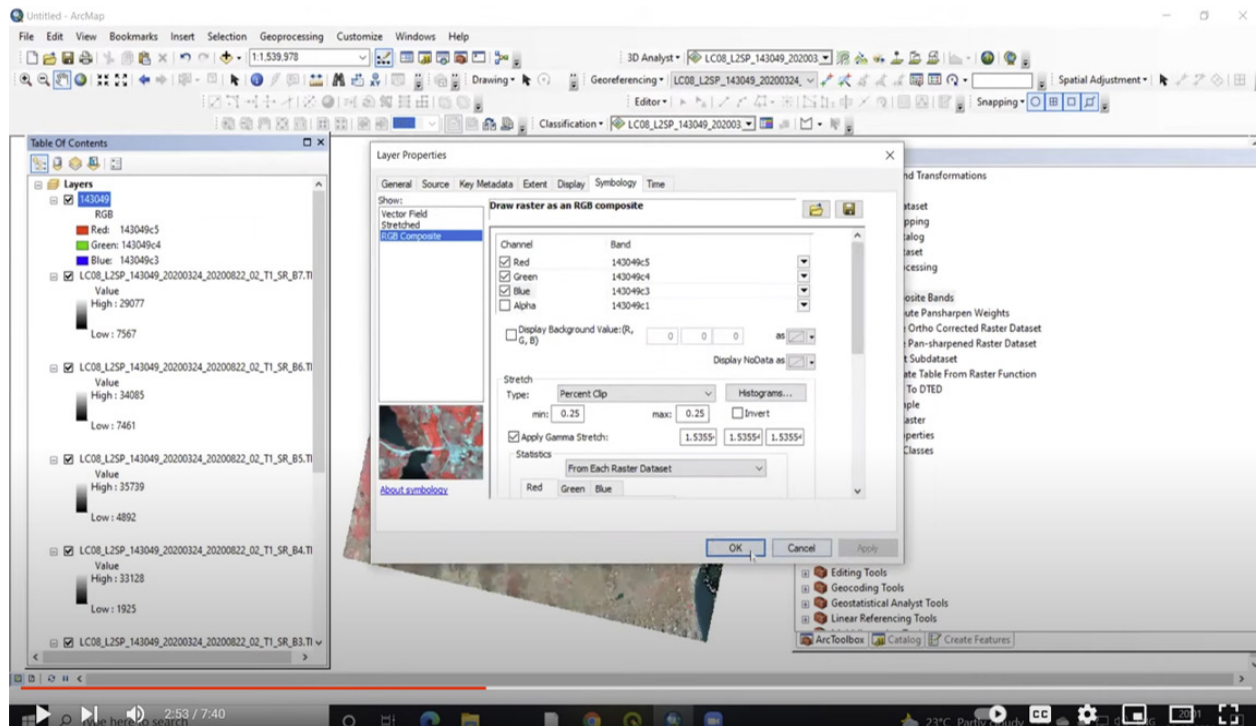
- Add the 7 bands in composite band tool (orderly)



