



Multilayered Vulnerability Profile for Pakse, Lao PDR

Climate, Urban, and Biodiversity Dimensions

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





UN-HABITAT

Multilayered Vulnerability Profile: [Pakse City, Lao PDR]

This publication was funded by the 2030 Agenda for Sustainable Development Sub-Fund under the United Nations Peace and Development Trust Fund (UNPDF)

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Front page photo: Pakse Flood in 2019 [Phanphet, 2019]

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Abbreviations

UN-Habitat	United Nations Human Settlements Programme
RISE UP	Resilient Settlements for the Urban Poor Programme
SIDA	Swedish International Development Cooperation Agency
USD	United States Dollar
MVA	Multilayered Vulnerability Assessment
GMS	Greater Mekong Subregion
SEZ	Special Economic Zone
SMEs	Small and Medium Enterprises
GDP	Gross Domestic Product
PDR	People's Democratic Republic (as in Lao PDR)
NDVI	Normalized Difference Vegetation Index
BAI	Burn Area Index
MSA	Mean Species Abundance Index
ASEAN	Association of Southeast Asian Nations
ASUS	ASEAN Sustainable Urbanisation Strategy
LEDs	Low Emission Development Strategies
GIS	Geographic Information System
GIRI	Global Infrastructure Risk Model and Resilience Index
GRID	Global Resource Information Database
COP28	28th Conference of the Parties to the UNFCCC
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
UHI	Urban Heat Island

LST	Land Surface Temperature
TOA	Top of Atmosphere
NIR	Near-Infrared (satellite band)
RED / R	Red Band (satellite band)
PV	Proportion of Vegetation
LSE	Land Surface Emissivity
BT	Brightness Temperature



Lao traditional house in Pakse city [UN-Habitat, 2025]

Traditional houses still exist in the urban core area of Pakse City, where weak foundations make them vulnerable to climate hazards.

Executive summary

This report presents a Multilayered Vulnerability Assessment (MVA) for Pakse City, Lao PDR, developed under UN-Habitat's Resilient Settlements for the Urban Poor Programme. The report aims to identify 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.

As the capital of Champasak Province and the third-largest city in Lao PDR, Pakse is a key regional hub for trade, tourism, and services. However, rapid and largely unregulated urbanisation 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 15.4 km² in 2006 to 32.8 km² in 2025, representing an average annual growth of 0.87 km² (approximately 5.6 per cent), leading to unplanned settlements and pressure on infrastructure.
- **Climate risks:** Pakse faces significant flood risk due to its location on a low-lying floodplain at the confluence of the Mekong and Xe Don rivers, combined with inadequate drainage systems and increasing surface runoff. Rising temperatures and drought further compound environmental stress.
- **Biodiversity decline:** Ongoing deforestation and land conversion for agriculture and urban development are reducing habitat quality and ecosystem services, despite the city's proximity to important conservation areas.

- **Infrastructure gaps:** Infrastructure development has not kept pace with urban growth, particularly in drainage, flood protection, roads, and waste management, leaving peri-urban communities underserved.

- **Multilayered vulnerability hotspots:** Several villages experience overlapping urban, climate, and biodiversity risks. Community consultations confirm frequent flooding, deteriorating roads, and unmanaged waste systems, particularly in peri-urban areas.

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, Pakse faces increasing disaster risks, declining ecosystem services, and widening inequalities in access to infrastructure and services.

Recommendations and way forward

The findings highlight the need for integrated and place-based actions to address multilayered vulnerabilities in Pakse City. Given the city's location at the confluence of the Mekong and Xe Don rivers, priority should be placed on strengthening flood risk management, including improved drainage systems, protection of natural floodplains, and more effective land-use control in flood-prone areas.

Urban development should be better guided to manage ongoing expansion, particularly in peri-urban areas where infrastructure and services remain limited. Improving connectivity, waste management, and basic services is essential to reduce vulnerability and enhance living conditions in these communities. At the same time, safeguarding surrounding forests and ecological areas is critical to maintaining ecosystem services and supporting long-term resilience.

The MVA provides a strong evidence base for the forthcoming Urban Resilience Action Plan. Moving forward, priority should be given to translating identified hotspots into targeted, climate-resilient and investment-ready projects, aligned with national priorities and regional frameworks, to support sustainable and inclusive urban development in Pakse.



Introduction





Aerial view of urban core and Phoumalong mountain in Pakse, Lao PDR [Noy Khantivong, 2022]

01

Background and context

The climate crisis and fast urban growth are increasing risks in cities, especially for poor communities, and harming nature that helps protect people. In Lao PDR, UN-Habitat's RISE UP programme is using the Multilayered Vulnerability Assessment to map risk hotspots in Pakse and Kaysone and guide practical, inclusive resilience actions.

1.1 Climate change, urbanization, and multilayered vulnerabilities in cities

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.

In the context of Lao PDR, the country is undergoing rapid urbanization, with many emerging towns driven by sharp economic growth and rural-urban migration 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, Lao PDR faces increasing threats from floods, droughts, cyclones, and extreme weather events. The lack of coordinated urban planning, disaster risk management, 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 Lao PDR is intensifying the adverse impacts, shocks and stresses

caused by climate change on both people, infrastructure, systems, and the environment.

UN-Habitat's Resilient Settlements for the Urban Poor (RISE UP) programme addresses these challenges through a multidimensional approach, targeting the marginalized, urban poor living in informal, low-income, hazard-prone areas. With over USD 150 million mobilized globally since 2019, RISE UP supports infrastructure development, green spaces, and ecosystem restoration across 28 countries. Projects include mangrove restoration in Cambodia and flood-resilient infrastructure in Southeast Africa, showcasing the interlinkage between climate resilience and biodiversity. Lao PDR became 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 (MVA) 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 in Lao PDR include fragmented governance, limited

and unreliable data, and lack of community engagement—particularly for the most vulnerable groups, including the urban poor, who face the highest risks yet have the least voice in decisionmaking.

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.



Strengthening climate plans

Provides technical expertise to support inclusive, evidence-based climate plans at urban, regional, and national levels.

Increasing investment for climate resilience

Innovates financing schemes and mobilizes resources for cities at high risk, fostering climate resilience with social and economic co-benefits.



Increasing capacities

Delivers training to enhance governments' and local stakeholders' capabilities, empowering them to implement successful, locally-driven climate projects.

Amplifying expertise

Ensures key stakeholders benefit from UN-Habitat's successful initiatives, contributing to the SURGe initiative to advance sustainable urban resilience.



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

02

Climate change, urbanization and biodiversity in Pakse city, Lao PDR

2.1 Location and geography

Pakse is strategically located in the southern region of Lao PDR, making it a critical transport and trade hub not just for Champasak Province, but for the entire southern Lao PDR region. The city sits on a plain at an elevation of approximately 102 metres above sea level, surrounded by mountains that contribute to its scenic beauty and environmental significance. Pakse's geography places it at a crossroads of critical regional trade routes, connecting Lao PDR with Cambodia, Thailand, and Vietnam. This makes the city pivotal for regional commerce, particularly for the export of coffee from the Bolaven Plateau, one of the country's key agricultural zones.

Geographically, Pakse is located near significant natural features, including the Mekong River, which provides critical water resources and serves as a natural boundary. The city's position between rivers and mountains has historically shaped its urban layout and infrastructure development, but it also exposes Pakse to environmental challenges, such as flooding during the rainy season and vulnerability to climate change impacts.

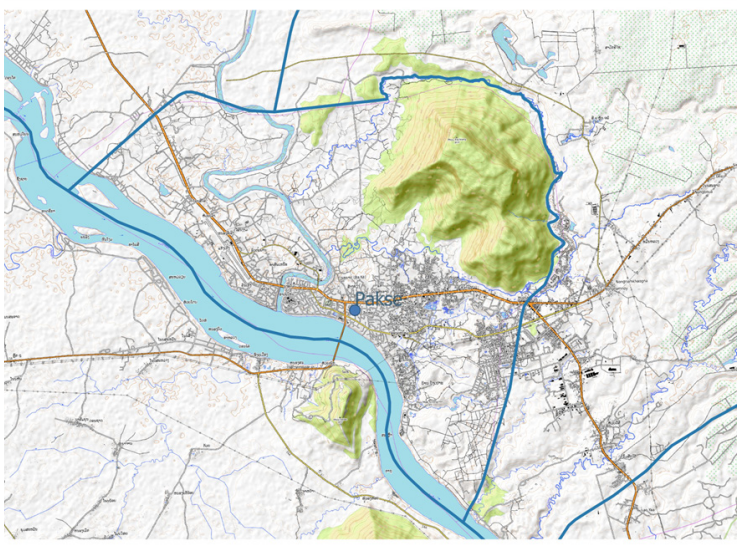
2.2 History of city development and growth

Pakse was founded in the early 20th century by the French as part of their colonial administration of Lao PDR. Over the decades, the city has transformed from a small colonial outpost into one of Lao PDR's most important urban centers. Pakse's development was greatly influenced by its strategic location at the confluence of the Mekong and Xe Don Rivers, which facilitated its growth as a trading centre.

Following Lao PDR's independence, Pakse experienced rapid population growth, driven by migration from rural areas as people sought better economic opportunities. This shift brought about significant changes in the city's physical and social infrastructure, necessitating the expansion of housing, transport, and basic services. In recent decades, Pakse has become increasingly integrated into regional economic networks, further spurring its development as a commercial hub. However, this growth has not been without challenges, such as the need for improved infrastructure and the management of rapidly growing informal settlements.



Arial view of Xedon and Mekong rivers in the urban core of Pakse, Lao PDR [Noy Khantivong, 2022]



Map of Pakse city boundary, Lao PDR [UN-Habitat/Lao PDR, 2025]

The most recent study¹ indicates a population growth of 32.30 per cent from 78,669 people in 2005 to 116,200 in 2020. Economic development is also evident, with GDP per capita rising by 56.86 per cent, from \$1,097 in 2005 to \$2,543 in 2020. Additionally, the city's construction area expanded by 47.03 per cent, growing from 285 hectares in 2005 to 538 hectares in 2020. In Pakse city municipality, construction area growth reached 46.35 per cent, increasing from 279 hectares to 520 hectares in 2020. Most of the built-up area is concentrated in the city center, covering 96.65 per cent of the total, and the number of buildings rose by 45.18 per cent, from 17,262 in 2005 to 30,870 in 2020.

¹ <http://www.su-journal.com/index.php/su/article/view/771/535>

2.3 Demographics

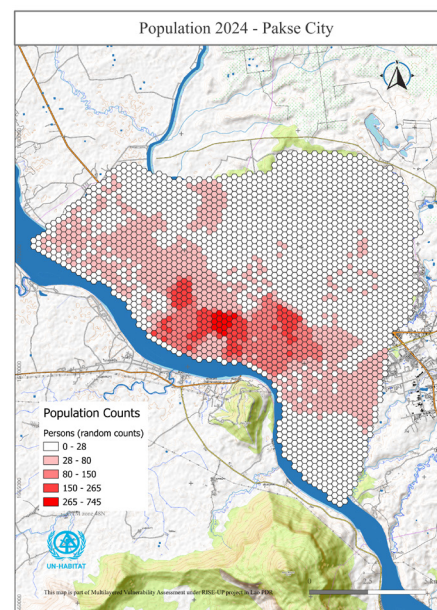
Pakse is home to an estimated population of 89,797 as of 2024², making it the third-largest city in Lao PDR. The city has seen a steady increase in population over the years, driven by both natural growth and migration from surrounding rural areas. Approximately 87.5 per cent of the population lives in urban areas³, reflecting the city's role as a primary urban centre in southern Lao PDR.

The active labour force in Pakse accounts for about 60 per cent of the total population, with a significant portion employed in the services sector⁴. The government employs 27 per cent of the workforce, while 13 per cent are involved in agriculture. Another 60 per cent comprises traders, service providers, and daily wage labourers. Despite its economic growth, Pakse still grapples with poverty, with 14.9 per cent of its population living below the poverty line, highlighting the need for inclusive development initiatives⁵.

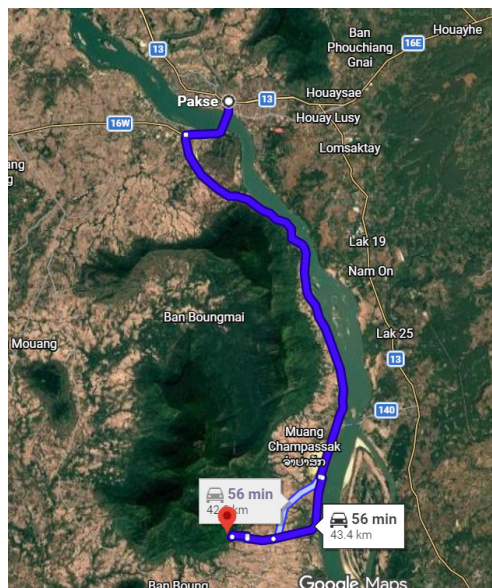
² https://www.citypopulation.de/en/Lao/PDR/admin/champasack/1601__pakse/
³ Population and Housing Census 2015

⁴ Pakse Urban Environmental Improvement Project <https://www.adb.org/sites/default/files/linked-documents/43316-012-lao-oth-09.pdf>

⁵ Pakse Urban Environmental Improvement Project <https://www.adb.org/sites/default/files/linked-documents/43316-012-lao-oth-09.pdf>



Population distribution in Pakse city in 2024 [UN-Habitat/ Lao PDR, 2025]



UNESCO world heritage site (VatPhou) travel time from Pakse

2.4 Key economic sectors

Pakse's economy is diverse but heavily reliant on the services sector, which contributed 73.39 per cent of the city's GDP in 2019. This includes tourism, retail trade, and public services, all of which benefit from Pakse's strategic location as a transport hub for southern Lao PDR. The city's proximity to tourist attractions, such as the UNESCO World Heritage Site of Vat Phou and the Bolaven Plateau, has further enhanced its position as a tourism centre.

Industry and handicrafts make up 22.6 per cent of the city's economy, with manufacturing and artisanal products playing important roles in job creation. The agricultural sector, although smaller, contributes 4.35 per cent to the GDP⁶, with coffee production being a notable economic activity in the surrounding region. Pakse also serves as a gateway for the export of agricultural goods, especially coffee, which is grown on the fertile Bolaven Plateau.

⁶ Pakse and Kaysone Phomvihane City GHG Inventory 2019

2.3 Environment, biodiversity and climate

2.5.1 Pakse's climate

Pakse has a tropical climate with distinct wet and dry seasons. Temperatures range from 17°C to 39°C, with an annual mean rainfall of 2,127 mm⁷. However, climate change is already impacting the city, with projections suggesting a 1.37°C increase in average monthly temperatures by 2050⁸. Pakse is particularly vulnerable to flooding, which poses a significant risk to its infrastructure and population, especially during the rainy season, when 85 per cent of the annual rainfall occurs. Pakse is highly vulnerable to flooding due to a combination of geographical, climatic, and socio-economic factors. The city lies on a low-lying floodplain at the confluence of the Mekong and Xe Don rivers, where seasonal monsoon rains and upstream water releases often overwhelm limited

drainage systems and cause inundation.

Rapid urban expansion has replaced wetlands and natural floodplains with built-up areas with dense infrastructure and impermeable surfaces, reducing water absorption and increasing surface runoff, while informal settlements and densely populated riverside communities are especially exposed.

These physical risks are compounded by socio-economic vulnerabilities, as many households have limited financial capacity, infrastructure, and resources to cope with or recover from flood events. Together, the heightened exposure and sensitivities and limited adaptive capacities of the cities' people, infrastructure and systems, make Pakse particularly susceptible to recurring and severe flood impacts.

7 <https://Lao PDRis.lsb.gov.la>

8 https://laopdr.un.org/sites/default/files/2019-08/2014%20Cities%20and%20Climate%20Change_Pakse.pdf



Photo of Pakse flood hazard in 2019 [Champa Post, 2019]

Following the flood in Pakse in 2019, the city implemented several projects to build climate resilience, including Construction of Mekong levee in 2020 to help safeguard vulnerable communities.



Photo of PhouBaChieng (Bachieng mountain), a national protection area in Pakse [Tonamcha, 2017]

2.5.2 Pakse environment and biodiversity

In terms of biodiversity, Pakse is a city surrounded by significant nationally-designed natural conservation areas and forests⁹. PhouBaChieng, a national protection area, is the largest forest conservation zone in the city, spanning 3,053 hectares. Located only 10 kilometres southeast of Pakse is the Dong Houasao National Biodiversity Conservation Area (NBCA), a vast expanse of 94,000 hectares of dense forest. Additionally, 20 kilometres to the north lies the Phouxiengthong NBCA, covering 106,000 hectares of forest land. Pakse is also 10 kilometres northeast of the Salivangveun Production Forest Area (PFA), which stretches over 37,600 hectares. These forests and protected areas provide essential ecosystem services such as water regulation, soil erosion control, carbon sequestration, and habitat provision for wildlife. They also help reduce flood risks by stabilising catchments and filtering runoff that flows into the Mekong River. Moreover, the city serves as a gateway to the Bolaven Plateau, renowned for its rich, high-quality soil, ideal for cultivating coffee and other crops. The city's proximity to these areas highlights the importance of balancing urban development with environmental preservation. However, deforestation and agricultural expansion are ongoing challenges, with forest areas being converted to agricultural land.

⁹ https://apps.k4d.la/analyst/?config=config_lo.json&locale=lo

2.6 Urbanization trends

Pakse has experienced rapid urbanisation in recent decades, leading to significant changes in land use and housing patterns. A substantial portion of the population lives in informal settlements or substandard housing, many of which are old, self-built structures constructed using low-cost materials such as timber, bamboo, brick, and corrugated metal sheets. These houses often lack proper foundations, ring beams, and bracing, making them vulnerable to structural failure during storms and floods, reflecting the challenges of providing adequate infrastructure for the growing population. Urban sprawl has also encroached upon flood-prone areas, exacerbating the city's vulnerability to climate-related risks such as heavy rainfall and flooding. According to the Study on Urban Growth of Pakse City¹⁰, there were 17,853 buildings in 2005; in 2020, the number of buildings grew to 32,569, which is equivalent to 44.08 per cent in 15 years.

