



Lao People's Democratic Republic
Peace Independence Democracy Unity Prosperity

Climate Risk Vulnerability Assessment

Agriculture and Forestry, Urban Development and Transport, and Water Resources in Lao PDR

Department of Environment,
Ministry of Agriculture and Environment
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CLIMATE RISK VULNERABILITY ASSESSMENT

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Prepared under the guidance of:

Department of Environment (DoE), Ministry of Agriculture and Environment, Government of Lao PDR



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Your Sincerely,



Ms. Phakkavanh Phissamay

**Director General, Department of Environment,
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Executive Summary

Climate change Context in Lao PDR

Lao PDR faces mounting climate risks that increasingly threaten the country's sustainable development trajectory and the resilience of its population. Its geographic diversity and socio-economic dependence on natural resources, particularly in agriculture, forestry, and water, make it highly vulnerable to climate variability and extremes. The country is already experiencing the adverse impacts of climate change, marked by both slow onset shifts and more frequent extreme weather events.

Observed trends include rising mean temperatures (approximately +1°C since 1950), shifting rainfall patterns, and increased incidence of floods, droughts, landslides, and heatwaves. Climate projections under RCP 4.5 and 8.5 scenarios suggest continued warming, with average temperatures expected to rise by 1.5°C to 2.5°C by mid-century under moderate emissions, and potentially up to 5°C by 2100 under high-emissions pathways (SSP5–8.5). Rainfall patterns are becoming more erratic, with historical declines of over 200 mm annually and future projections indicating more intense wet-season rainfall and prolonged dry periods. These changes are already translating into longer droughts, intensified heatwaves, and shifts in seasonal cycles—posing significant risks to food and water security, ecosystems, and human health.

The economic toll of these hazards is growing rapidly. Between 2009 and 2018, annual losses from disaster events, particularly floods and droughts, nearly quadrupled, from USD 94 million in 2009 to USD 371.5 million in 2018 equivalent to 2.1% of the national GDP and 10.2% of the national budget in that year (NDC Implementation Plan, 2024). Floods, droughts, and landslides are among the most pressing hazards, increasingly affecting both urban and rural areas. Riverine flooding is exacerbated by altered rainfall-runoff dynamics and upstream hydropower development, while flash floods frequently impact urban centers like Vientiane, Savannakhet, and Champasak. Upland provinces such as Xiengkhouang and Phongsaly face heightened exposure to prolonged dry spells, erosion, and landslides.

These projected climatic changes pose significant challenges to infrastructure, agriculture, water resources, and biodiversity. A comprehensive understanding of the country's evolving climate landscape is therefore critical to guide national adaptation planning, prioritize sectoral interventions, and strengthen resilience at all levels of society.

Climate Risk Vulnerability Assessment Report rationale

Developed by the Department of Environment, Ministry of Agriculture and Environment (MAE) with support from GGGI and Groupe Huit, this CRVA is aligned with Lao PDR's national climate priorities and the guidelines of the National Adaptation Plan (NAP).

The Climate Risk and Vulnerability Assessment (CRVA) report for Lao PDR presents a comprehensive evaluation of the current and future climate-related risks faced by three key sectors: Agriculture and Forestry, Water Resources, and Urban Development and Transport. This assessment is a foundational component under Output 3.1 of the Readiness project and is essential for informing the upcoming development of Sectoral Adaptation Guidelines and Plans (SAPs) under Output 3.2.

The study uses a combination of geospatial analysis, sectoral indicators, stakeholder engagement, and modeling to understand vulnerability at the provincial level, with particular attention to flood and drought hazards. The assessment integrates scientific climate projections with stakeholder-led inputs and uses a methodological framework combining qualitative and quantitative analysis. Building upon the findings of the Situation Analysis Report and sectoral consultations, which provided valuable local insights and validation of vulnerability factors,

this assessment identifies the main climate hazards affecting each sector and evaluates their likelihood and projected evolution under different climate scenarios.

Methodology and Approach

The CRVA evaluates the exposure of key sectors to climate hazards, alongside their vulnerability (defined through sensitivity factors and adaptive capacity). By combining these dimensions, the assessment identifies the level of climate-related impacts and risks for each sector. These findings are essential for informing a preliminary set of adaptation priorities, which will serve as the foundation for the next phase of the project: the development of Sectoral Adaptation Guidelines and Plans.

The analysis integrates both historical data and future projections based on the CMIP6 climate model under the RCP 4.5 and RCP 8.5 scenarios, aligned with national methodologies such as the *Lao PDR Provincial Storyline-based Climate Risk, Vulnerability and Adaptation Assessment*. The assessment is grounded in the Intergovernmental Panel on Climate Change (IPCC) framework with spatial analyses conducted using QGIS and the K'lim Tool (an in-house, Python-based modeling environment). K'lim processes daily climate variables (e.g., temperature, precipitation, humidity) and derives localized indicators such as seasonal shifts and extreme events. Data sources included ERA5-Land for historical trends and CMIP6 for future climate scenarios.

At the time of the CRVA preparation, a Water Resources sector-specific CRVA was developed in parallel by the Department of Water Resources (DWR). Its findings have been compiled in a complementary annex (see Annex 11), with a comparative analysis to provide additional perspectives on climate risks in the water sector.

Key findings

The CRVA reveals that all three sectors are significantly exposed to climate hazards, with differentiated impacts across provinces and systems. Using geospatial analysis, sector-specific indicators, and stakeholder consultations, the assessment identifies the main vulnerabilities and the urgent adaptation needs.

- ▶ **Agriculture and Forestry** are highly sensitive to droughts, floods, and rising temperatures, which impact crop productivity, livestock and fish stock health, soil stability, and forest biodiversity. Limited irrigation infrastructure and dependency on rain-fed systems exacerbate vulnerability, particularly in provinces like Savannakhet, Xiengkhouang, and Oudomxay.
- ▶ **Urban Development and Transport** is increasingly affected by flash floods, heatwaves, and landslides. Unplanned urban expansion into hazard-prone areas, combined with aging infrastructure and poor drainage, heightens the risk of service disruptions, safety issues, and public health impacts, especially in rapidly growing cities like Vientiane and Pakse.
- ▶ **Water Resources** are under pressure from both climate-induced and human-induced stressors. Seasonal water shortages, water quality degradation, and service disruption are aggravated by inadequate investment in infrastructure, unsustainable land and water management practices, and growing demand during hot seasons.