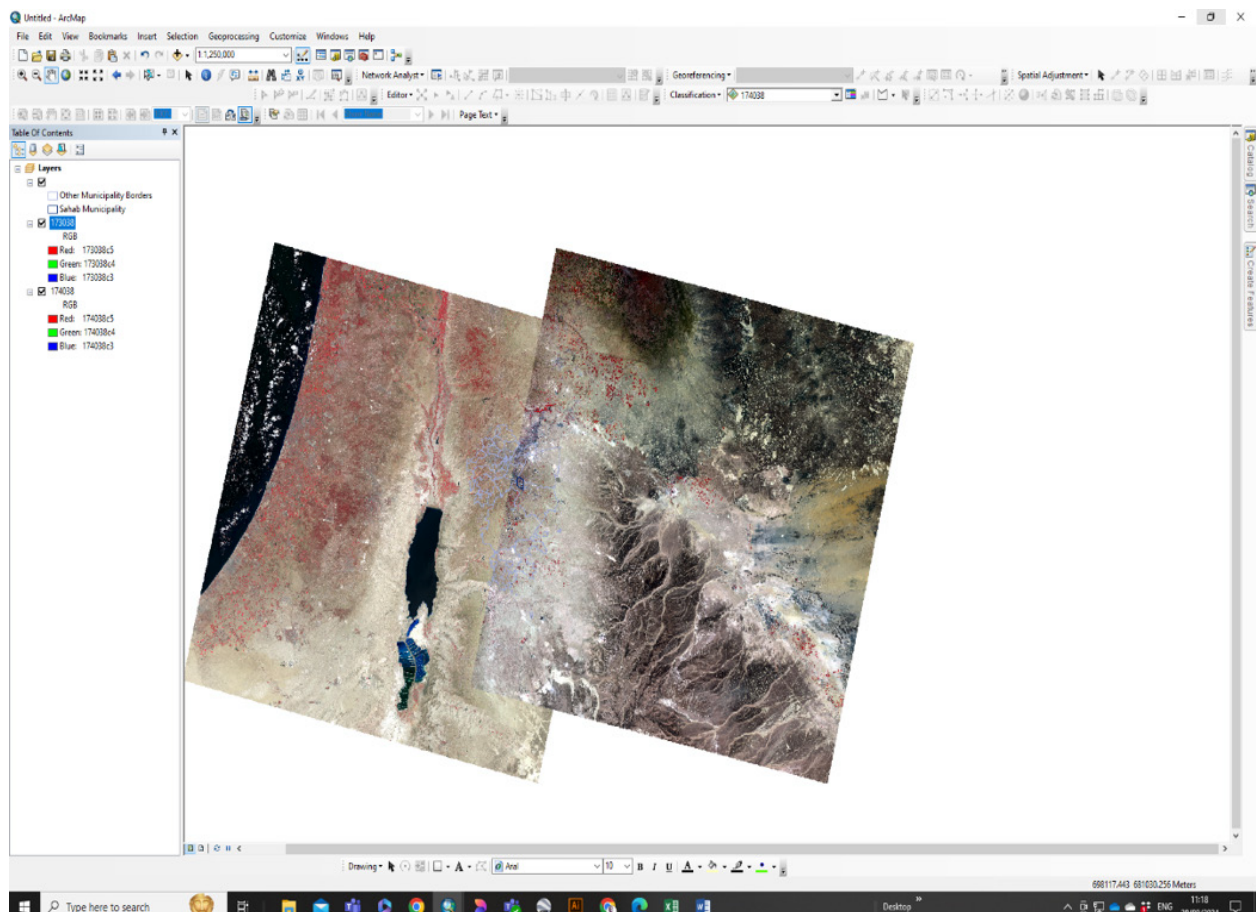
- Execute composite bands



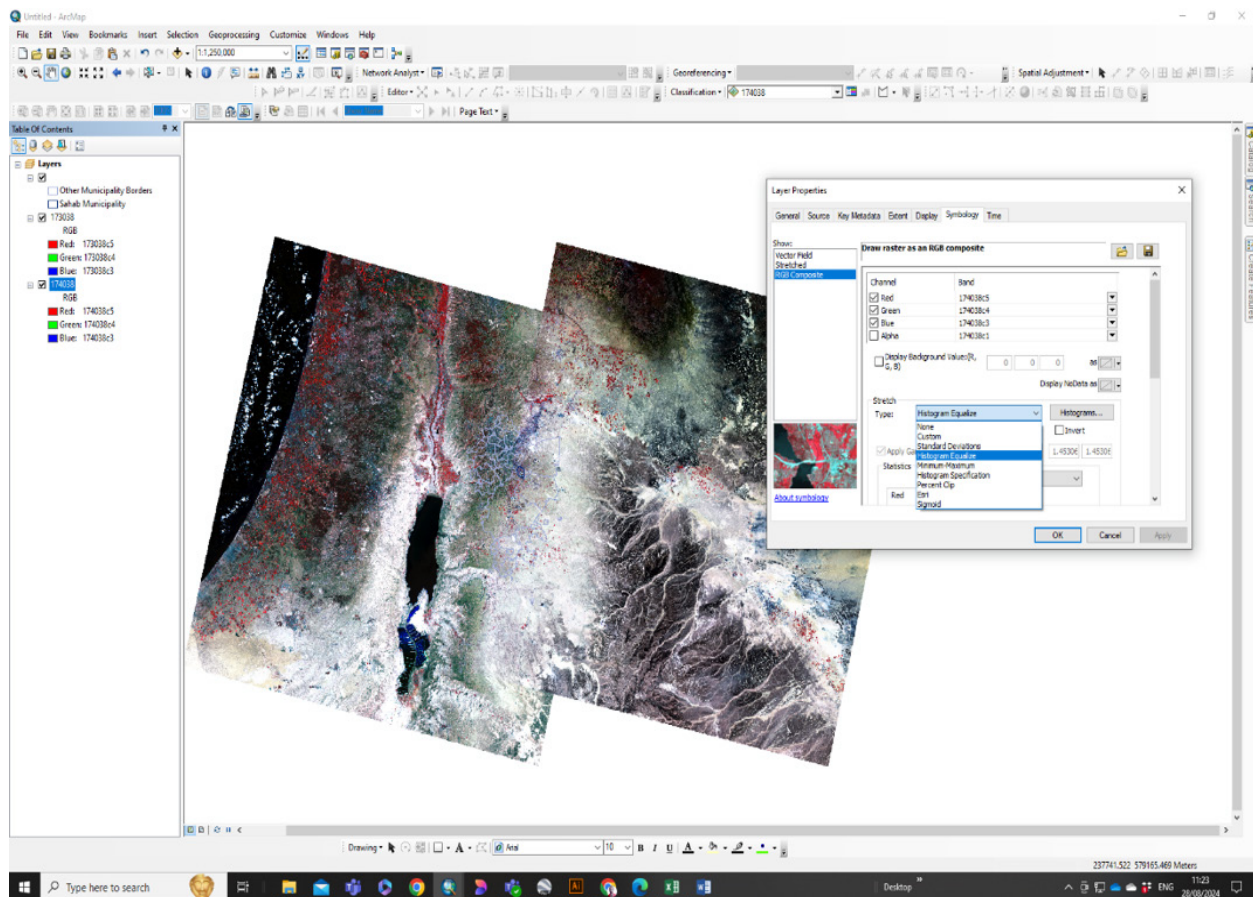
- Once the result is ready, go to zymology and select **band 5, 4 & 3** for **Red, Green and Blue**, respectively.