¹⁰(PDF) Study on Urban Growth of Pakse City (researchgate.net)

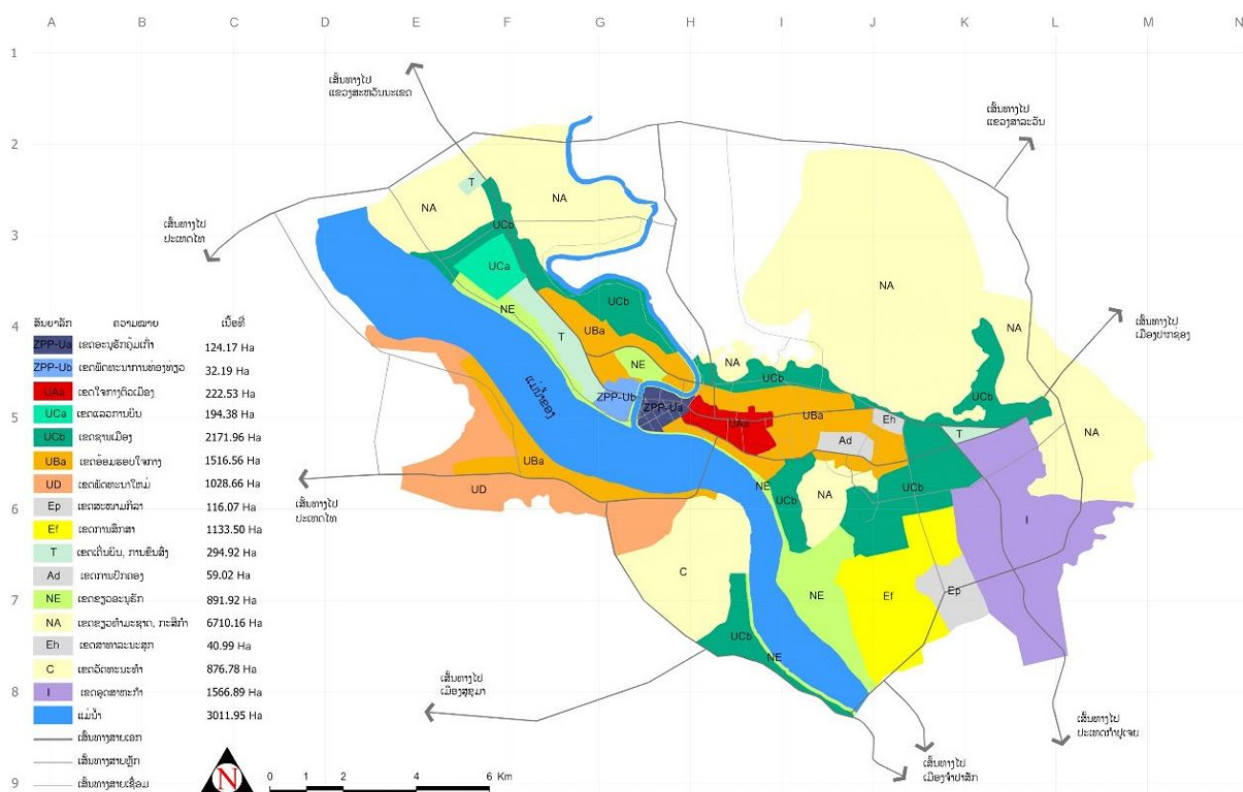
In response to these challenges, more coordinated urban planning efforts have been initiated, but the city still struggles with maintaining provision and maintenance of essential infrastructure, particularly in drainage and flood protection systems. The expansion of roads and housing into flood risk areas has reduced the city's ability to manage increasing runoff during the rainy season.



Urbanization Trend in Pakse city.

The study shows that Pakse is expanding to the north and west toward Phoubachiang mountain¹¹

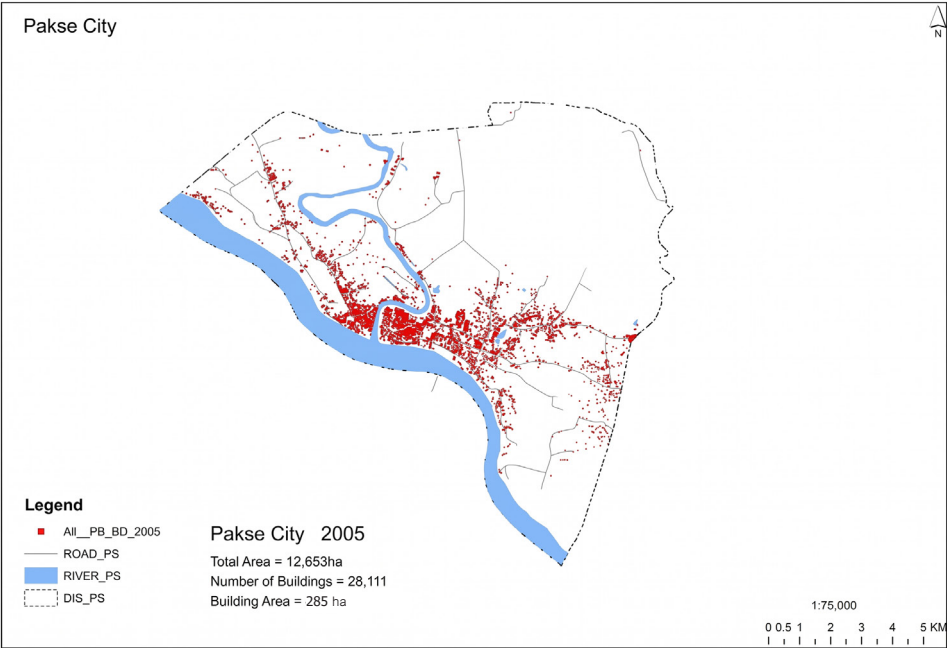
11 <https://www.adb.org/projects/43316-012/main>



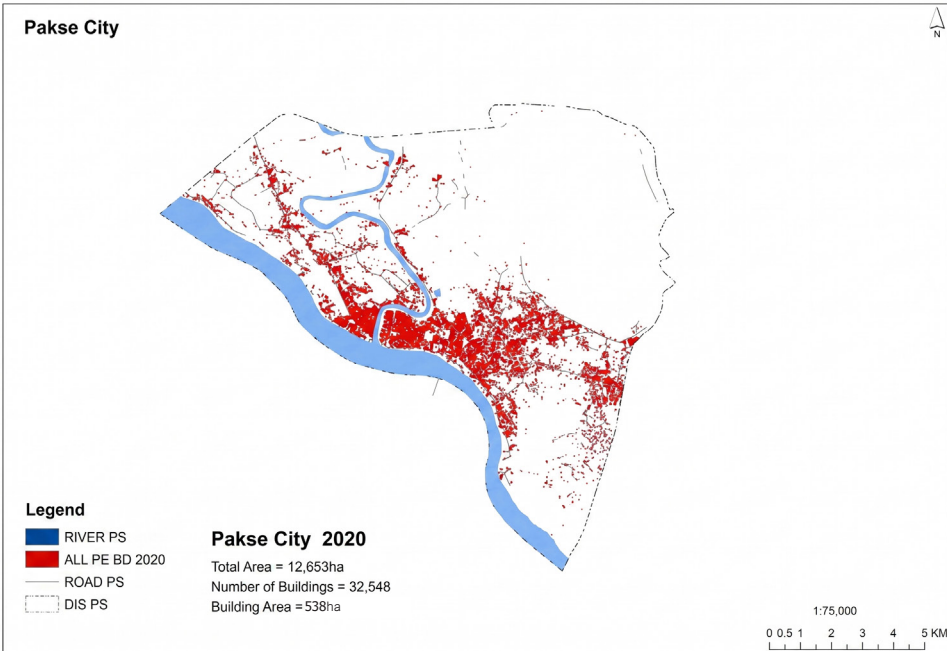
Land-use plan in Pakse city [Pakse GHG Inventory Report, 2019]

The urban core of Pakse City is situated at the confluence of the Xedon and Mekong rivers. Due to its low elevation, this central district is significantly vulnerable to flood events.

Built-up areas in Pakse municipality in 2005



Built-up areas in Pakse municipality in 2020



2.7 Physical and social infrastructure assets

Pakse's infrastructure development has not kept pace with its rapid urbanization, population growth and increased migration. While the city has made strides in improving transportation and communication networks, much of its physical infrastructure—such as roads, drainage systems, and flood protection—requires significant upgrades. In particular, the lack of maintenance of flood infrastructure has left parts of the city highly vulnerable to heavy rains, flash flood, cyclones, and subsequent flooding.

Social infrastructure, such as healthcare and education facilities, also faces challenges. As the population grows, the demand for these services increases, putting pressure on existing resources. Efforts to improve these sectors are ongoing, but there is a clear need for more investment to ensure that all residents have access to quality social services.

2.8 Institutional and policy frameworks

Pakse's development is shaped by a combination of national policies and international frameworks aimed at promoting sustainable urban growth. The Government of Lao PDR has recognised urbanisation as a key driver of economic development and has implemented policies to manage urban expansion while reducing environmental risks. The city's development planning aligns with the Ninth National Socio-Economic Development Plan (NSED, 2021–2025), approved by the National Assembly, which integrates priorities for sustainable urban development, biodiversity conservation, and climate resilience. The

plan emphasises balanced urban–rural growth, improved infrastructure, and waste management, alongside commitments to protect natural habitats, promote sustainable land use, and strengthen conservation areas.

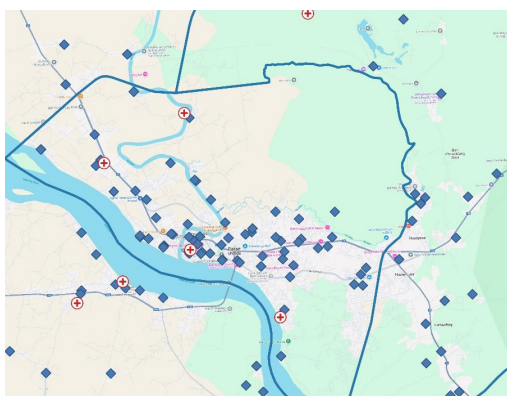
Climate change initiatives are guided by the Lao PDR's NDCs and NAP, which outline national strategies to reduce greenhouse gas emissions, build adaptive capacity, and integrate climate resilience into all sectors of development. These frameworks ensure coherence between national urban policies and international environmental commitments under the Paris Agreement.

In line with these commitments, the Lao government launched the first Green City Action Plan (GCAP) in Pakse in 2023—the inaugural GCAP in Lao PDR. This plan aims to transform cities into liveable, low-carbon, and climate-resilient urban centres that provide inclusive services while fostering socio-economic development. Pakse is also involved in regional initiatives such as the ASEAN Sustainable Urbanisation Strategy (ASUS), which offers a blueprint for addressing the challenges of rapid urbanisation and climate change. Additionally, the city participates in the UN-Habitat Cities and Climate Change Initiative (CCCI), making it one of the first Lao cities to engage in structured climate resilience planning, particularly targeting vulnerabilities related to flooding and rising temperatures.

Construction of
Mekong levee in 2020
[vientianetime, 2020]



Schools and health
Facilities in Pakse [UN-
Habitat Lao PDR, 2025]





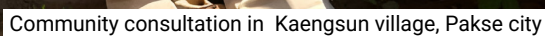
Methodology



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Kaengsun village, Pakse city is one of the villages in Pakse that experience uran flood flash flood from Xedon River

01

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:

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.



An overview of MVA approach

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 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 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.

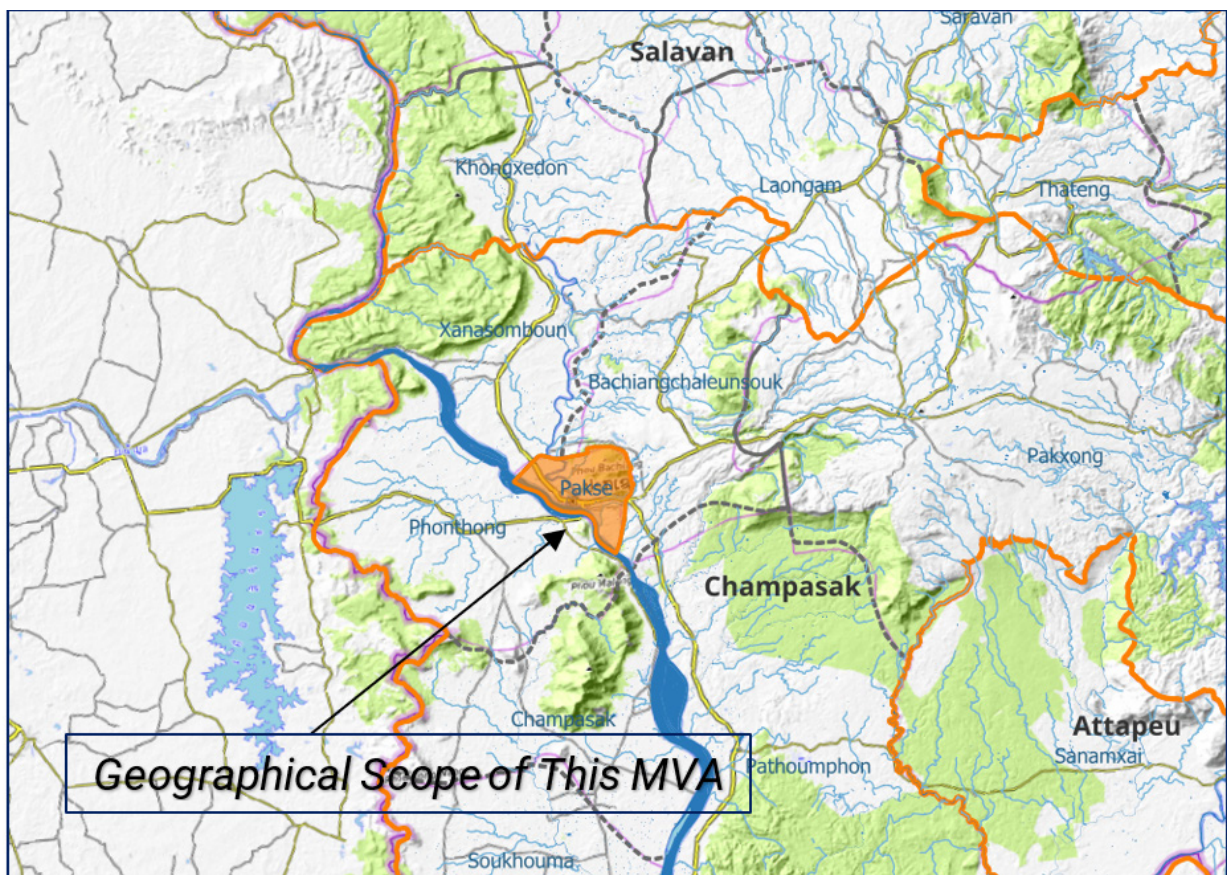
This MVA for Pakse City serves as an evidence-based foundation for resilience planning under the RISE UP programme. The assessment focuses on identifying spatial vulnerability patterns and validating them through community consultations, rather than defining specific interventions at this stage. The results of the MVA will be used to inform the forthcoming Urban Resilience Action Plan (URAP) for Pakse City (Stage 3), where vulnerability hotspots will be further prioritised and translated into actionable, location-specific resilience measures. The URAP will integrate additional technical assessments and stakeholder inputs to ensure that proposed actions are feasible, inclusive, and aligned with local development priorities.

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

02

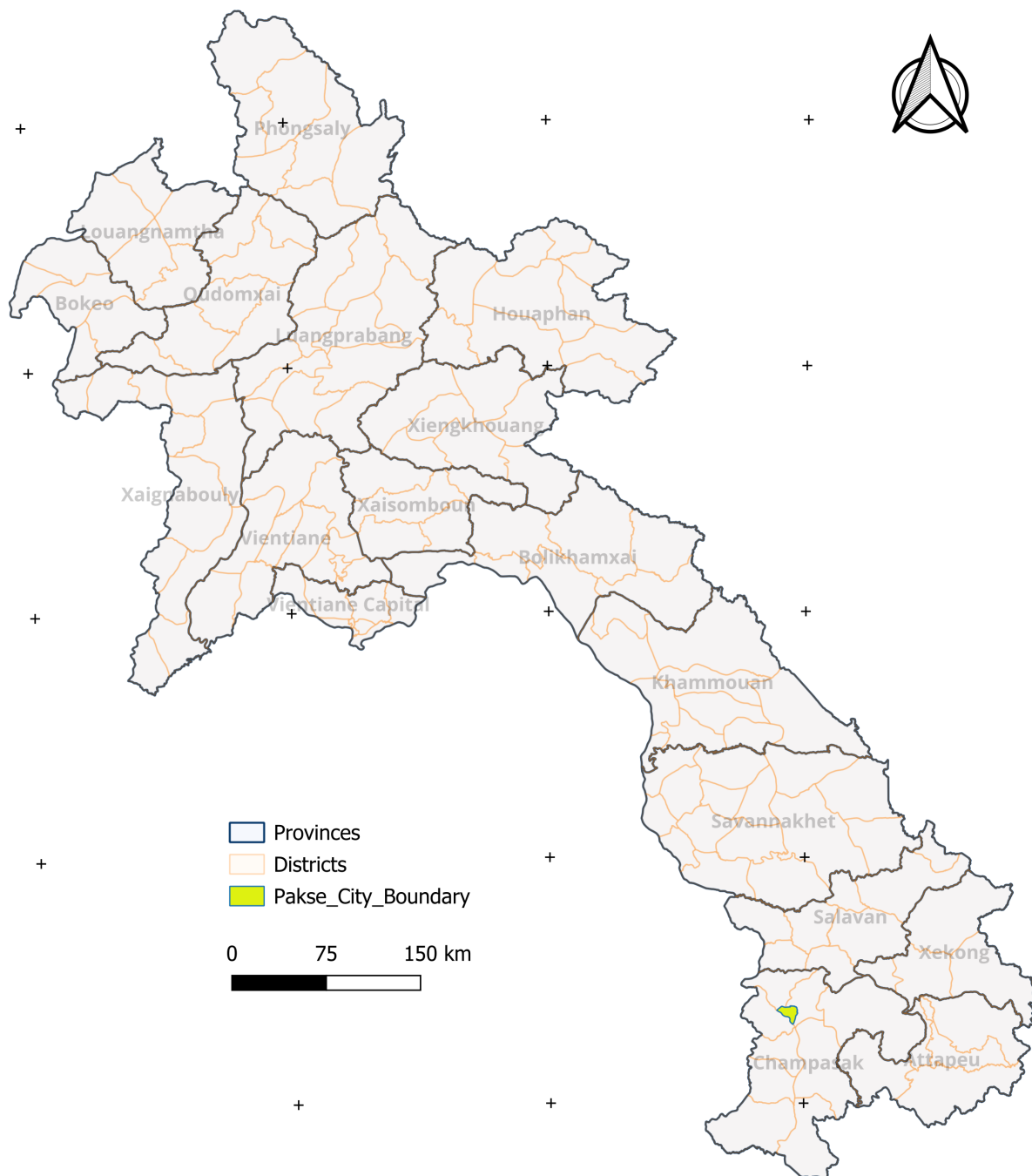
Geographic scope

The scope of this analysis is comprehensive, covering the entire 126.6 square kilometre official administrative boundary of Pakse city. This includes all 42 villages under city governance, encompassing diverse landscapes such as urban, peri-urban, agricultural, lake, and forest areas. Notably, Pakse serves as the capital of Champasak province, is the province's most urbanized region, and stands as the third-largest city in Lao PDR.