Climate hazards assessment

Most exposed categories per sector:

- ▶ **Agriculture & Forestry:** Agriculture yields and forest biodiversity.
- ▶ **Urban Development & Transport:** Urban infrastructure, urban clean up and urban ecosystems.
- ▶ **Water Resources:** River and reservoir flow and water quality.

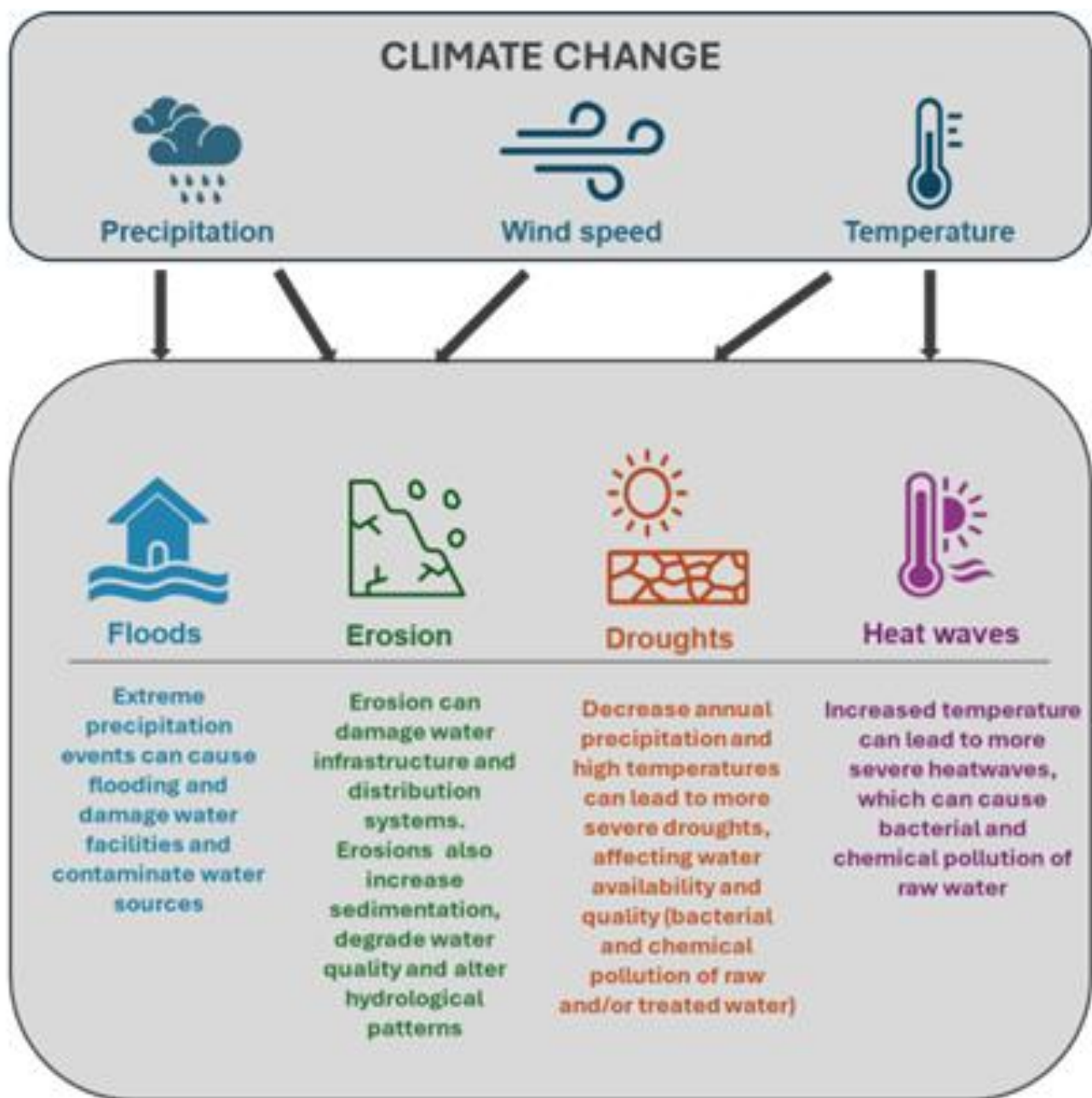


Figure 1 Climate hazards addressed through the study

Source: Internal production

Sectoral Vulnerability

- ▶ **Agriculture and Forestry (high vulnerability):** Highly sensitive to climate variability and extremes (rainfall variability, flooding, heat stress, etc.) coupled with socio economic stressors (insecure land tenure, demographic vulnerabilities, etc.) and with limited adaptive capacity.
- ▶ **Urban Development and Transport (moderate vulnerability):** Important sensitivity to climate hazards coupled socio-economic stressors (aging infrastructure, socio economic gaps, etc.) but attenuated by strong to moderate adaptive capacity mainly thanks to greater access to planning tools (e.g., zoning, urban resilience programs) and investment for risk reduction.

- ▶ **Water Resources (high vulnerability):** Highly sensitive to climate variability and hazards (rainfall variability, flooding, landslides, etc.) coupled with socio economic stressors (hydropower reliance, aging and non-adapted infrastructures, etc.) and limited adaptative capacity with management systems that remain under-resourced and important institutional fragmentation.

Impact evaluation

Climate hazards' main impact on the **Agriculture and Forestry** sectors are the following:

1. Extreme risk: Crop reduction and failure
2. Extreme risk: Soil degradation and loss of arable land
3. High risk: Livestock and Fish stock reduction
4. High risks: Biodiversity loss

Climate hazards' main impact on the **Urban Development & Transport** sectors are the following:

5. High risk: Public health issues for urban population
6. High risk: Infrastructures strains and/ or damages
7. High risk: Services interruption and economic disruption
8. Moderate risk: Safety issues for urban population
9. Moderate risk: Increased energy demand

Climate hazards' main impact on the **Water Resources** sectors are the following:

10. Extreme risk: Reduced River flow and surface water level
11. Extreme risk: Contamination of water resources and degradation of water quality
12. Extreme risk: Infrastructure damage and service disruption
13. High risk: Reduce groundwater availability

Conclusion and first recommendations for sectoral adaptation

Initial recommendations, to be refined in the Sectoral Adaptation Guidelines (next deliverable), include the top ten adaption recommendations scored under the multi-criteria Analysis for each sector and derived from a combination of sources, including the National Adaptation Plan (NAP) developed with UNEP, 5 years plans and strategies of the relevant ministries, and inputs gathered during the CRVA consultation and validation workshops.