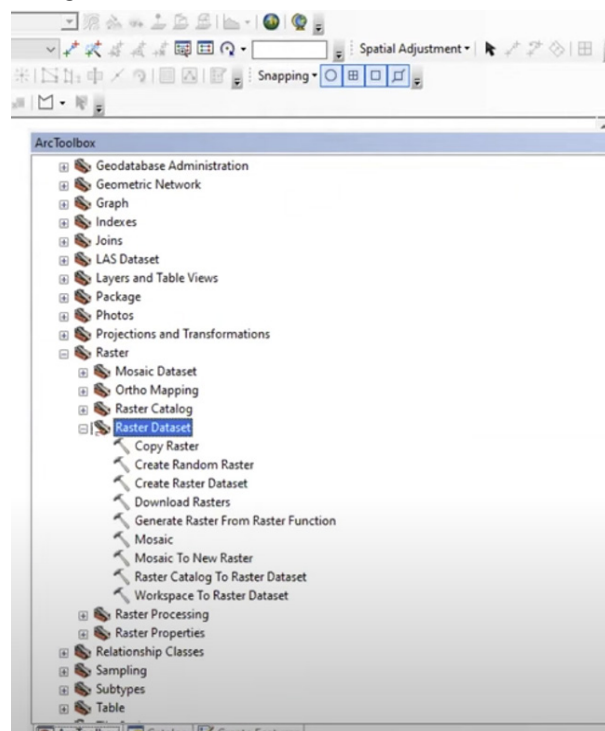
- Repeat same process if there is a second footprint that would require merging/create mosaic. Now we have (say) 2 images but of different contrast