Pakse administrative boundary

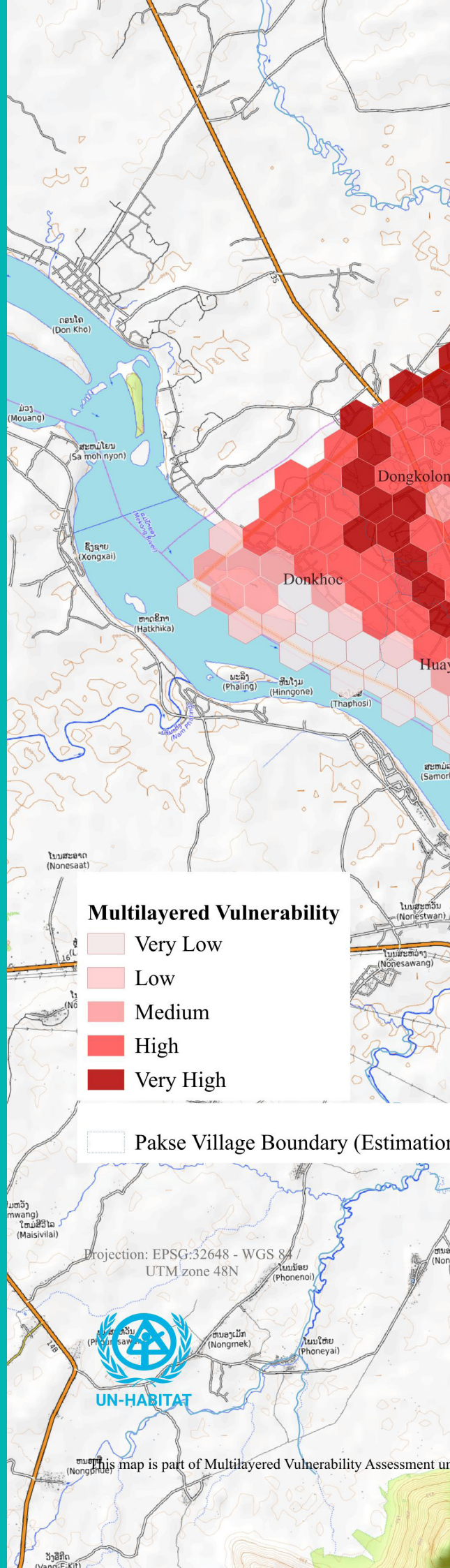
Districts and Provinces in Lao PDR



Location of Pakse city in Lao PDR



Key Findings



01

Urban dimension

Pakse is struggling with unregulated growth, as the city's expansion has quickly outpaced its infrastructure.. The analysis maps hotspots using five indicators: urban growth, population density, access to green space, road type, and land cover.

Pakse, the capital of Champasak Province, is undergoing rapid urbanisation similar to many other cities in Lao PDR. However, this growth remains largely unregulated, creating significant urban management challenges. Weak enforcement of land use planning and the unchecked conversion of agricultural land into urban areas have led to fragmented and precarious development. Essential urban services, such as solid waste management, wastewater treatment, water supply, and road infrastructure, have not kept pace with the city's expanding population. Paved roads are concentrated mainly in the old urban core, while newer areas lack sufficient infrastructure and public amenities.

Although agriculture still dominates land use, urban expansion is poorly managed, with limited attention to green space, pedestrian facilities, public amenities, and the broader urban landscape. Population density is highest around trade centres and government offices, putting growing pressure on already strained infrastructure, services, and mobility.

The analysis based on five urban-related indicators is presented in the map (p.36) using a five-class orange colour scale, where darker shades indicate higher levels of vulnerability and lighter shades represent lower vulnerability. A detailed analysis of this dimension is provided in Section 1.2, Urban Dimension Analysis.

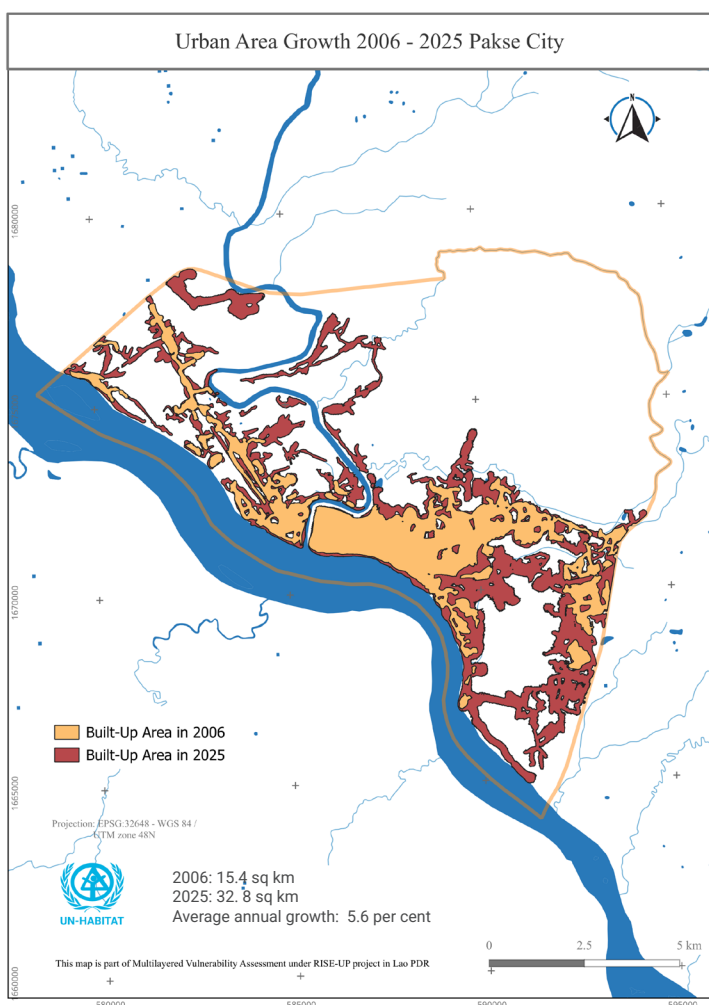
Addressing these issues requires stronger policy action aligned with national and regional strategies, including the Lao PDR's 2030 Vision and 10-Year Socio-Economic Development Strategy (2016–2025), the National Green Growth Strategy to 2030, and regional initiatives such as the ASEAN Sustainable Urbanisation Strategy and the Green City Action Plan. These frameworks aim to strengthen urban governance, upgrade infrastructure, and promote sustainable, resilient development in Pakse.

1.1 Indicators – urban dimension

Within the urban dimension, five urban-related indicators are utilized to spatially analyze and identify vulnerability hotspots in Pakse 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.

1.1.1 Urban area growth

This indicator is based on high-resolution imagery data from a study conducted between 2006 and 2025, utilizing Google Earth



Pakse urban area growth 2006 and 2025

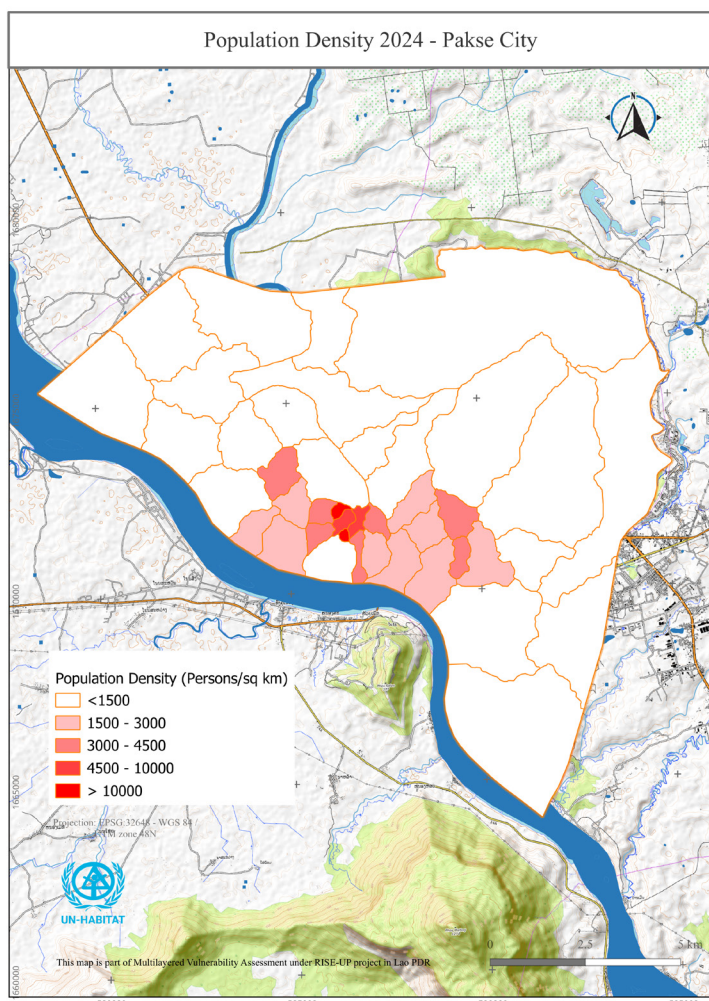
historical data within Google Earth Pro. Image classification techniques were employed to identify the urban area of Pakse in both 2006 and 2025. Further details on this methodology can be found in the annex 1.

The analysis reveals that the built-up area was 15.4 sq km in 2006 and expanded to 32.8 sq km in 2025. This represents significant growth, averaging 0.87 sq km (87 ha) per year, or around 5.6 per cent annually over the past 20 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 map above show analysis of built-up area in 2006 and its

growth in 2025 in Pakse city. The orange color represent built-up area detected by satellite image in 2006 while red color indicate built-up area expansion across the city in 2025.

Under this indicator, the old urban core of the city is assessed as having low vulnerability, as its basic services were originally designed to adequately support residents' livelihoods. By contrast, newly expanded urban areas, characterised by rapid and largely unregulated growth, often lack access to essential services and infrastructure. Populations in these areas tend to be poorer, as lower land prices make them more affordable compared to the old urban centre. However, infrastructure and service provision have not kept pace with this expansion, leaving these new built-up areas without critical services – such as water and sanitation – significantly more marginalized and underserved. For this reason, the indicator specifically focuses on the new urban expansion, which is assigned a vulnerability score of 1, while the remaining areas are not scored.



Pakse population density 2024 (Persons/sq km)

density exceeds 10,000 people per square kilometre. For this indicator, higher population density is considered to increase vulnerability. As shown in the Pakse population density 2024 map, the densely populated area of Pakse City is concentrated in the central part of the city near the Mekong River and its tributary, the Sedon River. This area is relatively low-lying compared to the surrounding mountainous areas to the north and west.

Dense urban areas face heightened risks due to the pressure placed on infrastructure, services, and social systems. Overcrowding can strain waste management, water supply, and transport networks, reducing their effectiveness during disruptions. Limited green space and extensive sealed surfaces also exacerbate the urban heat island effect, raising health risks during extreme heat. In addition, high density can lead to social challenges, such as higher crime rates and weaker social cohesion, which may undermine community resilience and emergency response. Collectively, these factors make densely populated areas more vulnerable to climate hazards, including floods, storms, and heatwaves.

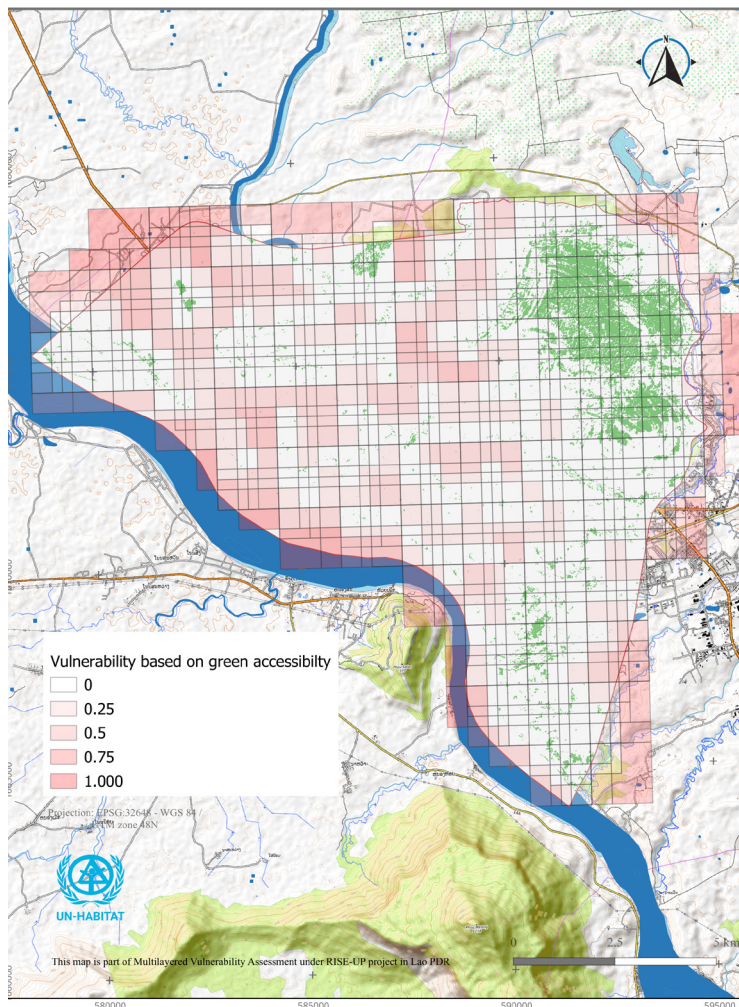
1.1.2 Population density

According to the Pakse Administrative Office, the population of Pakse City in 2024 is 89,797, of which 46,119 are women, representing 51.36 per cent of the total. These residents are distributed across 42 villages within the city boundaries (see map). The majority live in the central area, where trade centres and key government offices are concentrated.

Lao PDR has one of the lowest population densities in both ASEAN and the world. In Pakse, the average density is 713 people per square kilometre-low compared to major global cities, where the average is about 10,650 people per square kilometre¹². However, in a few central villages,

¹² <https://demographia.com/db-worlduasizeclass.htm>

Vulnerability based on green space accessibility - Pakse City



Vulnerability based on green space accessibility in Pakse

1.1.3 Green space accessibility

In Pakse City, green areas are mainly composed of natural forests located in the surrounding mountains-most notably Phoubachiang Mountain to the north, and Phousalao and Phoumalong to the south, both close to the urban core. Although local authorities acknowledge the importance of urban greenery, tree planting along roads remains limited and fragmented, falling well short of standards common in developed cities. During the dry season, urban temperatures often exceed 40°C, creating harsh conditions for pedestrians due to the lack of shade and cooling vegetation.

This indicator focuses on the availability and accessibility of green space within the city. The underlying assumption is

that communities located closer to green areas enjoy multiple benefits, including improved air quality, cooler ambient temperatures, reduced pollution, better health outcomes, greater longevity, and an overall enhanced urban environment. Consequently, these communities are considered less vulnerable than those with limited or no access to greenery. The map (left) 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 is assessed 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 grid cells at four spatial resolutions (500×500 m, 750×750 m, 1000×1000 m, and 1500×1500 m). A green score is then assigned to each grid depending on its size and the presence of at least 100 m² of green area-smaller grids (e.g., 500 m) are given the highest score (1), while larger grids receive progressively lower scores (0.75, 0.5, and 0.25).

These scores are merged across grid scales using a union process in QGIS and normalized to avoid overlapping values. The final green accessibility score is then inverted using the formula $Vulnerability = 1 - Green\ Score$, so areas with less accessible green space receive higher vulnerability values. The results are converted into a 30×30 m raster for spatial analysis, producing a detailed vulnerability map that highlights neighbourhoods with limited access to green space, and therefore greater exposure to heat stress and reduced urban resilience. Full details of the methodology are provided in Annex 2.

1.1.4 Community vulnerability by road types

Urban expansion in Pakse is occurring alongside rapid population growth, driven both by natural increase and migration from rural areas. However, annual funding for infrastructure-especially roads-remains insufficient to meet rising demand. Weak land-use regulation and the spread of unplanned settlements across former paddy fields and agricultural zones make infrastructure investment more difficult, costly, and less efficient. To manage these challenges, greater financial and technical assistance from the central government is needed.

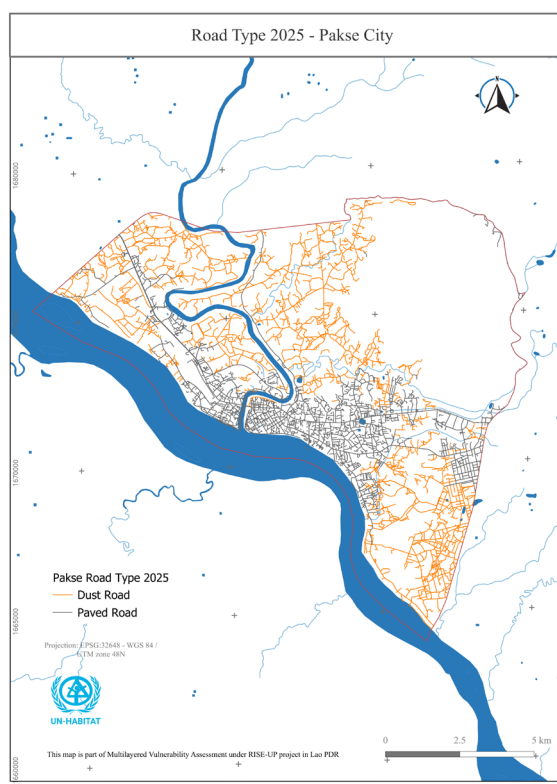
The map below (left) illustrates that paved roads (in grey color) are concentrated in the central urban area and along major routes, while dirt roads (in orange color) are largely found in newly developed communities on the city's outskirts. In larger cities such as Luang Prabang, Kaysone, and Pakse, essential infrastructure projects-such as roads, landfills, and wastewater treatment plants have often depended on external financing, particularly loans from the

Asian Development Bank (ADB) under initiatives like the Livable Cities Project¹³ and various Urban Improvement Projects¹⁴. The map below (right) presents vulnerability calculated based on the percentage of unpaved (dust) roads within each 500-metre hexagon. Dark red areas indicate higher vulnerability, reflecting a greater proportion of dust road coverage within the hexagonal unit.