Agriculture and Forestry	Urban Development & Transport	Water Resources
Strengthen livestock and fisheries that can adapt to C.C	Create building management regulations (Building Code)	Build sustainable basic infrastructure and develop community water supply
Promote the use of technology in agricultural production	Invest in low-carbon public transport.	Improve the irrigation systems to be more efficient and resilient to C.C
Improve irrigation and storage of excess rainfall to reduce impacts from droughts.	Improve and build urban drainage systems.	Develop small, medium and large-scale community water supply systems
Strengthen regulations on land leases and concessions.	Improve and build model landfills in small towns, second-ranked towns and big towns.	Strengthen legislation and plans on groundwater management and protection.
Promote reforestation in areas exposed to high risks of floods, storms and landslides.	Develop manuals on technical standards for managing the construction and repair of public works and transport infrastructure	Survey, collect data and assess water shortages and suitable areas for building water supply infrastructure.
Strengthen Provincial level control of seasonal burning	Assess the impact of Climate Change on the sector of public infrastructure and transportation.	Implement the adaptation measures against natural disasters to ensure the quality of water resources in the face of floods and droughts.
Apply sustainable forest and land management in the planning process.	Build organizational and personnel capacity to develop and manage infrastructure to be resilient and able to adapt to climate change	Identify areas at climate risk for groundwater quantity.
Utilize climate resilient designed infrastructure	Study and collect data on drainage ditches within the city that are prone to floods during the rainy season in areas across the country.	Identify water and water resources protection zones.
Address landslide resilience in land management plans.	Study and develop standards and techniques for the construction and maintenance of infrastructure.	Create and implement an integrated water resources management plan.
Conduct a pilot study to develop a standardized estimation of the value of loss and damage in agriculture.	Develop regulations, standards and plans for adaptation and investment in the field of public infrastructure and transportation.	Expand meteorological and hydrological stations across the country

Implications for Policy and Investment

This CRVA serves as a foundational step toward informed national adaptation planning. It offers decision-makers, donors, and technical agencies a roadmap for aligning investments with the realities of climate risk, ensuring that Lao PDR's development trajectory is both resilient and inclusive. Findings from this assessment underscore that Lao PDR's development pathway is increasingly shaped by the compounding effects of climate change and human pressures. The assessment calls for a shift from reactive, sector-specific responses to integrated and forward-looking planning frameworks that embed adaptation into development decisions. Strategic Policy implications include:

1. Prioritizing investment in the most vulnerable sectors categories, where climate hazard exposure intersects with institutional or socio-economic fragilities.
2. Mainstreaming risk screening and adaptation priorities into sectoral policies and programs.
3. Strengthening institutional coordination and data systems, especially in water governance and land-use planning and targeting capacity building at subnational levels to support the implementation of climate-resilient practices and enforcement of environmental regulations.
4. Mobilizing climate finance through adaptation projects aligned with the NAP and sectoral strategies.

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Acronyms and Abbreviations

ASEAN	Association of Southeast Asian Nations
CC	Climate Change
CECCAP	Implementation Centric Evolving Climate Change Adaptation Process
CRVA	Climate Risk and Impact Assessment
DEM	Digital Elevation Model
DMH	Department of Meteorology and Hydrology
DOE	Department of Environment
DWR	Department of Water Resources
EbA	Ecosystem-based adaptation
EGDP	Ethnic Group Development Plan
ESA	European Space Agency
FAO	Food and Agriculture Organization of the United Nation
GBV	Gender Based Violence
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEDSI	Gender Equality Disability and Social Inclusion
GIS	Geographic Information Systems
GHG	Greenhouse Gas
GGGI	Global Green Growth Institute
HI	Heat Index
IPCC	Intergovernmental Panel on Climate Change
IWA	International Water Association
IWRM	Integrated Water Resources Management
M&E	Monitoring and Evaluation
MAE	Ministry of Agriculture and Environment
MCA	Multi Criteria Analysis
MEM	Ministry of Energy and Mines
MRC	Mekong River Commission
NAFRI	National Agriculture and Forestry Research Institute
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NBS	nature-based solutions
NBCA	National Biodiversity Conservation Area
NDC	Nationally Determined Contribution

NGO	Non-Government Organizations
NPA	National Protected Area
NPDS	National Power Development Strategy
NSEDP	National Socio-Economic Development Plan
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
PDNA	Post Disaster Needs Assessments
PET	Potential Evapotranspiration
RCP	Representative Concentration Pathways
SAPs	Sectoral Adaptation Plans
SSP	Shared Socio-Economic Pathways
ToR	Terms of references
UHI	Urban Heat Island
UN	United Nations
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nation Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UXO	Unexploded Ordinance
UXO	Unexploded Ordinance
WASH	Water Sanitation and Hygiene
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization
WASH	Water Sanitation and Hygiene
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization

1 INTRODUCTION

1.1 The project

Lao PDR is highly vulnerable to climate change, particularly floods and droughts and completed its second Nationally Determined Contribution (NDC) in 2020 and finalized the National Adaptation Plan (NAP) in 2025 which updates the 2009 National Adaptation Programme of Action (NAPA). As a signatory to the UNFCCC and Paris Agreement, the country is committed to addressing climate change through technical and financial support for adaptation planning. The 2020 NDC highlights challenges in measuring adaptation progress, especially due to a lack of sector-specific adaptation plans and indicators, particularly in agriculture, forestry, urban development, and water resources.

In November 2022, the Green Climate Fund (GCF) approved a project to help mainstream climate adaptation into sectoral planning in Lao PDR, focusing on agriculture, forestry, transport, urban development, and water resources. This project was initially led by the Department of Climate Change (DCC). Following the merger of the ministries, the Department of Environment (DoE) under the Ministry of Agriculture and Environment (MAE) is now the key government implementer of the project with technical assistance from GGGI, aims to enhance climate resilience and develop concept notes for adaptation projects to access GCF funding. It will run for 18 months, ending in November 2025.

Two similar projects are also underway: the UN Habitat's NAP, funded by GCF, and UNEP's NAPs, funded by the Global Environment Facility (GEF). The UNEP project focuses on creating the first national NAP, while the UN Habitat project targets local-level climate vulnerability assessments for disaster risk management in settlements. Both projects aim to support and align with Lao PDR's NAP process.

The goal of this project is to strengthen climate resilience in Lao PDR by incorporating climate change adaptation into the strategic planning of three vulnerable sectors: agriculture and forestry, urban development and transport, and water resources. This will be achieved by conducting a climate risk and vulnerability assessment at the national level. Sectoral adaptation plans will be developed, along with recommendations for integrating them into the sectors' five-year development plans (2025-2030) and relevant strategies to improve their climate resilience. This project will undergo regular validations and exchanges with key stakeholders through various workshops.