- To achieve same contrast, go to properties of each image> Symbology> Histogram Equalize> OK



- Create the 2 images to a single image/Mosaic:
- Open ArcToolbox > Data Management tools> Raster>Raster Dataset> **Mosaic to New Raster**



Part 2: Estimation of urban heat island: ArcGIS methodology

Step 1: Conversion to Top of Atmosphere (TOA) radiance:

Using the radiance rescaling factor, Thermal Infra-Red Digital Numbers can be converted to TOA spectral radiance.

$$L\lambda = ML * Q_{cal} + AL - O_i$$

$$L\lambda = 0.0003342 * \text{Band10} + 0.10000 - 0.29$$

Where:

$L\lambda$ = TOA spectral radiance (Watts/ (m² * sr * μm))

ML = Radiance multiplicative Band number

AL = Radiance Add Band (No.)

Q_{cal} = Quantized and calibrated standard product pixel values (DN)

O_i = correction value for band 10 is **0.29**

Step 2: Conversion to Top of Atmosphere (TOA) Brightness Temperature (BT):

Spectral radiance data can be converted to top of atmosphere brightness temperature using the thermal constant Values in Meta data file.

$$\text{Kelvin (K) to Celsius (°C) Degrees } BT = K2 / \ln(k1 / L\lambda + 1) - 273.15$$

$$BT = (1321.0789 / \ln(774.8853 / ToA + 1)) - 273.15$$

Where:

BT = Top of atmosphere brightness temperature (°C)

$L\lambda$ = TOA spectral radiance (Watts/ (m² * sr * μm))

$K1$ = $K1$ Constant Band (No.)

$K2$ = $K2$ Constant Band (No.)

Step 3: Normalized Difference Vegetation Index (NDVI):

The Normalized Differential Vegetation Index (NDVI) is a standardized vegetation index which Calculated using Near Infra-red (Band 5) and Red (Band 4) bands.

$$NDVI = (NIR - RED) / (NIR + RED) \quad NDVI = (\text{Band 5} - \text{Band 4}) / (\text{Band 5} + \text{Band 4})$$

Where:

RED = DN values from the RED band

NIR = DN values from Near-Infrared band

Step 4: Land Surface Emissivity (LSE):

Land surface emissivity (LSE) is the average emissivity of an element of the surface of the Earth calculated from NDVI values.

$$PV = ((NDVI - NDVI_{min}) / (NDVI_{max} - NDVI_{min}))^2$$

Where:

PV = Proportion of Vegetation

$NDVI$ = DN values from NDVI Image

$NDVI_{min}$ = Minimum DN values from NDVI Image

$NDVI_{max}$ = Maximum DN values from NDVI Image

$$E = 0.004 * PV + 0.986$$

Where:

E = Land Surface Emissivity

PV = Proportion of Vegetation

0.986 corresponds to a correction value of the equation

Step 5: Land Surface Temperature (LST):

The Land Surface Temperature (LST) is the radiative temperature Which calculated using Top of atmosphere brightness temperature, Wavelength of emitted radiance, Land Surface Emissivity.

$$LST = BT / (1 + (\lambda * BT / c2) * \ln(E))$$

Here, c2= 14388 mm K

Where

BT = Top of atmosphere brightness temperature (°C) λ = Wavelength of emitted radiance E = Land Surface Emissivity $c2 = h * c / s = 1.4388 * 10^{-2} \text{ mK} = 14388 \text{ mK}$
 h = Planck's Constant = $6.626 * 10^{-34} \text{ J s}$ s = Boltzmann constant = $1.38 * 10^{-23} \text{ JK}$

c = velocity of light = $2.998 * 10^8 \text{ m/s}$

The values of λ for Landsat 8:

For Band 10 is 10.8

and

for Band 11 is 12.0

Estimation of urban heat island

Urban heat island (UHI) refers to the phenomenon where urban areas experience higher temperatures due to human activities and the built environment. Causes include land surface modification, reduced vegetation, heat from buildings and infrastructure, altered air circulation, and waste heat. UHI has adverse effects on human health, energy consumption, and air quality.