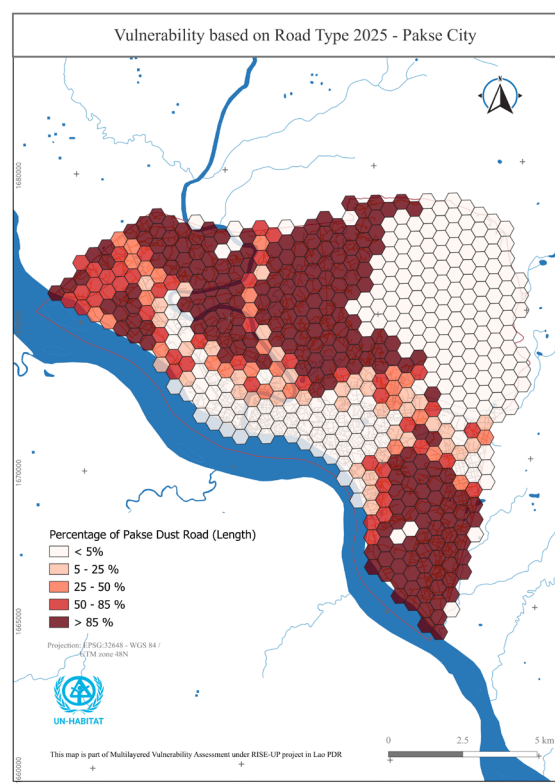
For this indicator, vulnerability is measured by road type, using the share of unpaved roads as a proxy. Communities reliant on dirt roads are considered more vulnerable due to limited access to essential services such as schools, hospitals, and waste collection-problems that worsen during the rainy season when road conditions decline. . Poor road infrastructure also restricts access to emergency health.

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

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



Paved and dust roads in Pakse



Vulnerability based on road types

.services during disasters and limits connectivity to evacuation routes and centres, significantly increasing risk during floods or other emergencies. For example, in Pakse, waste collection services only reach the central urban villages, leaving peri-urban areas with serious waste management issues-one of the main concerns highlighted during the RISE-UP project consultation workshop.

These areas also tend to house lower-income populations, as limited services and lower land values make them more affordable. As a result, the prevalence of unpaved roads is closely linked with higher vulnerability. A detailed description of the methodology used for this indicator is provided in Annex 3.

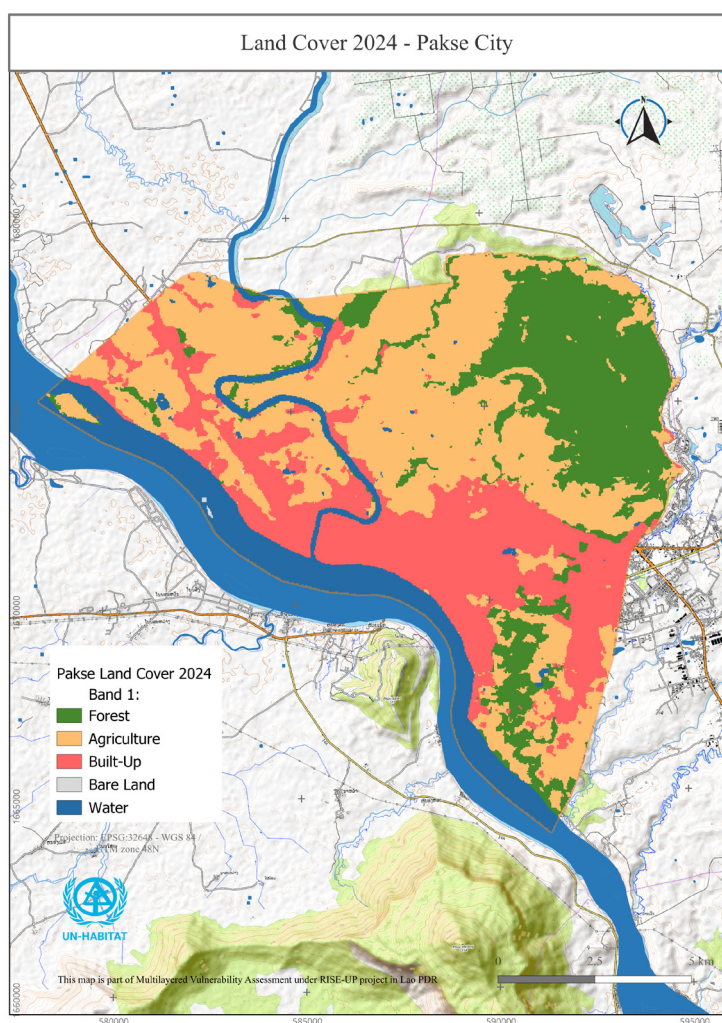
1.1.5 Land cover

Land use in Pakse reflects the city's rapid but uneven urbanisation, with the urban core dominated by commercial activities, government offices, and high-density residential areas, while the surrounding zones remain largely agricultural, particularly paddy fields and smallholder farms. Expansion has been largely unregulated, leading to the scattered conversion of farmland into residential and commercial developments without adequate infrastructure or public amenities. Green spaces are limited within the city, with most natural forests located in the surrounding mountains rather than integrated into urban planning. As a result, land use in Pakse is characterised by a fragmented urban landscape, where dense central areas place pressure on services and mobility, while peripheral communities struggle with poor connectivity, limited access to basic services, and reduced resilience to climate and environmental stresses.

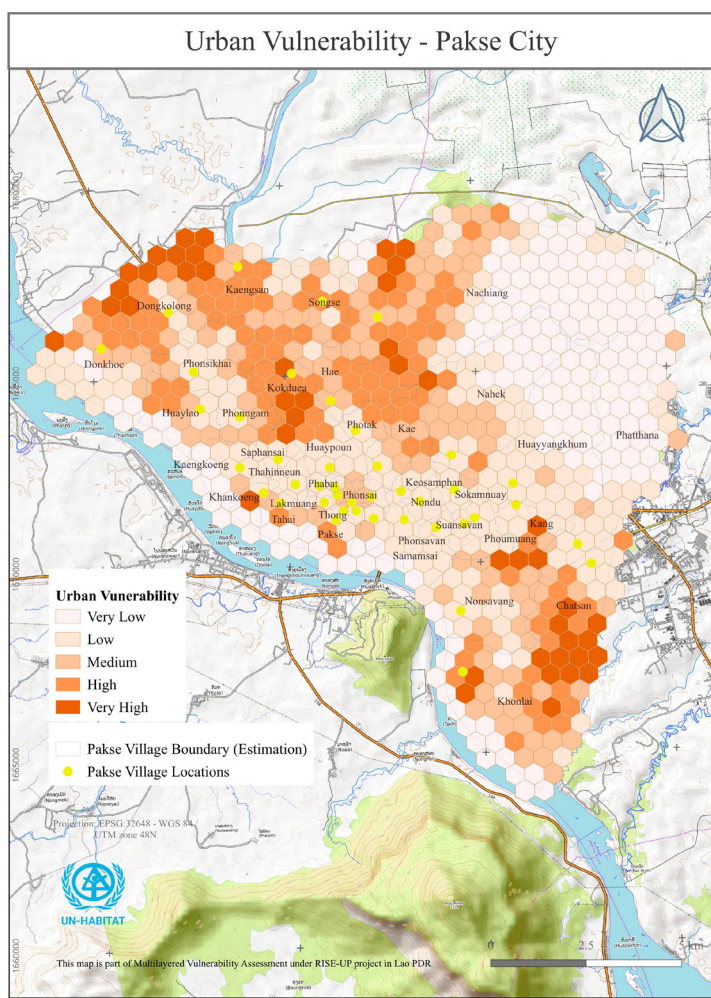
Under this indicator, land cover is used to represent directly different types of land use within the city boundary. The data for this indicator is generated using Sentinel 2 satellite imagery. This is a global dataset available online¹⁵. The use of land cover data from satellite imagery is preferred 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 map (left) show different types of land cover within Pakse city.

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.

¹⁵ <https://livingatlas.arcgis.com/landcoverexplorer>



Land cover in pakse city 2024



Urban hotspots and community locations

by household socioeconomic conditions than by dense slum-like development. Because Lao PDR has one of the lowest population densities globally, cities such as Pakse do not have congested slums but instead have poorer neighbourhoods where access to clean water, adequate roads, sanitation, and waste collection is limited. Land tenure can be a challenge, but most residents occupy land with either use-right documents or customary rights, which still provide a sense of ownership and security. Vulnerability hotspots are also evident within the urban core. In these communities, the main contributing factor is limited access to green spaces. Since most greenery is located in the mountainous area, residents of central areas miss out on the environmental benefits associated with urban vegetation especially along with the road where pedestrian can benefit from improved air quality, cooler temperatures, reduced pollution, better health, and enhanced well-being. Consultation feedback from Pakse Village confirms that community members experience high temperatures and limited shade in densely built-up areas, reinforcing the significance of green-space accessibility as a vulnerability factor.

Most of the hotspots of very high vulnerability in the urban dimension of Pakse are concentrated in the villages of Pakse, Chatsan, Kokduea, Donkhoc, Khankoeng, Dongkalong, Kang, Kaengsun, as shown in the map above.

1.2 Urban dimension analysis

Peri-urban areas around Pakse's city centre (with the exception of the forested and mountainous northern zone) show the highest levels of vulnerability. This is largely due to poor access to basic services, higher poverty rates, a larger share of unpaved roads (a proxy for limited connectivity), and the rapid growth of new urban settlements. These combined factors drive elevated vulnerability scores in these areas. This aligns with community consultations in Kaengsun and Nahaek Villages, where residents reported limited road access, particularly during the rainy season and insufficient waste management services, both of which compound everyday vulnerability (Annex 1).

While the concept of informal settlements in Lao PDR differs from that in other countries, they are typically defined more

"Our village usually collects and burns our rubbish every Friday. However, you can see trash along the road because nearby villagers dump their waste near the forest, likely because they don't have access to waste collection services."- Mr. Phoxay Panyavong, vice village chief of Kaengsun



Main road access to Kaengsun village



Waste issue along the Kaengsun village's road

1.3 Urban future vulnerabilities

Although trend data on future urban vulnerability is not available, it is likely that vulnerability will persist or worsen without significant investment in basic service improvements. With continued population growth, vulnerable areas are expected to expand further, particularly in peri-urban zones and outer villages. Urban growth projections estimate that Pakse will expand by about 87 hectares per year - equivalent to roughly 5.6 per cent of its total area - which, if unmanaged, could intensify existing vulnerabilities. Community consultations in Kaengsun and Nahaek underscore this concern, as both villages expressed that infrastructure has not kept pace with recent settlement expansion, particularly regarding road improvement and waste management. Stronger enforcement of land-use planning regulations is therefore critical to control urban sprawl and prevent more communities from facing limited access to essential services.

Given the city's large size, low density, and scattered population, substantial investment is needed to improve core 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 for government institutions alongside public awareness initiatives. These soft measures must complement physical infrastructure investments to effectively reduce future vulnerabilities. For example, residents in Pakse Village highlighted the need for improved drainage and maintenance of older infrastructure, indicating that both new and old urban areas require tailored resilience measures.

Finally, interventions should be cross-sectoral, coordinated under the leadership of urban planning authorities, and supported by strict enforcement of laws to ensure long-term sustainability and resilience.

02

Climate change dimension

Pakse City is highly vulnerable to climate change, particularly flooding, due to its low-lying location at the Mekong–Xe Don river confluence. Increased rainfall intensity, rapid urban growth, and inadequate drainage systems have worsened flood risks, while land-use change and waste blockage further reduce water flow capacity. Drought and rising temperatures pose additional but less significant challenges.

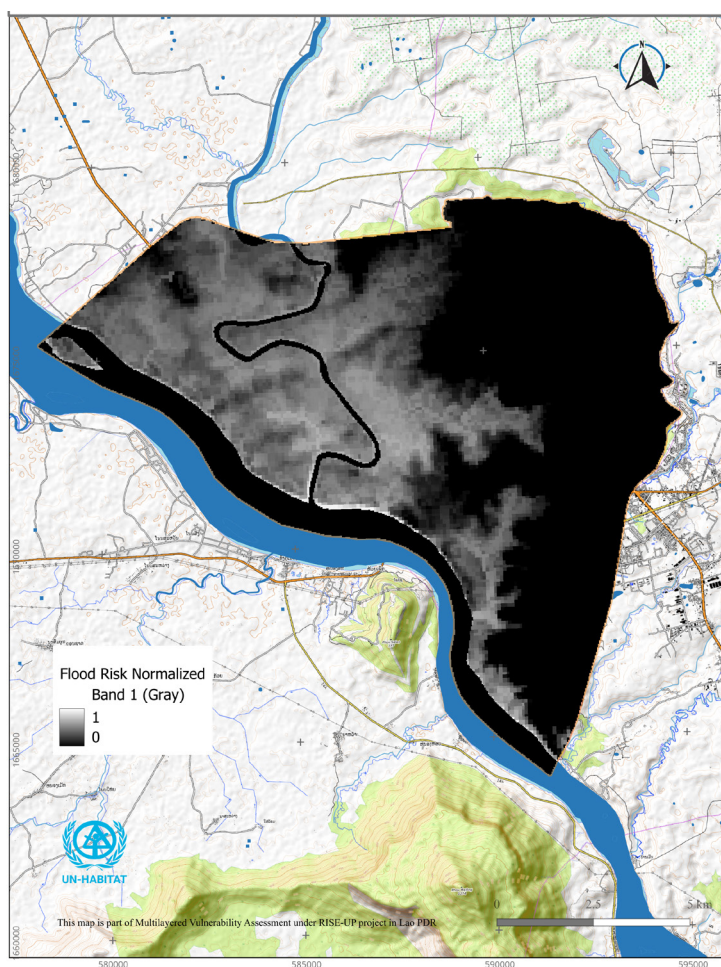
Pakse City, located in the lowland areas along the Mekong River, is highly exposed to climate change-related hazards, particularly heavy rainfall and flooding. Floods frequently affect residential areas, public service buildings, and agricultural land situated along the Mekong and Xe Don rivers, as well as the natural streams that connect them. The city's vulnerability largely stems from its geographical position at the confluence of these rivers and its low-lying terrain, which increases the risk of river overflow during intense rainfall and upstream water discharge. Rapid urban expansion, often occurring without adequate drainage systems or flood-resilient infrastructure, has further reduced the city's natural capacity to absorb excess water. Deforestation and land-use changes in surrounding catchments intensify runoff, while climate change has amplified rainfall events, making floods both more frequent and severe. Inadequate drainage networks and continued reliance on natural streams for water management exacerbate these issues, particularly during heavy rains, while blocked waterways from unmanaged waste further hinder flood discharge.

The analysis of the three climate-related indicators—flood risk, drought risk, and land surface temperature—is presented in the map in page 42. Darker blue areas indicate higher average scores across the three indicators and therefore higher climate vulnerability, while lighter blue areas represent lower vulnerability. Detailed analysis is provided in Section 2.2, Climate Change Dimension

Analysis.

Although national frameworks, such as the National Strategy on Disaster Risk Reduction (2021–2030)¹⁶, aim to strengthen resilience, implementation at the city level remains constrained by limited funding, technical capacity, and the lack of effective early warning systems. This climate risk assessment also considers other hazards such as drought and rising land surface temperatures using secondary data and satellite imagery. However, compared to flooding, these hazards currently pose less direct impacts on the Pakse community. To reflect this, flooding is assigned a higher weight of 1.5 in the overall risk analysis, while drought and land surface temperature are each weighted at 0.5.

¹⁶ <https://faolex.fao.org/docs/pdf/lao215507eng.pdf>



Flood risk map in Pakse city - 100 years return period

areas indicate lower risk. Results show that flood-prone areas are concentrated along the Mekong and Xe Don rivers, as well as the natural streams that flow into them. A large share of the city's urban area falls within these flood risk zones. Floodwaters typically originate from rising levels of the Mekong and Xe Don, which overflow into urban, agricultural, and low-lying areas of Pakse. As illustrated in the map showing on the left side (the map uses whiter shades to represent higher flood risk), historical data over the past 100 years indicates that most communities in Pakse face significant flood risk.

"In 2025 alone, our village has experienced three floods." – Mr. Phoxay Panyavong, Vice Village Chief of Kaengsun Village, Pakse City.

2.1 Indicators – climate change dimension

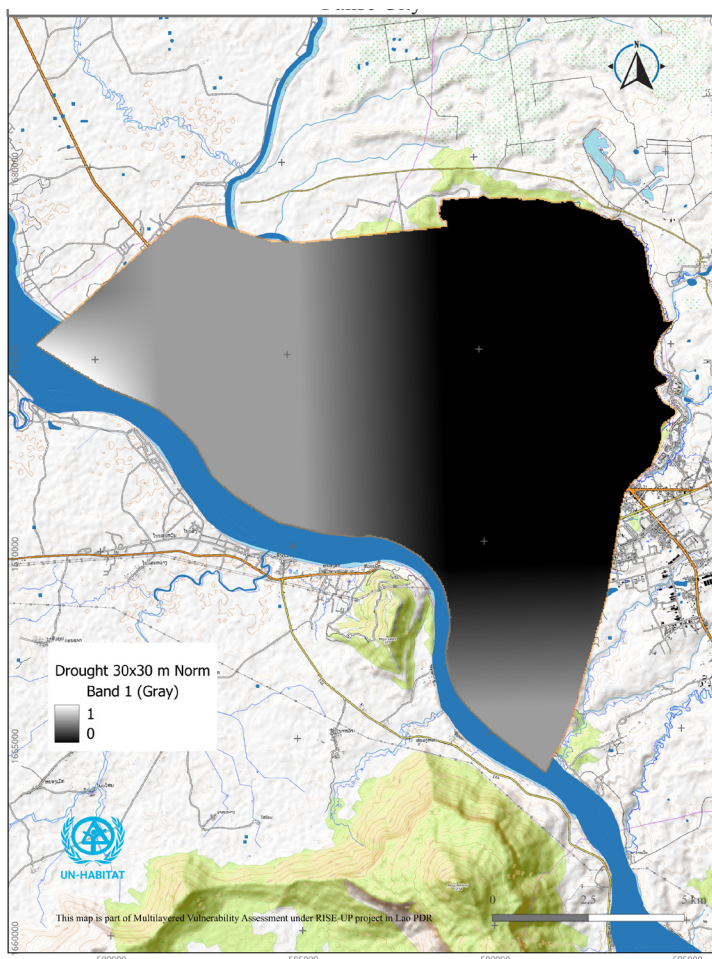
Within the urban dimension, three urban-related indicators are utilized to spatially analyze and identify vulnerability hotspots in Pakse City.