The present assignment contributes directly to Outcome 3.2 of the GCF Readiness Project, which aims to strengthen the evidence base for designing impactful adaptation solutions. In particular, this work supports the development of sectoral adaptation action plans in the agriculture & forestry, urban development, and water sectors. This report is aligned with the activities under Output 3.2.1, including the vulnerability and risk assessment and the groundwork for upcoming planning and integration phases.

While the present assignment is designed to inform the implementation of the GCF Readiness project, its methodology and findings are also intended to support broader national planning and policy processes in Lao PDR. The CRVA provides an analytical framework and evidence base that can inform the integration of climate risks into sectoral strategies and planning instruments, including the National Adaptation Plan (NAP), sectoral strategies, and the National Socio-Economic Development Plans (NSEDPP). The approach developed through this assessment may also serve as a reference for future climate risk analyses conducted by national institutions.

1.2 Purpose of the CRVA

The main objective of the climate risk and vulnerability assessment under this project is to identify the primary drivers of exposure and vulnerability to climate change-related hazards in order to inform sectoral adaptation strategies and strengthen the resilience of development planning in the sectors of agriculture and forestry, urban development and transport, and water resources in Lao PDR. By linking climate hazards with sector-specific exposure, sensitivity, and adaptive capacity, the assessment aims to enable the identification of key risk hotspots and underlying vulnerability drivers. The assessment aims to provide an evidence base that supports the integration of climate adaptation measures into the strategic and sectoral planning processes. The CRVA findings are intended to directly inform sectoral decision-making, including the prioritization of adaptation measures, the design of targeted interventions, and the integration of climate risk considerations into sectoral policies, strategies, and investment planning processes.

The CRVA will play a key role in supporting the development of robust, sector-specific adaptation action plans. It aims to offer technical guidance to mitigate climate risks to sectoral development goals while also identifying co-benefits related to mitigation, such as limiting GHG emissions where relevant. The CRVA report provides the analytical foundation for subsequent decision-making steps. In particular, its findings on climate risks, vulnerability drivers, and hotspots complement the Multi-Criteria Analysis (MCA), which supports the identification and prioritization of adaptation measures from the National Adaptation Plan (NAP). This process aims to ensure that selected actions are evidence-based and responsive to the most critical risks identified. As such, the CRVA serves as a key input to the formulation of Sectoral Adaptation Strategies and Action Plans (SAPs) and informs the integration of climate risk considerations into sectoral planning and investment processes. This will lead to specific recommendations aligned with Outcome 3.2 and Output 3.2.1 of the GCF Readiness Project, including:

- ▶ Review and analysis of available climate information and vulnerability data for the target sectors
- ▶ Identification of priority climate risks and exposure hotspots through sector-specific assessments
- ▶ Guidance on the integration of climate adaptation criteria in sectoral infrastructure and planning design
- ▶ Recommendations to inform the development of sectoral adaptation action plans (Activities 3.2.1.5 and 3.2.1.6)
- ▶ Inputs to capacity-building roadmaps and multi-stakeholder workshops to strengthen adaptation planning processes

Beyond its immediate application to the priority sectors covered under this project, the CRVA is also intended to serve as a methodological template for conducting future climate risk and vulnerability assessments in other sectors in Lao PDR. The assessment framework, structured around the analysis of hazards, exposure, sensitivity, and adaptive capacity, provides a replicable and adaptable approach that can be applied across different sectoral contexts. It combines qualitative and quantitative data, integrates stakeholder consultations, and aligns with national planning frameworks, ensuring both technical robustness and policy relevance. As such, the CRVA can support national institutions in systematically identifying climate risks, prioritizing adaptation responses, and strengthening the integration of climate considerations into sectoral planning and decision-making processes over time.

1.3 Terminology

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Impacts: Effects on natural and human systems. The term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts

Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. In this report, the term risk is used primarily to refer to the risks of climate-change impacts.

Our definition of risk, and that in the NAP and the document “Lao PDR Provincial Storyline-based Climate Risk, Vulnerability and Adaptation Assessment” are based on the IPCC Fifth Assessment Report (AR5; <https://www.ipcc.ch/assessment-report/ar5/>). Climate risk centres on the interaction between hazard, vulnerability and exposure. Also, the consultant will adopt the same definitions detailed above based on the IPCC report, AR5.

1.4 Scope of the CRVA

1.4.1 Geographical scope

The Climate Risk and Vulnerability Assessment (CRVA), along with the adaptation action plans, will be developed at the national scale for Lao PDR.

For the hazard analysis, the consultant will use the data from the report “Lao PDR Provincial Storyline-based Climate Risk, Vulnerability, and Adaptation Assessment”, which primarily focuses on six provinces. The selection of these six provinces was made by the Project Management Unit (PMU) and Department of Environment (DoE) in the framework of this previous assignment to ensure a representation of the country's diverse geographies and livelihoods. These provinces are as follows:

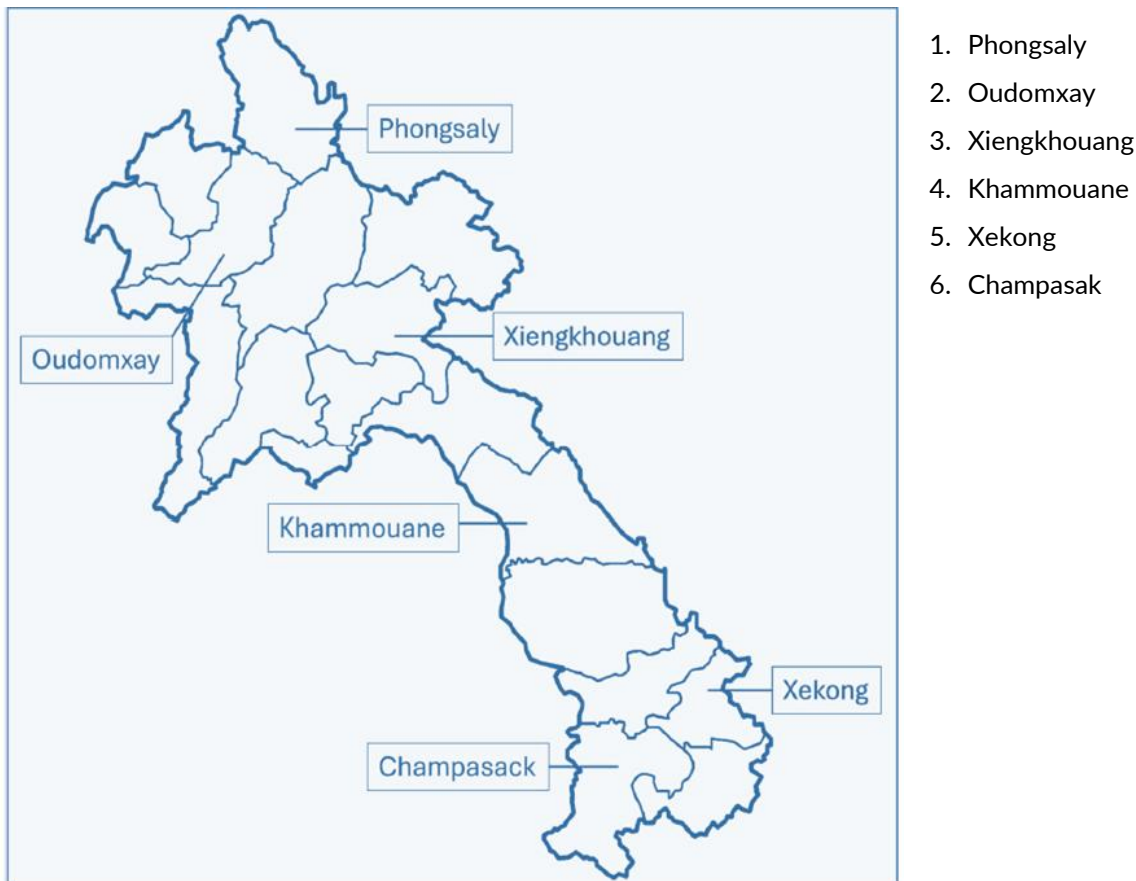


Figure 2: The six selected provinces for this assessment

Source: Internal production

While the hazard analysis focuses on these six provinces to capture geographically diverse climate risk profiles, the sectoral vulnerability analysis is conducted at the national level to ensure policy relevance and alignment with sectoral planning processes.

The use of provincial-level hazard data allows the assessment to capture spatial variability in climate risks, as hazard patterns and impacts can differ significantly across regions. The six provinces provide a representative sample of the country's diverse geographies and livelihoods. As such, the provincial analysis helps identify differentiated hazard dynamics, which are then interpreted to inform a nationally relevant assessment of sectoral vulnerability. In particular, stakeholder consultations and Focus Group Discussions (FGDs) were conducted with technical officers from line ministries, reflecting national-level perspectives on sectoral vulnerabilities, capacities, and priorities. This combined approach ensures both analytical depth and applicability to national-level decision-making, while also providing a basis for more localized assessments in future work.

Conducting a similarly detailed assessment at the provincial level would have required extensive engagement with provincial offices (PAE and other line offices across multiple sectors), which was not feasible within the timeframe of this assignment, but could usefully complement future CRVAs.

1.4.2 Sectors scope descriptions

Based on the NAP-UNEP documents¹ review, the sectors considered in the CRVA, and the proposed Sectoral Action Plan are briefly described below:

► Agriculture and Forestry

The agricultural sector in Laos is foundational to its economy and livelihoods, employing a significant portion of the population despite a decreasing share of the national GDP². Rice remains the primary crop, supplemented by increasing production of cash crops like coffee, maize, bananas, and rubber, largely for export to regional markets such as China, Vietnam, and Thailand³.

Government initiatives, including the Agricultural Development Strategy for 2025 and Vision 2030 for Land Management, aim to enhance food security, promote commercial production, and ensure sustainable practice⁴. These strategies encourage modernization, diversification away from traditional subsistence farming, and attracting foreign investment, particularly in agro-industries benefiting from improved infrastructure like the Laos-China railway⁵. Efforts are also underway to reduce reliance on imported inputs like animal feed and fertilizers to mitigate the impact of the depreciating Lao Kip on production cost⁶.

The forestry sector in Laos is a critical component of its natural heritage and economy, with extensive forest cover classified into three main categories: Protection, Conservation, and Production Forests⁷. The GoL and the MAE aim to increase the country forest cover to 70% of the country's land area by 2035, recognizing the vital role forests play in environmental protection, biodiversity, and the livelihoods of rural communities⁸. Policies emphasize sustainable forest management, community participation, and a shift towards plantation timber for commercial purposes⁹. The country has also engaged in international initiatives like the EU Forest Law Enforcement, Governance and Trade (FLEGT) process and REDD+ (Reducing Emissions from Deforestation and Forest Degradation) to improve governance and secure carbon financing.

Key challenges

1. Low productivity among smallholder farmers, high cost due to imported inputs and limited access to market infrastructure, significantly hinder agricultural growth.
2. Climate change impacts, such as floods and droughts, further threaten agricultural output and livelihoods, while animal diseases contribute to livestock losses.
3. Concurrently, deforestation and forest degradation are major concerns, fueled by illegal logging, agricultural expansion (especially for crops like cassava), hydropower development, and mining. Although official figures suggest increased forest cover, the quality of forests, particularly primary forests, has declined.
4. Illegal logging remains rampant, with large volumes of timber illicitly harvested and exported, often disguised through loopholes or alongside legitimate development projects.

¹ National Adaptation Plan – Draft version - 2023 and Lao PDR Provincial Storyline-based Climate Risk, Vulnerability and Adaptation Assessment

² MAF. (2024). Lao PDR Forestry Strategy to 2035 and Vision to 2050

³ LNC-IC. (2024). Report on Trade and Investment Opportunities in Laos. Law on Forestry (Amended) No. 64/NA date 13 June 2019

⁴ MAF. (2023). Agricultural Development Strategy 2025 and Vision 2030. Vientiane, Laos.

⁵ MPI. (2024). Investment Promotion Strategy 2024-2028. Vientiane, Laos.

⁶ Bank of the Lao PDR. (2024). Annual Economic Report 2023

⁷ FAO. (2021). Laos country profile

⁸ KPL. (2025a, March 19). Infrastructure Development: A Priority for Laos' Economic Growth

⁹ Digital 2025: Laos. Retrieved from <https://datareportal.com/reports/digital-2025-laos>

5. Weak governance, including issues with law enforcement, corruption, unclear land tenure, and limited institutional capacity, undermines effective forest management.
6. These challenges also impact on the livelihoods of forest-dependent communities, highlighting the need for equitable benefit-sharing in conservation. Despite these hurdles, opportunities exist in leveraging regional connectivity for exports, meeting the growing demand for organic produce, and attracting investment in technology and cold chain logistics.