How We Can Calculate Urban Heat Island using GIS?

Where,

UHI= Urban Heat Islands

LST= Land Surface Temperature

LST_m= The mean temperature of the land surface temperature in the study area

SD= Standard deviation of temperature

$$UHI = \frac{LST - LST_m}{SD}$$

Reference:

Rahman, M. N., Rony, M. R. H., Jannat, F. A., Chandra Pal, S., Islam, M. S., Alam, E., & Islam, A. R. M. T. (2022). Impact of urbanization on urban heat island intensity in major districts of Bangladesh using remote sensing and geo-spatial tools. *Climate*, 10(1), 3.

Annex 6: Community consultation questionnaires (English)

Multi-layered vulnerability consultation questionnaires

Purpose:

To validate the MVA findings and gain a deeper understanding of the local context through qualitative insights, the collected information can be used to refine the project proposal and design. This process will help verify the MVA results and allow for revisions to the report where necessary. Additionally, the insights gathered can inform the development of project interventions that effectively address local issues.

During the community visits, there will also be opportunities to take photos and record interview videos with villagers to document local challenges and stories. These materials can later be compiled into promotional videos to showcase the project's impact and visibility.

Target respondents: Village leaders, community members (men/women/youth), local service providers.

Format: Semi-structured with both multiple-choice and open-ended questions.

Instructions for enumerators:

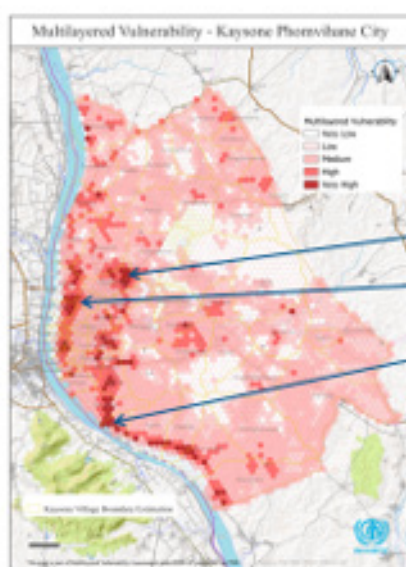
- Ask each question clearly and record responses exactly as given.
- Tick or circle the selected answer.
- If a question does not apply, mark N/A.

Kaysone City:

Target Villages: Udomvilay, Nakae, Huamuang Tai, Donxeng, and Sompoi

Video recording:

1. Introducing Interviewee (Name, Age, Roles in the Village?)



ສິ່ງຕ່ອນນີ້ໄປພຽງເຮົາຈະມີການສຶກສາເພີ່ມເຕີມໂດຍມີການສົ່ງໄປຫາບ້ານເພື່ອພາບເຂົ້າຄວາມບອກມາຫາຊຸມຊົນສູງ ໂດຍໃຫ້ຈະມີການກະກຽມອຸດົມການ ໄປຕາມ ອຸມຊົນ ເພື່ອໃຫ້ເຂົາເຈົ້າສຶກສາພາບ ເພື່ອນຳຂໍ້ມູນທີ່ໄດ້ໄປ ສຶກສາພາບ ຕົວເມືອງ ໂຄງການ ເພື່ອມາລະບົບປັນຫາ ໃຫ້ອຸມຊົນ.

ບ້ານເຫຼົ່ານີ້ມີຄວາມບອກບາງຫຼາຍຊັ້ນສູງ:
ບາງສ່ວນຂອງ ບ້ານ ດຸດົມວິໄລ, ນາແກ, ຫົວເມືອງໃຕ້, ດອນເຊັງ, ສົມປອຍ

2. Can you please tell us about Flood Situation in the village ?
3. Drought Situation?
4. Urban Heats and Rain Parttern?
5. How do people in the village deal with waste?
6. How's forest in the village change previously?