2.1.1 Flooding

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)¹⁷, 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 with other indicators. The results of the analysis are shown in the map above using a greyscale map, where lighter (whiter) areas represent higher risk and darker

¹⁷ <https://giri.unepgrid.ch>

"In the past two years, we experienced flood hazards from the river; because the heavy rains lasted a long time, the river overflowed into our village." – Ms. Tim Khamphoumee, Vice Village Chief of Nahaek Village, Pakse City.

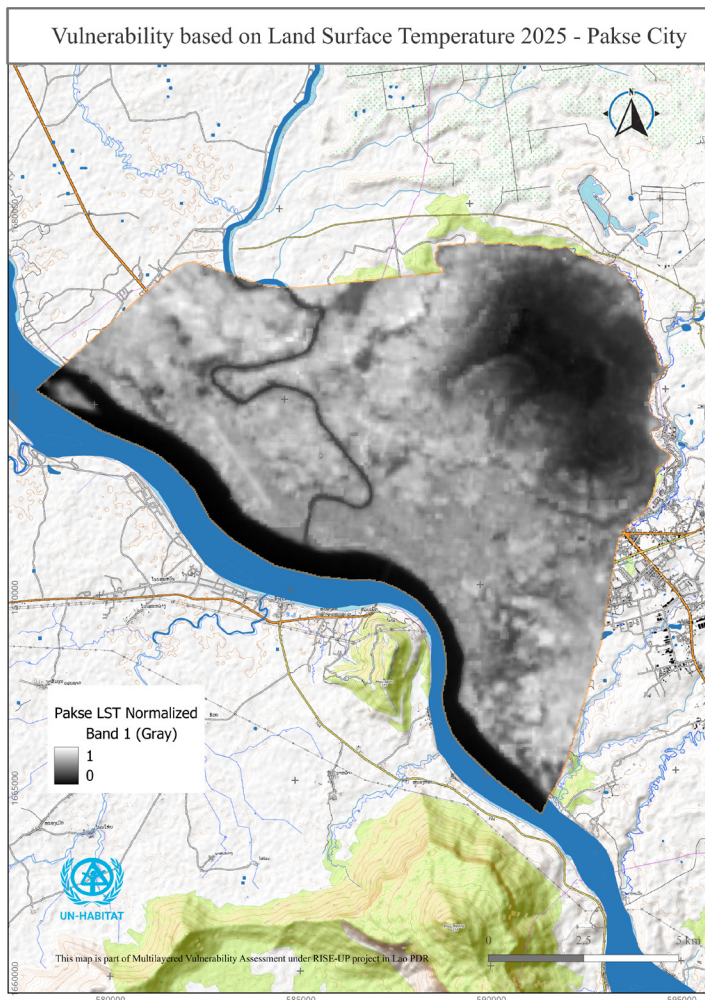


Drought risk map in Pakse city

erosion, increases the risk of land subsidence, and threatens local biodiversity by reducing habitat quality and freshwater availability. In urban areas, reduced water supply can disrupt essential services and place additional pressure on infrastructure and public health. For these reasons, drought is included as one of the assessment indicators. The analysis is shown in the map (left) using a greyscale map, where lighter (whiter) areas represent higher risk. The map indicates that drought risk is relatively low in the north-eastern area, which is dominated by forested and mountainous landscapes. In contrast, higher drought risk is observed in the north-western and southern areas, which are largely characterised by open land, agricultural areas, and residential development (the map uses whiter shades to represent higher flood risk). However, its relative impact on the city is considered less significant compared to flooding and is therefore assigned a lower weight of 0.5 in the analysis.

2.1.2 Drought

The drought indicator is derived from the global dataset available through GIRI (Global Infrastructure Risk Model and Resilience Index), hosted at giri.unepgrid.ch. GIRI is the first publicly accessible, fully probabilistic global risk model designed to estimate infrastructure risks from major geological and climate-related hazards worldwide. Pakse, situated on the Champasak Plain—the second largest plain in Lao PDR—along the Mekong River, is vulnerable to recurring drought conditions. Prolonged dry periods can lead to water scarcity, reduced agricultural productivity, and food insecurity, particularly affecting farming communities dependent on rainfed systems. Drought also accelerates soil degradation and

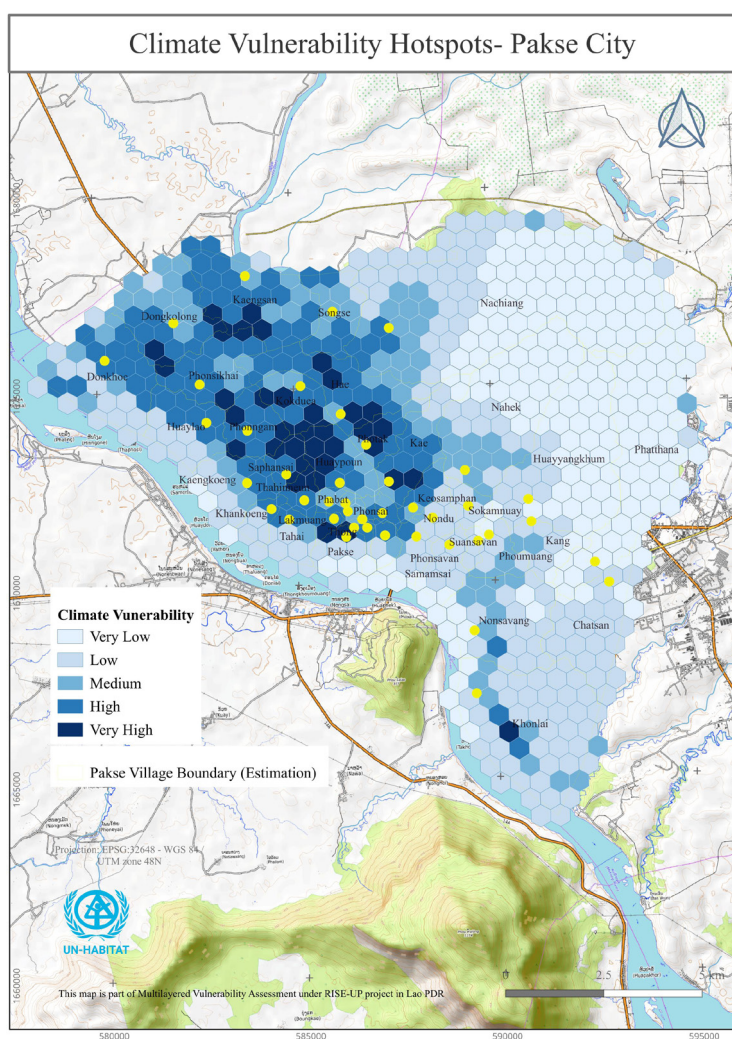


Land surface temperature – Pakse in 2025

higher land surface temperatures. The highest temperatures are concentrated in areas dominated by bare agricultural land and dense urban concrete surfaces where tree cover is minimal, in contrast to lower-temperature areas that are covered by vegetation. The temperature data was normalized and inverted to support this assumption. Similar to the drought indicator, it is weighted 0.5, as this factor is considered less impactful on communities compared to the flood indicator.

2.1.3 Land surface temperature

This indicator was generated using Landsat 9 imagery obtained from USGS EarthExplorer. The methodology follows the approach outlined in the study “Impact of Urbanization on Urban Heat Island in Arkana City, Sindh, Pakistan”, with detailed steps provided in Annex 4. The underlying assumption of this indicator is that areas with higher surface temperatures are more vulnerable due to increased risks of heatwaves and urban heat island effects, which can significantly impact the health of people working outdoors, both in urban and agricultural environments. The analysis using satellite imagery is shown in the map above in greyscale, where lighter (whiter) areas represent



Pakse vulnerable communities – climate dimension

2.2 Climate change dimension analysis

The analysis of all indicators under this dimension, based on overlapping and averaged vulnerability scores, shows that highly vulnerable hotspots are concentrated in low-lying areas near the Mekong and Xedon Rivers, which are prone to frequent flooding. Some of these areas also exhibit high surface temperatures and risk of drought due to bare land with little or no tree cover.

Notably, the identified hotspots encompass not only agricultural zones but also large areas of community settlements. As illustrated in the above map, several villages in Pakse City have been classified as very high climate vulnerability hotspots. These include Thong, Phonxai,

Keosamphan, Huaypoun, Kokdeua, Thahinneun, Paksxe, Kaengkeung, Kae, Nahaek, Hae, Kaengsun, Khonlai, and Nachiang and more. Community consultations confirmed this pattern, with Pakse Village residents reporting frequent flooding around older houses, while both Nahaek and Kaengsun residents described seasonal road flooding and overflow from natural creeks. These lived experiences validate the mapped flood risk zones.

2.3 Climate change future vulnerabilities

Data from the World Bank Climate Change Knowledge Portal¹⁸ indicate that by 2100, average annual precipitation in Champasak Province could increase to approximately 2,300 mm, compared with a historical average of about 1,950 mm during the 1991–2020 period. Although the spatial extent of low-lying, flood-prone areas is unlikely to change significantly, overall flood exposure is expected to increase as rapid urban expansion-driven by population growth and rural-to-urban migration-brings more people and assets into hazard-prone zones. Marginalised and low-income groups are particularly vulnerable, as limited housing options often force them to settle on cheaper land in precarious locations, frequently without full awareness of the associated flood risks. Consultation participants in Nahaek noted increasing dependence on natural creeks for drainage, which become easily overwhelmed during heavy rain, while Kaengsun residents expressed concern about limited evacuation access during flood events. Without the integration of land-use planning and strict enforcement of regulations to prevent construction in high-risk zones, this situation is likely to deteriorate further.

Although a 12 km embankment was constructed along the Mekong and Sedon rivers between 2016 and 2022 to protect the urban core¹⁹, its coverage is limited. While it may reduce flooding at a small scale within central areas, it cannot prevent high water levels

¹⁸ <https://climateknowledgeportal.worldbank.org/country/lao-pdr>
¹⁹ <https://kpl.gov.la/EN/detail.aspx?id=3110>



Local initiative to protect flood from the natural creek in Nahaek village

findings highlight these concerns, with residents in peri-urban villages such as Kaengsun and Nahaek frequently noting rapid surface runoff and localized flooding during heavy rains. Addressing these challenges requires a comprehensive long-term strategy to strengthen community-wide adaptation and resilience to recurrent flood threats.

Continuous warming may also exacerbate the urban heat island effect, particularly in areas with limited vegetation. Community members in Pakse Village described significant discomfort during peak dry-season heat, illustrating that temperature-related vulnerabilities are already being felt at the household and neighbourhood level.

from entering through unprotected peri-urban zones. These waters can still flow into low-lying areas of the core city where drainage systems remain ineffective, highlighting the structural and spatial limits of the embankment as a long-term solution.

A critical priority, therefore, is sustained investment in a systematic urban drainage and sewage system. While total annual rainfall may remain relatively stable in the coming decades, rainfall patterns are changing, with short, intense downpours becoming increasingly common. Enhancing natural streams and upgrading existing drainage channels will be essential to maintain efficient water flow and reduce flood risks across urban areas.

Pakse's geographic setting further heightens its vulnerability: the low-lying urban core receives runoff from surrounding mountains and is also affected by floodwaters from rivers originating in northern Lao PDR. Community consultation

03

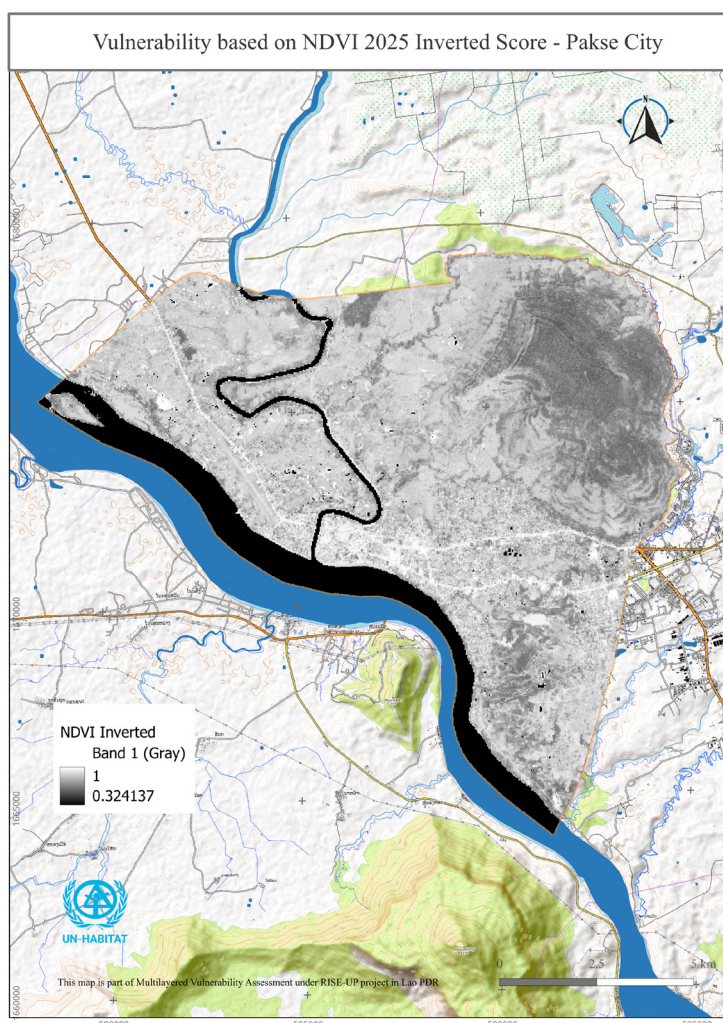
Biodiversity dimension

Pakse city is a biodiversity-rich area supported by surrounding forests and major river systems, including the Mekong and Xe Don, which provide important habitats and ecosystem services. However, biodiversity is increasingly threatened by urban expansion, agricultural conversion, infrastructure development, and unsustainable practices such as land clearing and burning.

Pakse, located in Champasak Province, is a region of high biodiversity, characterized by surrounding forests and two major rivers—the Mekong and Xe Don—that cut through the city. Within the city boundary, Phou Bachiang Mountain represents the largest protected forest, covering more than 3,000 hectares, while Phou Malong, situated just south of Pakse and across the Mekong River, is another significant protected forest spanning over 20,000 hectares. These forests play a crucial role in maintaining ecological balance, providing habitat for diverse flora and fauna, and sustaining ecosystem services. However, their biodiversity is increasingly threatened by agricultural expansion, land use conversion, shifting cultivation, infrastructure development, and unsustainable resource extraction practices. These pressures highlight the urgent need for stronger, coordinated and monitored conservation management and community-based initiatives to safeguard their ecological value.

Although government agencies, supported by NGOs and development partners, have made efforts to protect these areas, significant challenges persist due to limited budgets, limited understanding of the biodiversity value, insufficient staffing, and inadequate technical capacity for effective planning and law enforcement. Compounding these issues is the scarcity of detailed biodiversity data for both the province and the city. To address this gap, global datasets and satellite imagery are used in the analysis, applying indicators such as

the Normalized Difference Vegetation Index (NDVI), Burn Area Index (BAI), and Mean Species Abundance (MSA). In this assessment, all three indicators are weighted equally to provide a balanced perspective on biodiversity health and vulnerability. The analysis of the three biodiversity-related indicators is illustrated in page 48, where darker green areas indicate higher vulnerability scores. Details of this analysis are presented in Section 3.2, Biodiversity Dimension Analysis.



NDVI indicator – Pakse city

red (R) reflectance values:

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

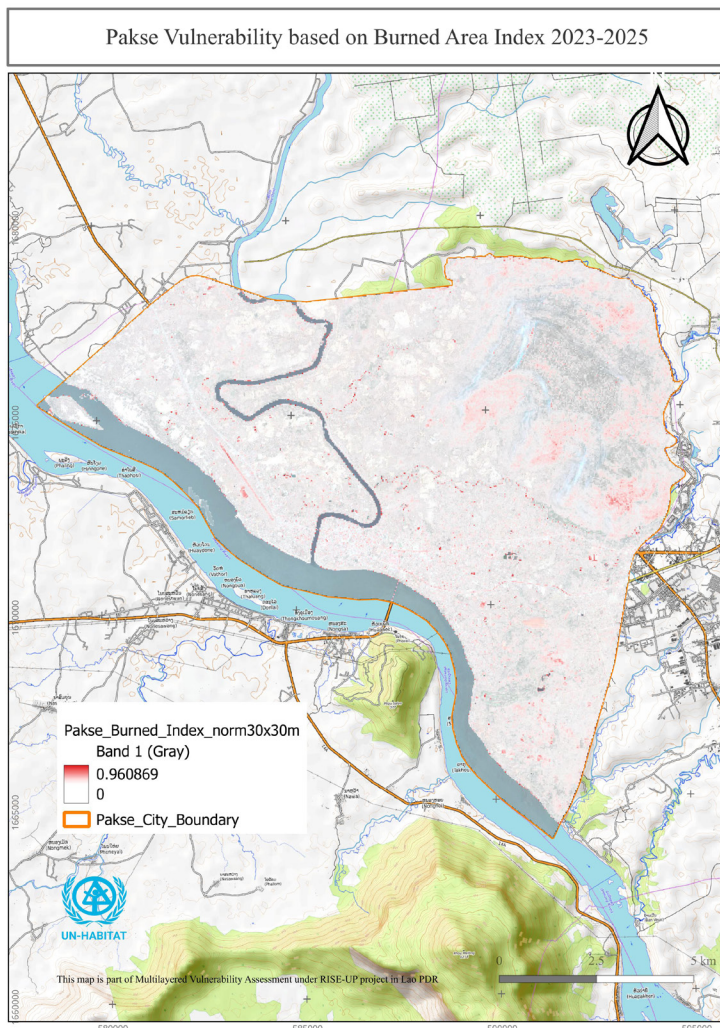
NDVI in this case is generated from Sentinel 2 data in February 2025 using Red and Near Infrared bands. The results from NDVI were inverted ($1 - NDVI$) to create a vulnerability index, ensuring that areas with lower vegetation cover are represented with higher vulnerability scores. The analysis of this indicator is illustrated in the map on the left using a greyscale map, where brighter areas indicate higher vulnerability scores. Areas of high vulnerability are mainly residential, urban, and developed zones characterised by extensive concrete surfaces and minimal tree cover.