► Urban development and transport

The urban development and transport sectors in Laos are critically important to the country's ongoing development, especially as urbanization continues to accelerate. Vientiane, the capital city, alongside other rapidly growing urban centers like Savannakhet and Pakse, are experiencing significant expansion. This brings both opportunities for economic growth and challenges related to infrastructure, housing, and public service¹⁰.

While the transport sector in Laos has historically been less developed than its regional neighbors, the government is actively prioritizing improvements to road networks, rail links, and air transport infrastructure to bolster economic growth and enhance connectivity.

Key Features:

7. **Growing Urbanization:** Urban development is increasing in major cities due to continued rural-to-urban migration for employment opportunities. This trend is driving expanded housing needs, infrastructure development, and demand for municipal services such as water supply, drainage, solid waste collection and landfilling, and sanitation¹¹. As of early 2025, approximately 39.2% of Laos's population resides in urban centers¹².
8. **Enhanced Urban Planning and Sustainability:** The Lao government is actively working to enhance urban planning, with a focus on sustainable city growth and public transport systems. Initiatives are underway to improve urban infrastructure and address climate resilience. The 3rd Lao National Urban Forum in December 2024 specifically focused on Sustainable Development Goals (SDG) localization and youth engagement in sustainable urban development.
9. **Expanding Transport Networks:** The transport sector comprises a network of roads, bridges, railways, and airports. Road infrastructure remains the dominant mode of transport, with continuous efforts to upgrade national highways and rural networks. Laos is also significantly expanding its rail network, with key regional connectivity projects such as the Kunming–Vientiane railway. This railway has substantially boosted both passenger and freight traffic since its launch. Further connectivity with the Thai rail network is also being developed, with the Vientiane end of the line eventually expected to connect with the Bangkok–Nong Khai high-speed railway. New highway projects are also being initiated, such as the Vientiane–Nam Soi border checkpoint highway, linking Laos with Vietnam. Additionally, National Road No. 12 is undergoing significant upgrades to enhance trade links between Thailand, Laos, Vietnam, and southern China¹³.

¹⁰ UN-Habitat Lao PDR. (2024, December 9). The 3rd Lao National Urban Forum 2024. Retrieved from <https://unhabitat.la/event/lnuf-2024/>

¹¹ WHO. (2025, April 30). Lao PDR Launches Groundbreaking Climate Health Resilience Initiative. Retrieved from <https://www.who.int/laos/news/detail/30-04-2025-lao-pdr-launches-groundbreaking-climate-health-resilience-initiative>

¹² United Nations Development Programme. (2025, April 3). PROTECTING WATER FOR PEOPLE AND NATURE. Retrieved from <https://www.undp.org/laopdr/blog/protecting-water-people-and-nature>

¹³ Laotian Times. (2025, June 5). Laos to upgrade National Road No.12 in 2025, enhancing Thailand–Vietnam–China trade link. Retrieved from <https://laotiantimes.com/2025/06/05/laos-to-upgrade-national-road-no-12-in-2025-enhancing-thailand-vietnam-china-trade-link/>

Key challenges:

- 10. Urban Planning and Informal Settlements:** Rapid urbanization necessitates robust urban planning to prevent unregulated expansion of informal settlements and ensure adequate access to basic services for all residents.
- 11. Public Transportation and Environmental Issues:** Significant gaps persist in public transportation systems. Additionally, with increasing urbanization, traffic congestion and pollution are emerging as pressing urban issues.
- 12. Regulatory Frameworks and Sustainability:** Infrastructure developments have outpaced regulatory frameworks, posing challenges related to sustainability, environmental impacts, and equitable development.
- 13. Outdated Drainage and Flood Management:** Many urban areas continue to struggle with outdated and inadequate drainage systems, leading to flash floods during heavy rainfall. Addressing urban drainage and flood management is crucial for building climate resilience and ensuring sustainable urban development. The Lao government in partnership with the UN and several international donors has launched several initiatives focused on climate-resilient infrastructure and green finance to address these vulnerabilities^{14 15 16}.

► Water resources

The water resources sector in Lao PDR remains pivotal for national development, underpinning agriculture, energy production, domestic consumption, and industry. Laos, situated predominantly within the Mekong River Basin, is endowed with abundant water resources, making it a critical regional player in water management¹⁷ Approximately 80% of the country lies within the Mekong Basin, contributing significantly to its annual flow¹⁸.

As per the draft NSEDP (10th version) and the draft NPDS (2025–2035), the hydropower industry is a cornerstone of Laos' energy strategy, with the nation aspiring to be the "battery of Southeast Asia." The former Ministry of Energy and Mines (MEM) now merged with Ministry of Industry and Commerce (MOIC) targets a hydropower capacity of 12 GW by 2025 and 20 GW by 2030, primarily for regional export¹⁹. As of 2021, Lao PDR had an installed power generation capacity of 11,661 MW, with hydropower accounting for approximately 94% of the electricity system's domestic supply capacity²⁰. Irrigation is also expanding, with 500,221 hectares irrigated in 2024, exceeding the 2025 national target²¹.

Key Features:

¹⁴ Green Climate Fund (GCF). (n.d.). *Integrating flood management and climate change adaptation in Lao PDR*. Project SAP009. Retrieved from <https://www.greenclimate.fund/project/sap009>

¹⁵ UN-Habitat. (n.d.). *Building Resilience of Urban Populations with Ecosystem-Based Solutions (EbS) in Lao PDR*. Retrieved from <https://unhabitat.la/projects/eb/s/>

¹⁶ World Bank. (n.d.). *Climate Resilient Infrastructure for Urban Flood Risk Management Project (P178534)*. Retrieved from <https://projects.worldbank.org/en/projects-operations/project-detail/P178534>

¹⁷ Asian Power. (2025, June 2). *Laos' large hydropower to reach 16 GW in 2035*. Retrieved from <https://asian-power.com/news/laos-large-hydropower-reach-16-gw-in-2035>

¹⁸ *Ibid.*

¹⁹ GlobalData Energy. (2023, September 26). *Laos targets 12GW hydropower capacity by 2025 to drive electricity export revenue*. Power Technology. Retrieved from <https://www.power-technology.com/analyst-comment/laos-hydropower-electricity-export-revenue/>