Photo sections:

Group photos

Section 1: General information

1. Village Name: _____ Phone Number: _____
2. District: _____
3. Province: _____
4. Respondent Name: _____ Phone Number: _____
5. Enumerator Name: _____
6. Enumerator Phone Number: _____

Section 2: Climate change theme

Q1. Has your village experienced any of the following hazards in the past 10 years?

(Tick Yes or No for each)

Hazard	Yes	No
Flood	☐	☐
Drought	☐	☐
Heat Waves	☐	☐
Storm	☐	☐

Q2. If YES, how often does each hazard occur? (Select one option per hazard – see definitions below)

Frequency definitions:

1 – Very Rare: Occurred only once in the past 10 years or more.

2 – Rare: Occurs approximately once every 5 to 8 years.

3 – Occasional: Occurs approximately once every 3 to 5 years.

4 – Frequent: Occurs about once every 2 years.

5 – Very Frequent: Occurs once or more every year.

Date	Agenda	Team
17 Nov 2025	Data Collection in Ban Phonsoung (Case study focus on Regula Flood Impact)	Kaysone City
18 Nov 2025	Data Collection in Ban Phonsim (Case study focus on Forest and Biodiversity Reduction)	Kaysone City
19 Nov 2025	Data Collection in Ban Houameung-tai (Case study focus on Urban Flood, Waste-Management and access to green space issues)	Kaysone City

Hazard	1	2	3	4	5
Flood	☐	☐	☐	☐	☐
Drought	☐	☐	☐	☐	☐
Heat Waves	☐	☐	☐	☐	☐

Q3. Which areas are most affected by flooding/drought? (Please describe)

.....

Q4. What are the main impacts on livelihoods, health, or housing?

.....

Q5. What coping strategies do households use during floods or droughts?

.....

Q6. What support is needed to reduce climate risks?

.....

Section 3: Urban theme

Q1. How has your village changed in the past 5–10 years?

☐ More buildings ☐ Less green space
☐ More people ☐ Better roads ☐ Other: ____

Q2. What are the main challenges related to urban services?

☐ Drainage/flooding ☐ Waste collection ☐ Water supply
☐ Roads ☐ Housing ☐ Other: ____

Q3. How do you rate road conditions in your village?

☐ Poor – No paved road ☐ Partially good
☐ Moderate ☐ All are paved roads

Q4. How far is the nearest green or shaded area (trees, park, open field)?

☐ Within 5 min walk ☐ 5–15 min ☐ Farther ☐ None nearby

Q5. Does the village get access to waste collection? If no, how do you deal with your waste?

.....

Q6. Does the village get access to other basic services?

Electricity: ☐ Yes ☐ No ☐ Partially

Water Supply: ☐ Yes ☐ No ☐ Partially

Q7. What would most help your community adapt to rapid urban change?

(e.g., better drainage, solid waste management, green space, road improvement, etc.)

.....

Section 4: Biodiversity and environment

Q1. Are there forests, rivers, or natural areas near your village?

☐ Yes ☐ No ☐ If yes, name or describe them:

Q2. Have these natural areas changed over time?

☐ More forest ☐ Less forest ☐ More burning
☐ More agriculture ☐ No change

Q3. Are wild plants, fish, or animals becoming less common?

☐ Yes ☐ No ☐ Not sure – If yes, which ones?

Q4. What environmental problems affect your village?

- ☐ Deforestation ☐ Soil erosion ☐ River pollution
☐ Burning ☐ Waste dumping

Q5. What actions or community initiatives exist to protect the environment?

.....

Q6. What support is needed to restore or protect local biodiversity?

.....

Section 5: Adaptive capacity and community strength

Q1. When your community faces flooding, drought, or other stress, how do people help each other?

- ☐ Work together ☐ Receive external help ☐ Individual coping only

Q2. Are there local groups or committees for disaster response or environment protection?

- ☐ Yes ☐ No If yes, please describe:

Q3. Do you receive information or warnings before hazards (e.g., flood)?

- ☐ Yes ☐ No ☐ Sometimes — Source:

Q4. What training or knowledge would help your community prepare better?

.....

Q5. In your opinion, what three main supports are needed to make your village safer and more resilient?

.....

A better quality of life for all in an urbanizing world



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