3.1 Indicators – biodiversity dimension

Within the biodiversity dimension, three biodiversity-related indicators are utilized to spatially analyze and identify vulnerability hotspots in Pakse City.

3.1.1 Normalised Difference Vegetation Index (NDVI)

This indicator focuses on the abundance of biodiversity within the boundary of Pakse 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, which are key components of habitat quality and species richness. NDVI is calculated from satellite imagery using the difference between near-infrared (NIR) and



Burn Area Index (BAI) indicator – Pakse city

degradation, as it effectively highlights zones impacted by forest fires. By detecting reductions in green vegetation and increases in charred soil and ash, BAI provides valuable insights into fire-induced changes in habitat quality, species abundance, and overall ecosystem structure within and around Pakse. The index is calculated from spectral information, specifically the near-infrared (NIR) and red (R) reflectance bands, using the following formula:

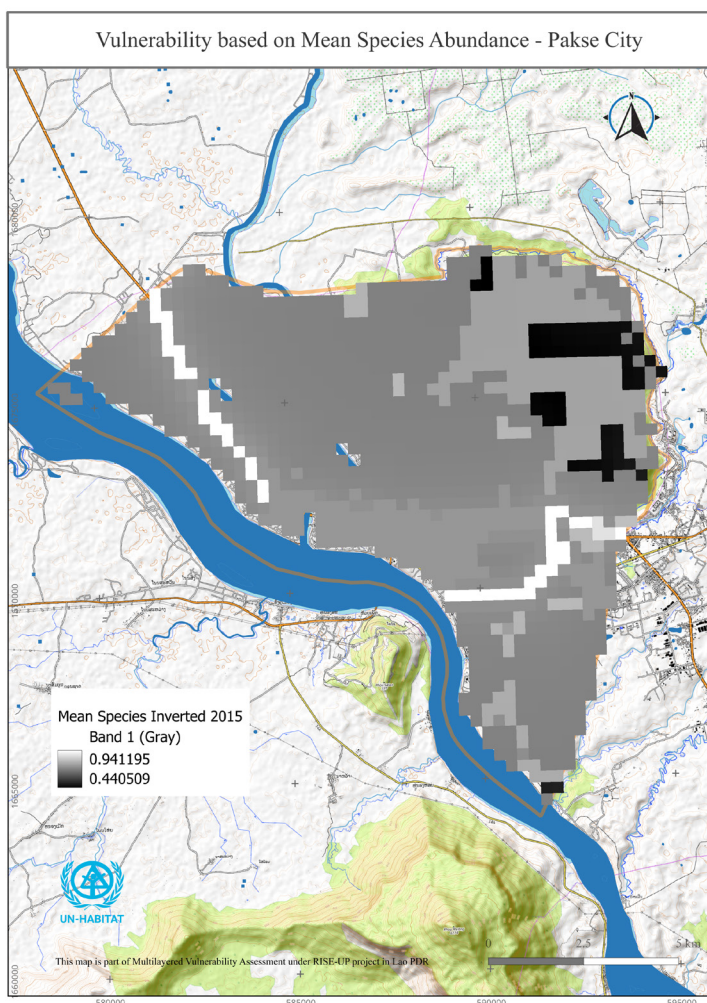
$$BAI = \frac{1}{(0.1 - R)^2 + (0.06 - NIR)^2}$$

The analysis of this indicator is mapped and shown on the left, where red areas indicate locations impacted by fire and therefore higher biodiversity vulnerability. In Pakse City, the areas most vulnerable to wildfire are mainly located in the northern and eastern parts of the city, where forest cover is concentrated.

3.1.2 Burn Area Index (BAI)

Wildfires have become an increasing concern in and around Pakse, occurring almost every year and often linked to human activities such as agricultural burning, land clearing, and encroachment near forested areas. These fires cause severe impacts on local biodiversity, damaging forest habitats, reducing wildlife populations, and degrading soil and vegetation cover.

This indicator assesses the extent of burned areas in Pakse City between 2023 and 2025 by analyzing Sentinel-2 satellite imagery. The Burn Area Index (BAI) is applied as a key measure of biodiversity loss and ecosystem



Mean Species Abundance (MSA) index Pakse city

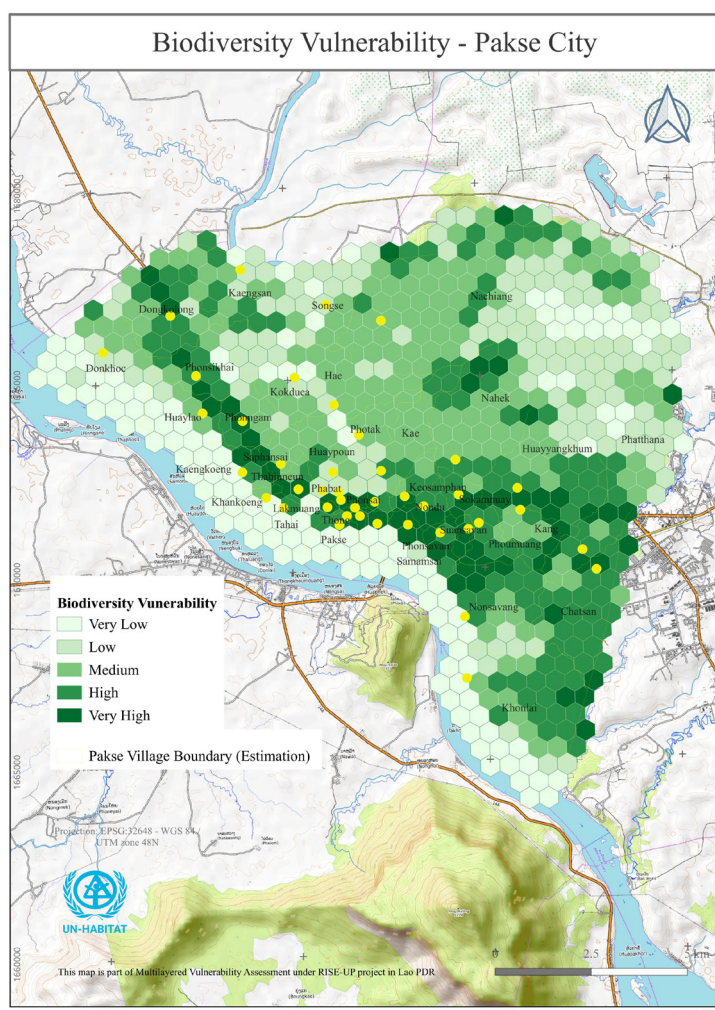
a value of 0 represents the complete loss of native species. For this assessment, the index was inverted so that higher values correspond to greater vulnerability, highlighting areas where biodiversity is under greater pressure.

the map on the left illustrates the vulnerability scores using a grayscale heat map, where brighter areas signify higher levels of vulnerability. The data reveal that species abundance is concentrated in the northeast of Pakse City, an area characterized by primary forest and minimal human disturbance. Conversely, abundance levels are significantly lower within urban centers, where dense infrastructure and concrete surfaces predominate.

3.1.3 Mean Species Abundance (MSA) index

This indicator as shown in the map above draws on a global dataset from the Global Biodiversity Information Facility (GBIF), with the latest release in 2020 based on data collected in 2015. Within the biodiversity index, the Mean Species Abundance (MSA) indicator is assigned an equal weight of 1, consistent with other indicators used in this analysis.

The MSA is a crucial measure of biodiversity, reflecting the average abundance of original species in a given area relative to their abundance in undisturbed ecosystems. An MSA value of 1 (100 per cent) indicates a fully intact ecosystem, while



Pakse vulnerable communities – biodiversity dimension

3.2 Biodiversity dimension analysis

The map above indicate that the most vulnerable biodiversity hotspots are concentrated in built-up areas within the city's urban core as well as in many peri-urban centers. These zones receive high vulnerability scores from both NDVI and the Mean Species Abundance (MSA) index, largely due to minimal or absent tree cover, which prevents them from sustaining healthy ecosystems or supporting biodiversity. Additional hotspots appear in agricultural areas, especially open paddy fields, where deforestation and land conversion have encroached on green spaces, damaged or destroyed habitats and ecological corridors, and significantly reduced biodiversity. In certain forested regions, elevated hotspot scores are associated with burn activities detected by the Burn Area

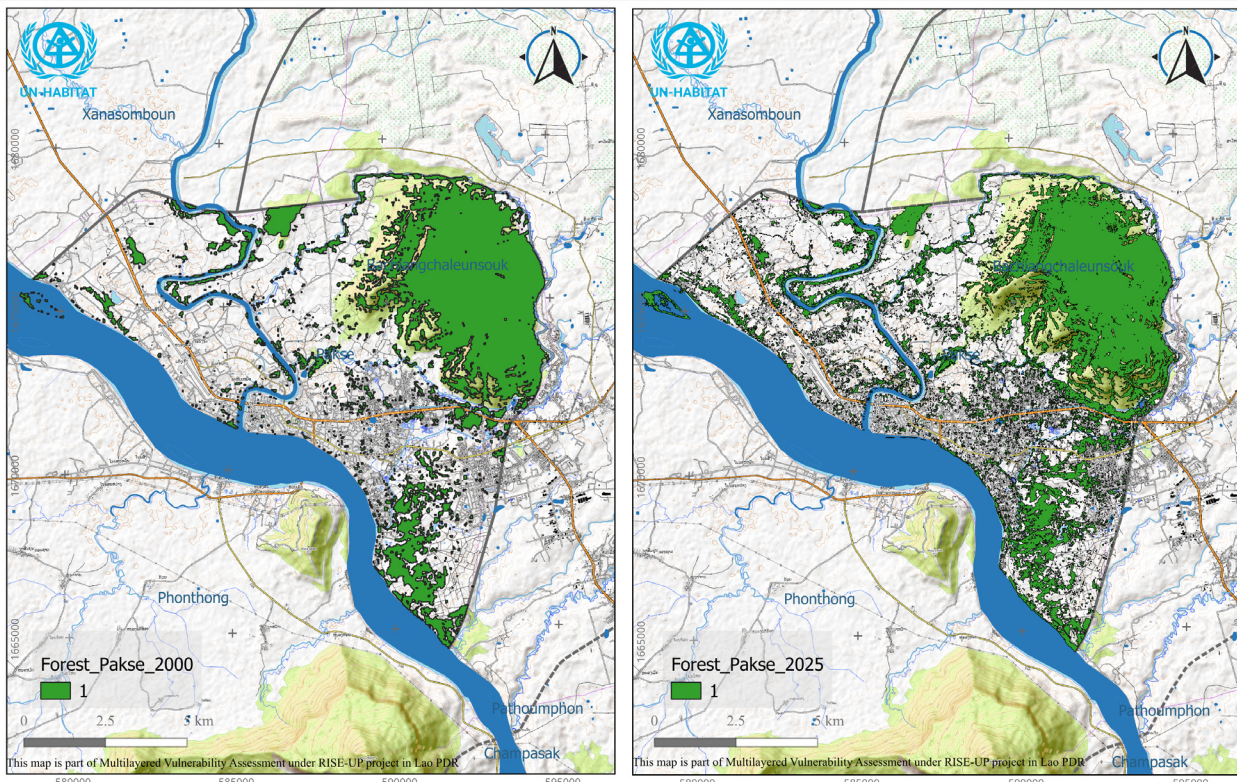
Index (BAI). Such fires, commonly set during the dry season to improve agricultural soils, often escape into adjacent forests, resulting in damage to wildlife and ecosystems. This corresponds with observations from Nahaek and Kaengsun communities, who reported noticeable reductions in nearby wildlife, increased land-burning activities, and changes to natural areas around their villages. These findings also align with patterns observed in Kaysone city, which shares a similar urban growth rate, size, and local conditions.

Based on the analysis, very high-vulnerability hotspots under the biodiversity dimension are partially found in several villages across Pakse City. These include Thong, Thahineun, Sokamnuay, Saphanxai, Phonngam, Phonxai, and Dongkalong (See map above).

3.3 Biodiversity future vulnerabilities

The future of biodiversity in Pakse City will be shaped by the combined pressures of rapid urbanization, agricultural expansion, and climate change. As shown in the forest cover map (page 49), forest cover in the city has not changed significantly over the past 25 years. This stability is largely because much of the original lowland forest was cleared for agriculture centuries ago, leaving only fragmented patches of forest in the surrounding mountainous areas that are protected and less accessible for cultivation. Despite this, biodiversity remains under threat. Without effective management, the remaining lowland forests - particularly those located near existing agricultural zones - are likely to face further conversion into farmland or settlement areas. This continued loss of natural habitats would accelerate biodiversity decline. Moreover, built-up areas with limited tree cover already record low Mean Species Abundance (MSA) values, suggesting reduced ecological integrity. As urban growth continues to expand outward from the city core, these pressures are expected to intensify, highlighting the need for proactive strategies to safeguard remaining ecosystems and maintain ecological resilience.

Pakse Forest Cover in 2000 and 2025



Pakse forest cover in 2000 and 2025

Biodiversity in Pakse City faces increasing threats due to rapid urbanization and land-use change. As the city expands outward, natural habitats are being fragmented or completely replaced by built-up areas, reducing the capacity of ecosystems to support native species. Agricultural intensification, particularly the conversion of forests into open paddy fields, has further diminished ecological diversity and tree cover, which are essential for sustaining biodiversity. Seasonal burning practices, commonly used to clear land or enhance soil fertility, add another layer of risk. These fires often escape beyond agricultural fields, spreading into nearby forests and causing extensive damage to wildlife and habitats. Climate change compounds these pressures, as rising temperatures, prolonged droughts, and irregular rainfall patterns stress ecosystems, leaving them more vulnerable to degradation and invasive species. Without careful management, these challenges are likely to result in continued biodiversity loss in both urban and peri-urban areas.

Despite these challenges, there are significant opportunities to conserve and restore biodiversity in Pakse. Expanding urban greening initiatives, such as creating tree-lined streets,

green corridors, and wetland restoration projects, could provide vital habitats within the city while improving ecosystem resilience. Promoting sustainable agricultural practices, including agroforestry and alternatives to field burning, offers another pathway to balance food production with biodiversity protection. Protecting remaining forest patches, riverbanks, and wetland ecosystems can serve as ecological buffers and safe havens for native species, helping to maintain ecological connectivity. Community participation also presents a valuable opportunity, as raising awareness and involving local people in conservation efforts can foster more sustainable land management practices. Finally, integrating biodiversity considerations into urban planning and climate adaptation strategies will be essential to ensure that the city's future growth does not come at the expense of its ecological health. With proactive measures, Pakse has the potential to secure a more resilient and biodiverse future.

04

Overlapping vulnerabilities

4.1 Urban and climate change vulnerabilities

Spatial analysis of vulnerability in Pakse City shows that some community are highly vulnerable under both the urban and climate change dimensions such as Kaengsun, Photak, Kokdeua, Hae, Houaypoun and Phonngam. The urban and climate hotspots map (page 51) presents the results of the overlapping analysis, where blue tones indicate higher climate vulnerability, orange tones indicate higher urban vulnerability, and darker mixed colours highlight hotspots where both urban and climate vulnerabilities are high, representing areas of compounded risk.