²⁰ Yogo, M. and K. Sudo (2024), 'A Resilient Power System and Power Market in Lao PDR', in Phoumin, H. and A. Phongsavath (eds.), *Energy Security White Paper: Policy Directions for Inclusive and Sustainable Development for Lao PDR and the Implications for ASEAN*. Jakarta: ERIA, pp. 70-87

²¹ The Star. (2025, June 6). *Laos takes steps to enhance irrigation development*. Retrieved from <https://www.thestar.com.my/aseanplus/aseanplus-news/2025/06/06/laos-takes-steps-to-enhance-irrigation-development>

14. **Mekong River Basin Dominance:** The Mekong River and its 14 discrete tributaries are primary water sources, vital for hydropower and agriculture²².
15. **Regional Hydropower Hub:** Laos is a major hydropower exporter, with ongoing dam development to meet ambitious capacity targets for domestic use and export to countries like Thailand, Vietnam, and Cambodia²³.
16. **Agricultural Support:** Irrigation systems, particularly in lowland rice-growing areas, are crucial for agricultural productivity, with increased focus on GIS integration for improved management.
17. **Evolving Governance:** Water resources are managed through government agencies, water user associations, and private investments, guided by policies like the Law on Water and Water Resources and the National Water Resources Management Strategy 2030. Recent collaborations, such as the MoU between the Department of Water Resources and the International Water Management Institute, aim to enhance water resource management.

Key Challenges:

18. **Water Quality Degradation:** Pollution from industrial activities, untreated domestic wastewater, and agricultural runoff remains a concern, impacting drinking water and ecosystem health²⁴. Many urban areas lack adequate wastewater treatment, and arsenic contamination in tubewells is noted in some regions.
19. **Transboundary Water Management:** Hydropower development raises regional concerns regarding water sharing and the impacts of large dams on downstream countries, leading to issues like unexpected floods from dam releases and water shortages. A technical study release in 2023²⁵ using Mekong Dam Monitor observations and Mekong River Commission (MRC) data of the 3S tributary system (comprising the Sesan, Xekong, and Srepok rivers) found that dam operations reduce wet-season flows by up to 1.48%, increase dry-season flows by at least 5.84%, and introduce unnatural daily and weekly flow variability—effects that propagate downstream into Cambodia and Vietnam. These altered seasonal patterns can result in unexpected floods, especially during reservoir releases, and contribute to water shortages during dry periods.
20. **Climate Change Vulnerabilities:** Water scarcity is intensifying in some areas, particularly during dry seasons, exacerbated by climate change impacts like drying natural springs and altered rainfall patterns. Seasonal flooding also continues to cause significant devastation.
21. **Inadequate Infrastructure for Water Supply and Sanitation (WASH):** Significant gaps persist, especially in rural areas, with 82% of households lack access to a safely managed water supply, and 39% lack access to safe sanitation²⁶. This contributes to public health issues like dysentery and diarrhea. Efforts are underway to address this, including some international donors financing packages for water supply and sanitation services.
22. **Economic Dependence on Hydropower:** Laos' reliance on hydropower export revenue makes its economy vulnerable to external market fluctuations and limits bargaining power. This necessitates infrastructure enhancements for cross-border electricity flows and investments in energy storage.

²²Xinhua. (2025, June 5). Laos takes steps to enhance irrigation development. Retrieved from <https://english.news.cn/20250605/be78923e28e0447190aaf01959d09532/c.html>

²³ GlobalData. (2025, May 28). Laos' large hydropower capacity to reach 16GW in 2035, forecasts GlobalData. Retrieved from <https://www.globaldata.com/media/power/laos-large-hydropower-capacity-reach-16gw-2035-forecasts-globaldata/>

²⁴ United Nations in Lao PDR. (2024, November). Flood Needs and Early Recovery Assessment Report_Luangnamtha_October 2024. Retrieved from https://laopdr.un.org/sites/default/files/2024-11/Flood%20Needs%20and%20Early%20Recovery%20Assessment%20Report_Luangnamtha_October%202024.pdf

²⁵ Eyler, B., Kwan, R., & Basist, A. (2023, June 13). *Analysis of hydropower impacts in the Mekong's 3S Basin: A technical report using Mekong Dam Monitor observations and MRC data to show how 20 dams are changing the hydrological flow of the 3S Basin and the Mekong River at large*. Stimson Center. Retrieved from [Analysis of Hydropower Impacts in the Mekong's 3S Basin • Stimson Center](#)

²⁶ Planet Water Foundation. (n.d.). *Where we operate: Laos*. Retrieved July 8, 2025, from <https://planet-water.org/where-we-operate/laos>

1.5 Global approach & Methodology Overview

As the overall project focuses on three targeted sectors, the methodology was developed in order to address challenges related to climate change and its impacts in the following sectors: water resources, agriculture and forestry, urban development and transport.

While the CRVA developed under this project focuses on three sectors only (Agriculture & Forestry, Water Resources, Urban Development and Transport), its underlying analytical logic can be transferable to other sectors in Lao PDR. The core framework, structured around the assessment of hazards, exposure, sensitivity, and adaptive capacity, provides a consistent approach that can be adapted to different sectoral contexts. This includes the identification of sector-specific climate risks, the analysis of vulnerability drivers, and the linkage of findings to decision-making processes through prioritization tools such as Multi-Criteria Analysis (MCA).

However, the application of this framework to other sectors would require adjustments to reflect sector-specific characteristics, including the selection of relevant indicators, data availability, and institutional arrangements. In particular, the depth of analysis may vary depending on the availability of sectoral data and the level of stakeholder engagement achievable. Despite these adaptations, the overall logic remains applicable and provides a structured entry point for systematically integrating climate risk considerations into sectoral planning. As such, the CRVA approach can support national institutions in extending climate risk assessments to additional sectors over time, contributing to a more harmonized and scalable approach to climate adaptation planning in Lao PDR.

The proposed methodology to perform the CRVA is as follows:

1. Scope identification
2. Set-up of the GIS environment and Klim tool
3. Data Collection Climate context and projection analysis

Analyze key climate parameters and necessary derived parameters to assess climate normal, extremes, historical trends, and impact of climate change on these parameters, necessary to determine related climate hazard in present and future conditions under the reference SSP scenario(s) at project horizon(s).

Klim tool

The Klim tool used in this assessment is an in-house analytical tool developed by Groupe Huit to support detailed analysis of past and future climate conditions. It enables the processing of climate data, including the derivation of key indicators such as extreme events, seasonal cycles, and long-term trends, to inform hazard characterization.