Vulnerable house in Pakse village community (traditional/old house)

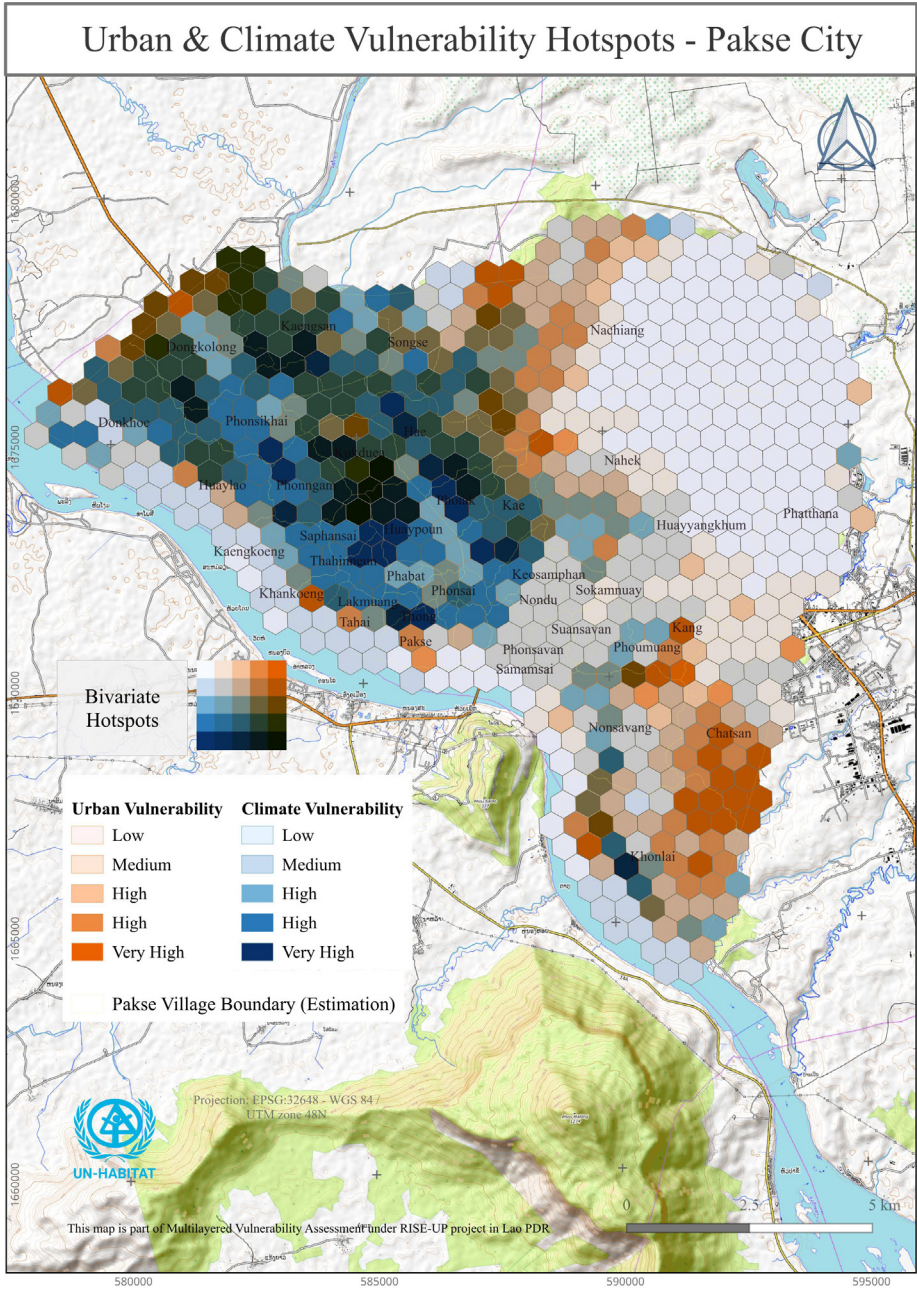
This is largely due to fast and often unregulated urban growth, which has resulted in weak infrastructure, limited basic services, and low availability of green spaces, especially in new and peri-urban settlements. Affordable land near the Xedon and Mekong rivers, as well as along natural streams, continues to draw low-income families, young households, and new migrants who seek inexpensive housing close to jobs in the city. However, much of Pakse is already flood-prone, and weak enforcement of land-use regulations allows construction in these high-risk areas. At the same time, poorly maintained drainage systems, lack of paved roads, and limited public service coverage and provision worsen the risks. The replacement of natural vegetation with bare land and impermeable concrete further raises surface temperatures, intensifying heat stress. High population density adds additional pressure on already inadequate infrastructure, lowering the overall adaptive capacity of communities. This pattern was strongly reflected in the community consultation in Pakse Village, where residents reported frequent flooding around older homes and slow drainage during heavy rainfall, demonstrating how ageing infrastructure amplifies climate risks in dense urban areas.

In peri-urban zones with limited paved roads and low access to services, the interaction between urban vulnerability and climate hazards is even more pronounced. Residents of Nahaek Village described how uncollected waste often blocks unmanaged natural creek

channels, causing water to overflow into houses during the rainy season, while Kaengsun Village residents explained that unpaved roads become impassable during floods, restricting mobility and emergency access. These examples demonstrate how urban service gaps magnify climate-related impacts, resulting in greater overall vulnerability.

urban planning, and climate-related hazards highlights the critical need for integrated solutions that combine resilient infrastructure, effective flood management, and inclusive land-use planning to safeguard the long-term resilience of Pakse’s most at-risk villages.

The overlap of socio-economic vulnerability, insufficient



Urban & climate vulnerabilities hotspots



Interviewing Village Authorities of Kaengsun

4.2 Climate change and biodiversity vulnerabilities

Spatial analysis of vulnerability in Pakse City shows that communities such as Kaengsun, Photak, Hae, Dongkalong, Pakse Village, and others are highly exposed to both climate change impacts and biodiversity loss. The map in page 53 presents the overlapping analysis of climate and biodiversity vulnerabilities. Blue tones indicate higher climate vulnerability, while green tones represent higher biodiversity vulnerability. Darker mixed colours highlight hotspots where both climate and biodiversity vulnerabilities are high, indicating areas of compounded environmental risk that may require integrated climate adaptation and ecosystem protection measures.

The overlap between climate and biodiversity vulnerabilities is particularly pronounced in areas where declining vegetation cover has reduced natural protection against extreme weather. Indicators such as low NDVI, elevated burn activity, and declining habitat quality weaken the city's ecosystem resilience, increasing susceptibility to drought, heat, and flooding. During community consultations, residents in Nahaek and Kaengsun reported increased burning of nearby fields and noticeable reductions in tree cover, which they believe have intensified local temperatures and reduced shade-observations that

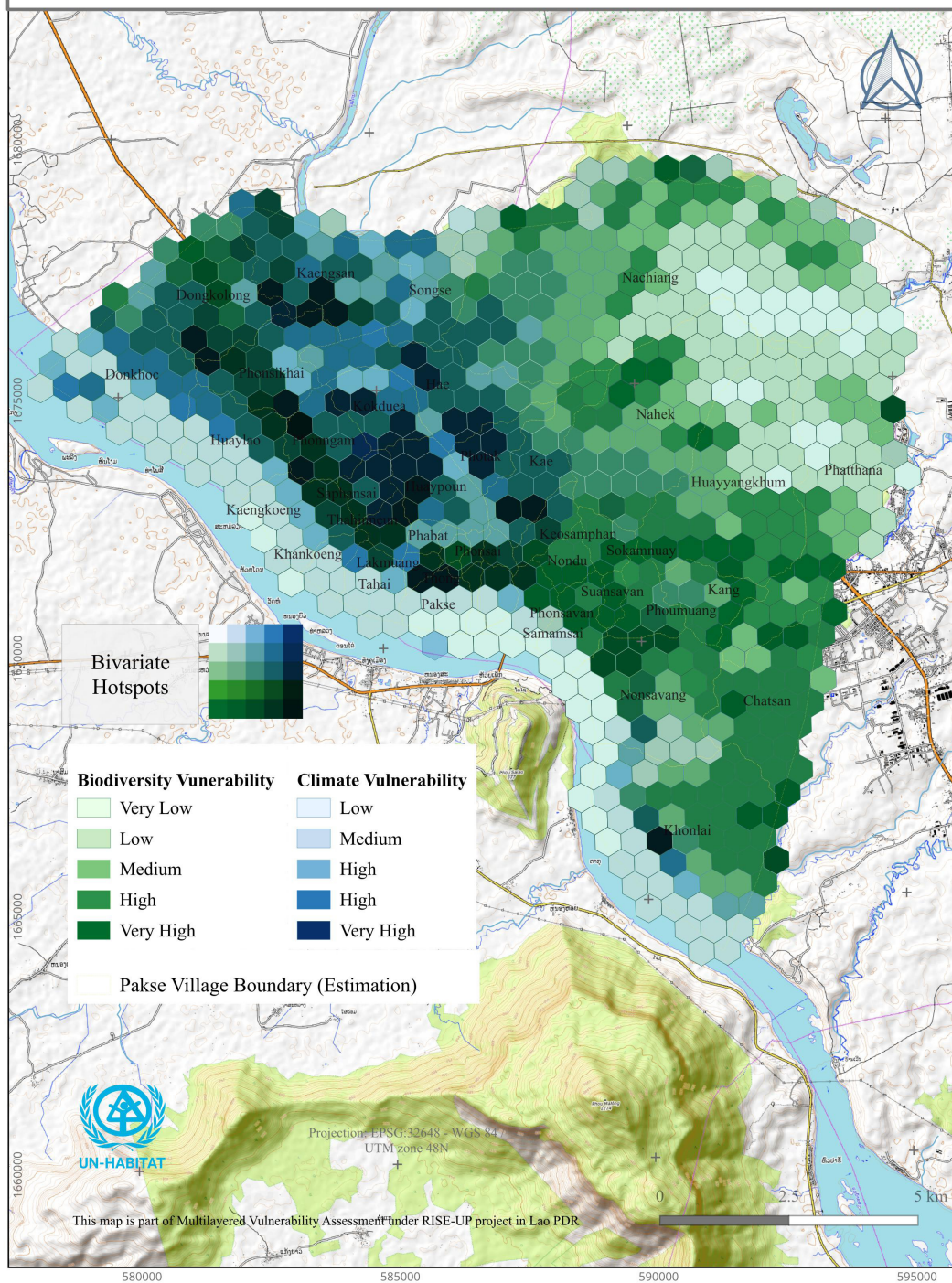
align with mapped land surface temperature hotspots.

Much of this vulnerability stems from rapid and largely unregulated urban expansion, which has transformed most lowland forests into agricultural land over the past centuries. The remaining natural forest areas are now constrained to steep, mountainous terrain that is difficult to cultivate, while accessible lowland forests near farms and settlements continue to be cleared. Affordable land prices in flood-prone zones and along waterways-combined with the need to remain close to employment opportunities in the urban core-have drawn low-income households, new settlers, and young families to these hazard-prone areas, further reinforcing patterns of environmental and climate vulnerability.

Although a 12 km embankment was built along the Mekong and Sedon rivers between 2016 and 2022 to protect the central urban area, its coverage is limited. While it can mitigate smaller flood events, high water levels still flow through unprotected peri-urban zones and inundate the lower parts of the city where drainage systems are inadequate.

Satellite-derived indices-including the Normalized Difference Vegetation Index (NDVI), Burned Area Index (BAI), and Mean Species Abundance (MSA)-further indicate that these villages suffer from low vegetation cover, recent burn scars, and degraded ecosystems with declining biodiversity. The combined pressures of climate-driven hazards (flooding, heat stress, and drought), ecological degradation (deforestation, fires, and habitat fragmentation), and increasing population density heighten both environmental and social vulnerability. Addressing these risks requires an integrated, long-term strategy that strengthens urban drainage, restores natural ecosystems, enforces land-use regulations, and promotes inclusive planning to safeguard the resilience of Pakse's most vulnerable communities.

Biodiversity & Climate Vulnerability Hotspots - Pakse City



Climate & biodiversity vulnerabilities hotspots - Pakse city



Consultation with village authorities in Nahaek village

4.3 Biodiversity and urban vulnerabilities

In Pakse City, hotspots of high urban and biodiversity vulnerability are concentrated in Chatsan, Phonmuang, Khonlai and Nonsavang, which have been identified as highly vulnerable across both dimensions.

The map in page 55 presents the overlapping analysis of urban and biodiversity vulnerabilities. Orange tones indicate higher urban vulnerability, while green tones represent higher biodiversity vulnerability. Darker mixed colours highlight hotspots where both urban and biodiversity vulnerabilities are high, indicating areas of compounded risk where urban development pressures intersect with ecological degradation.

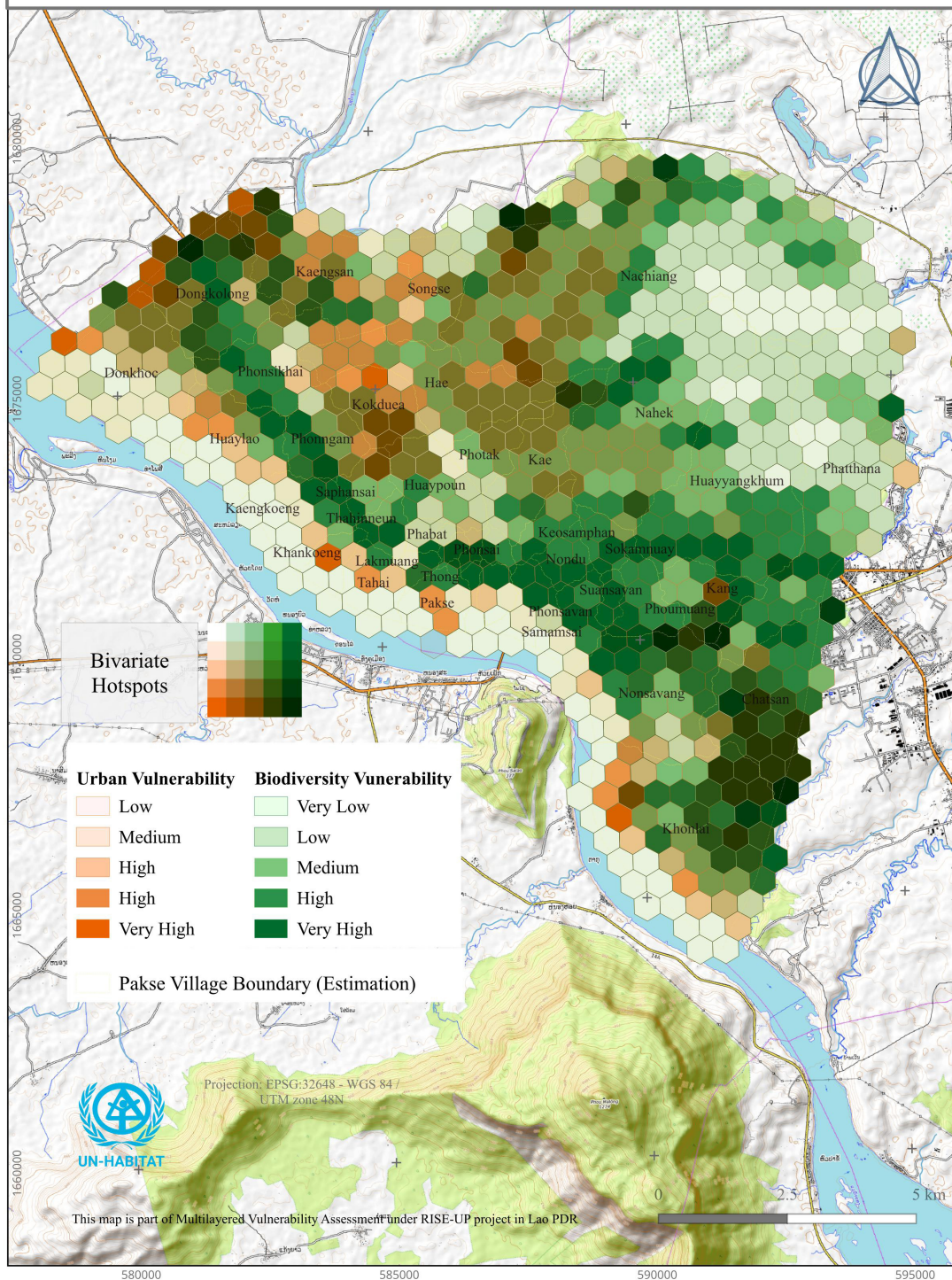
This dual vulnerability stems from overlapping pressures: rapid, unregulated urban expansion and widespread ecological degradation.

For an urban perspective, many of these villages are located in newly developed peri-urban areas or close to expanding trade centres, where infrastructure has not kept pace with population growth. As a result, residents often face limited access to essential services such as paved roads, a reliable water supply, and adequate waste management. Since most of these settlements are

still linked mainly by dirt roads, they remain difficult to access and are especially prone to service disruptions during the rainy season. High population density further intensifies the pressure on already fragile infrastructure and increases health risks through the urban heat island effect, which is worsened by the scarcity of green spaces.

From an ecological perspective, these same villages show declining resilience. Remote-sensing indicators-including the Normalized Difference Vegetation Index (NDVI), Burned Area Index (BAI), and Mean Species Abundance (MSA)-highlight low vegetation cover, recurring fire damage, and ongoing habitat fragmentation. The loss of tree cover in both urban and peri-urban areas has degraded habitats and reduced ecosystem services. Combined with more frequent floods, heat stress, and drought, these stresses exacerbate risks for both human communities and biodiversity. During the community consultation process, villagers in Nahaek and Kaengsun reported increased burning of nearby fields and noticeable reductions in biodiversity-particularly declining fish populations in the river, which they associated with waste dumping and degraded water quality. They also highlighted ongoing tree cover loss, which they believe has intensified local heat and reduced available shade. These community observations align closely with the mapped land surface temperature hotspots identified in the spatial analysis. Urgent, integrated measures - such as stricter land-use regulation, ecosystem restoration, improved drainage, and better access to basic services - are essential to build long-term resilience in Pakse's most vulnerable villages.

Urban & Biodiversity Vulnerability Hotspots - Pakse City



Urban & biodiversity vulnerabilities hotspots - Pakse city

05

Multilayered vulnerability hotspots

The spatial analysis identifies several areas within Pakse where high scores across urban, climate, and biodiversity dimensions overlap to form multilayered vulnerability hotspots. These hotspots are primarily located in rapidly expanding peri-urban zones, low-lying flood-prone neighbourhoods, and areas experiencing loss of vegetation cover (primarily found in the following villages: Kaengsun, Dongkalong, Houaypoun, Kokduea, Pakse, Hae, Photak, Phonxai). the map in page 57 presents the multilayered vulnerability analysis for Pakse City, combining urban, climate, and biodiversity dimensions. Lighter shades indicate lower overall vulnerability, while darker red tones represent higher and very high multilayered vulnerability. The darkest areas highlight hotspots where multiple risks overlap, indicating locations most exposed to compounded pressures from climate hazards, urban service deficits, and environmental degradation, and therefore priority areas for integrated resilience interventions.

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

In the urban core, Pakse Village demonstrates how ageing infrastructure, limited drainage capacity, and high population density intersect with climate hazards such as recurrent flooding and rising temperatures. Residents reported that heavy rainfall can cause water to accumulate in the flood prone area, while the lack of urban trees and green space exacerbates heat stress - illustrating an overlap of urban and climate vulnerabilities.

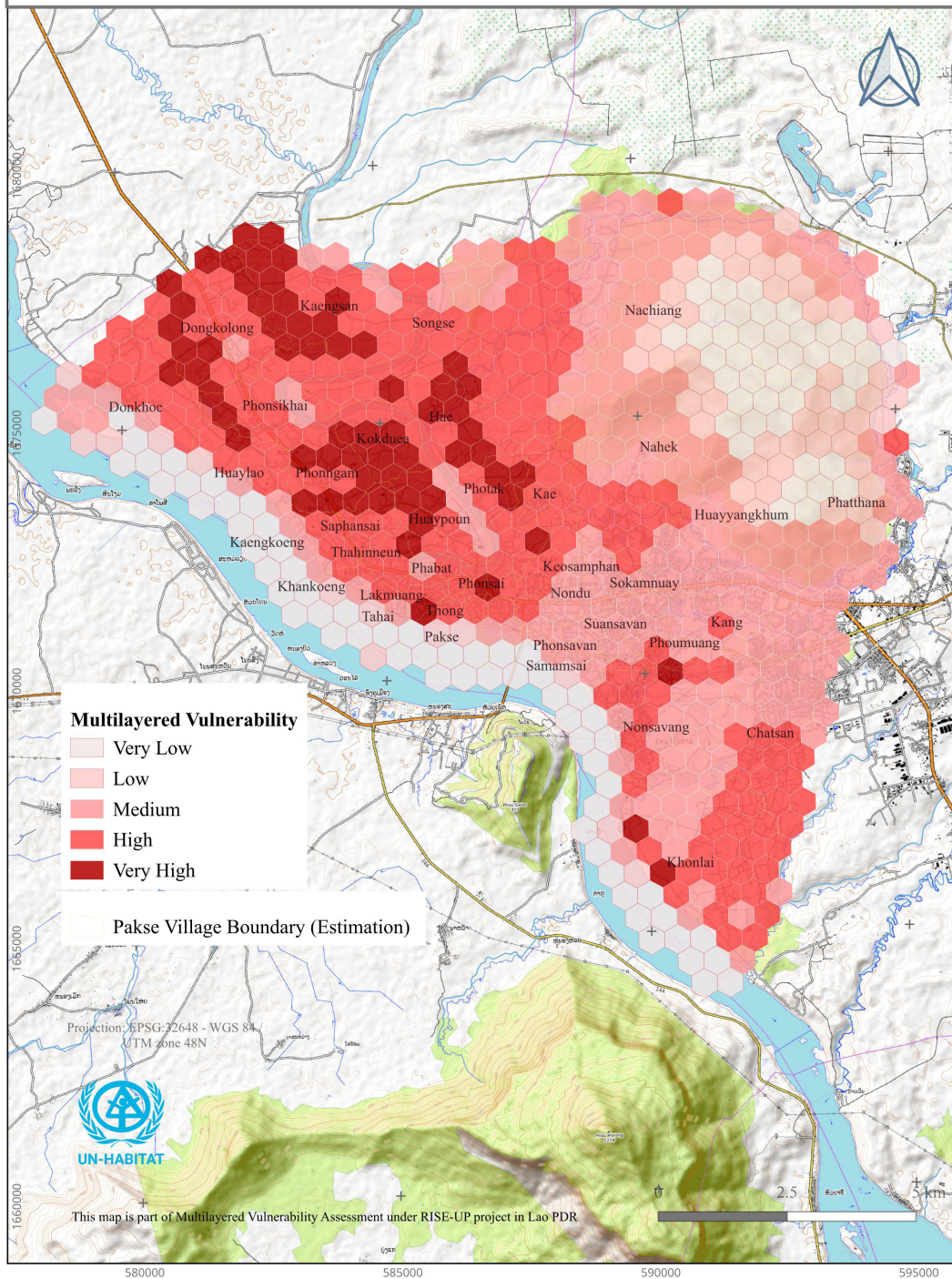
In peri-urban communities, multilayered vulnerabilities are even more pronounced. In Nahaek Village, the combination

of unpaved roads, unmanaged waste, seasonal flooding, and visible ecosystem degradation (including erosion along natural creeks and reduced wildlife presence) demonstrates how urban, climate, and biodiversity challenges reinforce one another. Residents explained that waste carried by stormwater often clogs natural drainage channels, which amplifies flood severity and reduces water quality - linking all three vulnerability dimensions.

Similarly, Kaengsun Village faces converging pressures, with poor road access, frequent inundation of dirt roads, and reduced vegetation cover contributing to increased exposure and reduced resilience. Community members noted that during severe rains, road access becomes restricted, preventing movement to schools or health centres, while loss of nearby vegetation has worsened heat and reduced wildlife - highlighting multiple overlapping vulnerabilities.

Together, the spatial analysis and community insights demonstrate that multilayered vulnerability hotspots are not only areas of theoretical risk but also locations where daily hardships and climate impacts are already tangible. These findings underscore the importance of integrated, cross-sectoral interventions that address infrastructure deficits, climate resilience, and ecosystem protection simultaneously.

Multilayered Vulnerability - Pakse City



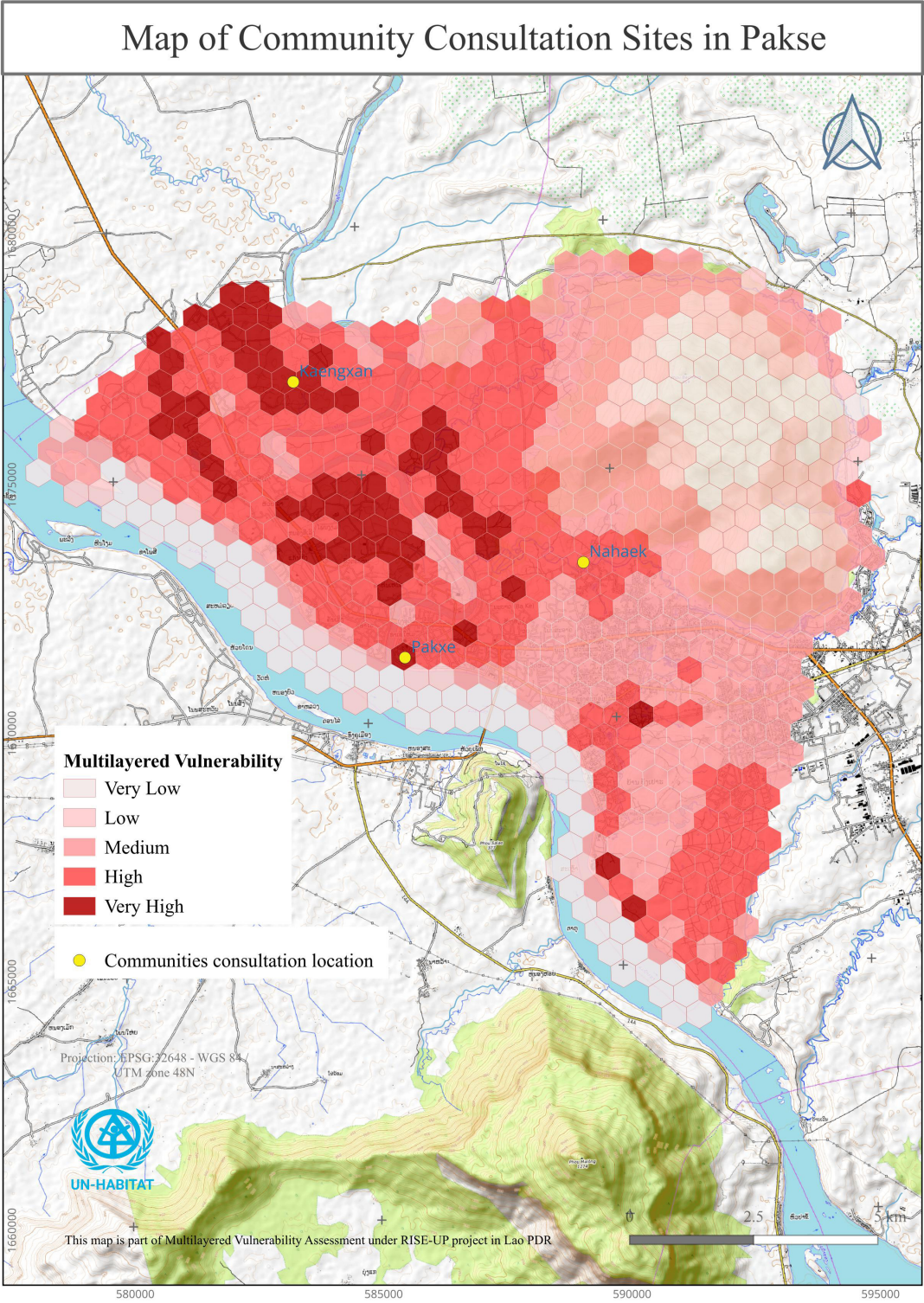
Multilayered vulnerabilities hotspots in Pakse city

Common Issues Identified in Community Consultations

Themes	Pakse village (urban core)	Nahaek village (peri-urban)	Kaengsun village (peri-urban)
Climate vulnerabilities	▪ Frequent flooding in urban area ▪ Slow drainage during heavy rain ▪ Heat stress due to limited green space	▪ Seasonal flooding from natural creek overflow ▪ Blocked waterways increase flood levels ▪ Erosion of creek banks after storms	▪ Roads become impassable during rain ▪ Flooding restricts mobility & access to services ▪ Strong heat exposure due to limited tree cover
Urban vulnerabilities	▪ Ageing infrastructure (drainage, roads, housing) ▪ Limited shade along streets ▪ High density placing pressure on services	▪ Unpaved roads worsening during rainy season ▪ Waste accumulation along roads and creeks ▪ Limited waste collection services	▪ Poor connectivity and limited paved roads ▪ Waste issues along village roads ▪ Restricted access to schools/healthcare during rain
Biodiversity / environmental vulnerabilities	▪ Limited green space in the urban core ▪ Loss of shade trees contributing to heat	▪ Reduction in local wildlife ▪ Increased burning in surrounding agricultural areas ▪ Degraded natural drainage channels	▪ Decreasing vegetation cover around settlement ▪ Fewer wildlife sightings ▪ Land clearing and field burning nearby

These multilayered vulnerabilities do not affect all community members equally. Consultations revealed that women, youth, elderly residents, low-income households, and people with disabilities face heightened challenges in hotspot areas. Limited mobility during floods, unsafe or inaccessible road conditions, and the burden of caregiving during climate shocks disproportionately affect women and the elderly. Youth often experience disruptions to schooling when roads become impassable, while low-income households have fewer resources to repair damaged homes or adapt to recurring hazards. People with disabilities are particularly at risk in areas with poor connectivity and inadequate drainage, where evacuation and access to essential services become significantly more difficult.

Looking ahead, projected climate change is likely to compound these existing challenges. Increases in the frequency and intensity of flooding, heatwaves, and extreme rainfall events may further strain already limited infrastructure and services in these villages, exacerbating access constraints and livelihood disruptions. Without targeted adaptation measures, vulnerable groups may face escalating risks, as repeated climate shocks reduce household resilience, deepen poverty, and limit long-term adaptive capacity. These insights highlight the need for resilience strategies that address the impacts of climate change on vulnerable groups.



Map of community consultationc sites in Pakse city

06

Conclusion

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

A key strength and 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 lived experiences on the ground. Issues such as frequent flooding, inadequate drainage, unpaved roads, limited access to basic services, unmanaged waste, rising heat, and visible environmental degradation were repeatedly raised by communities and closely aligned with the spatial patterns shown in the vulnerability maps. This consistency between data-driven analysis and community perspectives strengthens the credibility of the assessment and ensures that it is both technically robust and socially grounded.

The findings indicate that rapid and largely unregulated urban expansion has placed increasing pressure on infrastructure, services, and the natural environment in Pakse City. Peri-urban and newly developed areas are particularly vulnerable due to poor road connectivity, limited drainage systems, weak waste management, and restricted access to green space. At the same time, low-lying areas along the Mekong and Xe Don rivers and connected natural streams face high flood risk, while rising land surface temperatures and declining vegetation cover are intensifying heat stress and environmental degradation. Biodiversity loss, driven by land-

use change, burning, and habitat fragmentation, further reduces the ecosystem services that support climate resilience.

Another major outcome of this MVA is the identification of multilayered vulnerability hotspots, where risks across urban, climate, and biodiversity dimensions overlap. These areas face compounding pressures from climate hazards, urban poverty, and ecological degradation. The fact that communities located within these hotspots also reported the greatest day-to-day challenges demonstrates that the hotspot approach is both analytically sound 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 Pakse City authorities to identify priority actions based on the city's specific context. This will support the development of targeted proposals to attract donor investment and address the challenges identified and prioritised through the MVA process.

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 Pakse from 15–17 November 2025. Engagement was semi-structured and included interviews, focus groups, and on-site observations facilitated by the Pakse City Office. The selection of target villages was carried out in consultation with Pakse City authorities to ensure that the chosen villages represent key community challenges related to urban development, climate change, and biodiversity.

List of Communities, we have consulted with:

Date	Agenda	Team
15 Nov 2025	Data collection in Pakse Village (Case – Urban Flood – community and key facility – drainage systems – Waste management)	Pakse city
16 Nov 2025	Data collection in Nahaek Village (Case – Uran flood flash flood from the mountain)	Pakse city
17 Nov 2025	Data collection in Kaengsun Village (Case – Uran flood flash flood from Xedon River)	Pakse city

1. Pakse village (15 november 2025)

Primary Issue: Urban Flooding, Drainage Failures, Waste Management

Climate change

Flooding Frequency is every 5–8 years; in the 2019 flood has major impacts on 20 households and agricultural areas.

Urban issues

Drainage failure and smelly wastewater; waste collected but inefficient.

Biodiversity

Located near the Mekong River; no major forest loss but pollution present.

Local capacity

Community cooperates during floods; receives warnings from city/provincial sources.

Support Needed

- Water pumps for floodwater removal
- Waste collection improvements
- Drainage/sewage system upgrade
- Environmental hygiene support
- River pollution monitoring and cleanup initiatives

2 Nahaek village (16 november 2025)

Primary Issue: Flash Floods from Mountain Runoff and River

Climate change

Floods every 5–8 years; heatwaves every 3–5 years; impacts include asset loss and damaged houses.

Urban issues

Moderate roads; burning of waste; wastewater affecting natural creek.

Biodiversity

Creek and mountain forest nearby; wastewater pollution emerging.

Local capacity

Hazard committee plus army support; active community cooperation.

Support needed

- Evacuation centre for people and belongings
- Rubber boats
- Flood protection embankments
- Waste collection trucks to reduce burning
- Creek rehabilitation/wastewater control
- Road upgrades and improved drainage

3 Kaengsun village (17 november 2025)

Primary Issue: River Flooding from the Xe Don River

Climate change

Frequent floods damage agriculture and roads, alongside heatwaves and storms.

Urban issues

Poor, unpaved roads; no waste collection system; partial water supply.

Biodiversity

River nearby; noticeable fish decline; waste dumping and soil erosion observed.

Local capacity

Village hazard committee active; community works together; regular announcements.

Support needed

- Rubber boats and flood emergency equipment
- Road improvement and paving
- Village waste collection system
- Drainage improvement
- Tree planting along village roads
- Support for waste and river pollution mitigation

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 Pakse and Pakse city.**

Criteria for measurement:

Green Score is assigned to the following:

GREEN SCORING CONDITIONS | (Simplified & Minimal)

	500x500 m GRID AREA > 100 SQ M → 1 GREEN SCORE ⊖ → 0 SCORE	 For the area in the 500x500 sq m grid, a cell with a green area exceeding 100 sq meters is assigned a green score of 1. Cells that do not meet this condition are assigned a score of 0.
	750x750 m GRID AREA > 100 SQ M → 0.75 GREEN SCORE ⊖ → 0 SCORE	 Outside of the 500x500 cell, for the area in the 750x750 sq m grid, if a cell has a green area exceeding 100 sq m, it is scored. Cells that do not meet this condition are assigned a score of 0.
	1000x1000 m GRID AREA > 100 SQ M → 0.5 GREEN SCORE ⊖ → 0 SCORE	 Outside of the 500x500 and 750x750 cells, for the area in the 1000x1000 sq m grid, if a cell has a green area exceeding 100 sq m, it is scored. Cells that do not meet this condition are assigned a score of 0.
	1500x1500 m GRID AREA > 100 SQ M → 0.25 GREEN SCORE ⊖ → 0 SCORE	 Outside of the three preceding green cells, for the area in the 1500x1500 sq m grid, if a cell has a green area exceeding 100 sq m, it is assigned a 0.25 green score. Cells that do not meet this condition are assigned a score of 0.

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.
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;

ANNEX 4

Methodology for community vulnerability by road type

Data used:

OpenStreetMap: Road lines

Google Earth Imagery – Latest 2025

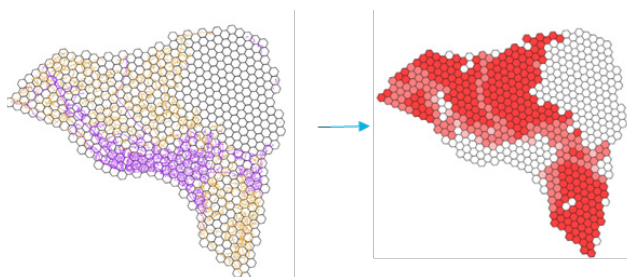
The boundary of Pakse and Pakse city

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:

$$\text{Proportion of Dirt Road} = \frac{\text{Dirt Road Length}}{\text{Total Road Length}}$$

$$\text{Proportion of Dirt Road} = \frac{\text{Dirt Road Length}}{\text{Dirt Road Length} + \text{Paved Road Length}}$$

(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

A. Raster processing (ArcGIS)

1. Data Download (Landsat 8)

Access USGS Earth Explorer and log in
Define Area of Interest (AOI) using polygon
Set date range and cloud cover (≤ 30 per cent)
Select dataset: Landsat 8–9 OLI/TIRS Collection 2 Level-2
Download required files:
MTL.txt
Bands 1–7 (TIF)

2. Image Processing in ArcGIS

Load Bands 1–7 into ArcGIS
Use Composite Bands tool -> combine bands
Set display: Band 5 (R), Band 4 (G), Band 3 (B)
If multiple scenes:
Apply Histogram Equalization for consistent contrast
Use Mosaic to New Raster to merge images

B. Land Surface Temperature (LST) estimation

Step 1: TOA Radiance

Convert Band 10 DN values to radiance:

Uses rescaling factors from metadata
Step 2: Brightness Temperature (BT)

Convert radiance -> temperature (Kelvin -> °C)

Uses thermal constants (K_1 , K_2)

Step 3: NDVI Calculation

$NDVI = (Band\ 5 - Band\ 4) / (Band\ 5 + Band\ 4)$

Represents vegetation density

Step 4: Land Surface Emissivity (LSE)

Compute vegetation proportion (PV) from NDVI

Calculate emissivity:

$E = 0.004 \times PV + 0.986$

Step 5: Land Surface Temperature (LST)

Combine BT + emissivity to derive LST

Uses wavelength and physical constants

C. Urban Heat Island (UHI) calculation

Step 6: UHI Intensity

$UHI = (LST - \text{mean } LST) / \text{standard deviation}$

Identifies hotter urban areas relative to surroundings

Key Idea (Simple Flow)

Satellite data -> Raster processing ->

Temperature extraction -> Vegetation

correction -> LST -> UHI mapping

ANNEX 6

Community consultation questionnaires

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.

Video Recording:

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

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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