While the Klim tool provides a structured and robust framework for climate data analysis, its use is not mandatory and should be understood as an illustrative analytical option. The methodology applied in this CRVA remains adaptable and can be implemented using alternative tools and datasets, depending on data availability and institutional capacities.

2 PRELIMINARY TASKS

2.1 Basic assumptions

2.1.1 Definition of reference SSPs

As per the 6th IPCC report, Socioeconomic Shared Scenarios (SSP) are forward-looking trajectories that describe the potential evolution of human societies in terms of economic development, demographics and governance, independently of climate change. They are coupled with RCPs (Representative Concentration Pathways) to assess the impacts of climate policies.

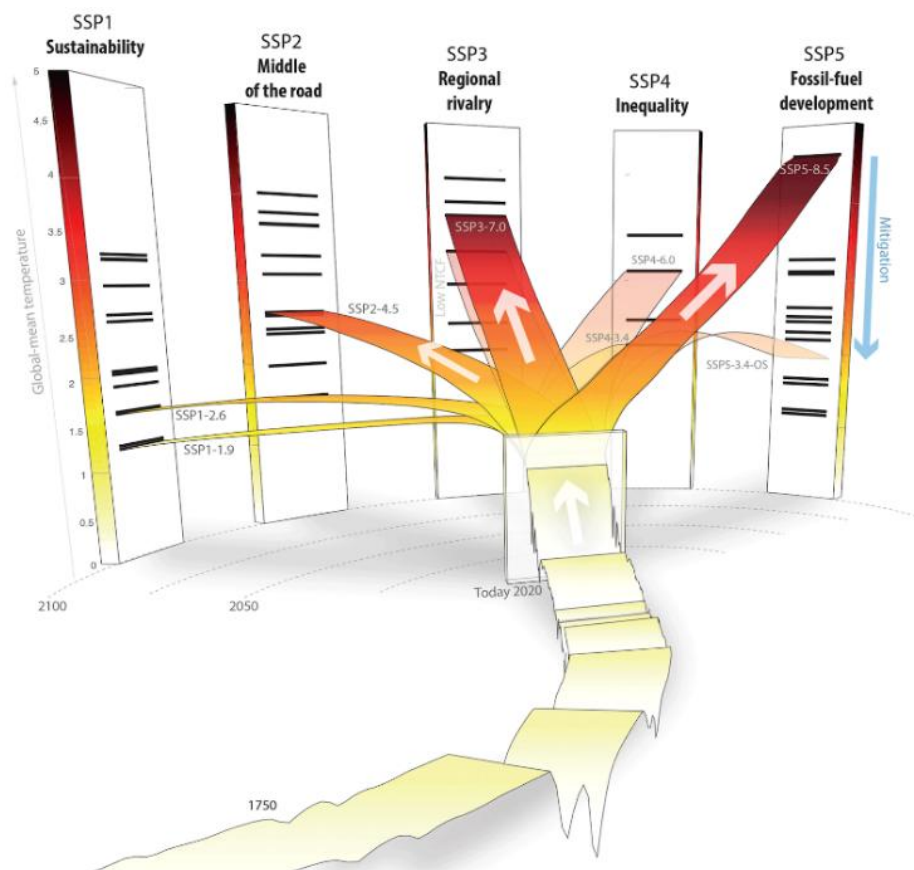


Figure 3: Illustration of shared socioeconomic pathway (SSP)

Source: climatedata.ca

Two scenarios were considered throughout the present study:

SSP2-4.5: This scenario stands for the average trajectory of future greenhouse gas emissions. This scenario assumes that climate protection measures are taken and that the rate of emissions does not undergo major sudden changes: it can therefore be considered the most likely in the long term.

SSP5-8.5: This scenario appears likely between now and 2050. It reflects the failure of mitigation policies and the continuity of trends in primary energy consumption and energy mix. In the longer term, it seems less likely (he considers, for example, inexhaustible fossil fuels) but it remains interesting to study on systems that are extremely sensitive to climatic hazards and on the other hand, current climate trends are in line with this scenario.

2.1.2 Definition of study horizons

In addition to the reference SSPs, it is also necessary to define the time horizons considered for climate projections. The present analysis includes both a retrospective (historical) assessment of hazard patterns over the past decades and a prospective analysis projecting future climate risk. Historical trends and current climate conditions are analyzed to understand existing hazard baselines, recurrence patterns, and recent climate extremes.

For future projections, the analysis focuses on long-term horizons, notably up to 2100's (long term). These projections are used to evaluate potential changes in extreme precipitation, temperature, and other key parameters under climate change scenarios. While the analysis focuses long-term projections up to 2100 to capture the full range of potential climate futures, particular attention is given to near- and mid-term horizons (e.g. 2030–2050), which are more directly relevant for sectoral planning and investment cycles. Projections are primarily based on the SSP2-4.5 scenario, representing a “middle-of-the-road” pathway and considered a plausible baseline for the coming decades. This approach allows for a balanced interpretation of climate projections, ensuring both strategic long-term foresight and practical relevance for decision-making within current planning frameworks.

It is important to note that for its internal tool, Groupe Huit uses the CMIP6 model, which is based on Shared Socioeconomic Pathways (SSPs), whereas the analysis provided in the report “Lao PDR Provincial Storyline-based Climate Risk, Vulnerability and Adaptation Assessment” primarily relies on CMIP5 global climate models, which use Representative Concentration Pathways (RCPs). To facilitate understanding and comparison, the consultant proposes the table 1 and will develop maps aligned with the same time horizons used in the “Lao PDR Provincial Storyline-based Climate Risk, Vulnerability and Adaptation Assessment”. Also, RCPs will be used for the CRVA analysis.

Table 1: Summary of the differences between SSPs (CMIP5 and CMIP6)

	CMIP5	CMIP6
Released	~2010	~2019
Scenario Framework	RCPs only (e.g., RCP4.5, RCP8.5)	SSP-RCPs (e.g., SSP1-2.6, SSP5-8.5)
Radiative Forcing	Fixed levels by 2100 (e.g., 2.6, 4.5 W/m ²)	Combines forcing with socioeconomic storylines
Socioeconomic Dimension	Limited or separate from climate modeling	Integrated via SSPs (population, land use, GDP, energy)
Model Improvements	Lower resolution, fewer Earth system interactions	Higher resolution, better clouds, aerosols, land-carbon links
Use Cases	Climate projections, mitigation scenarios	Policy analysis, risk assessment, adaptation planning

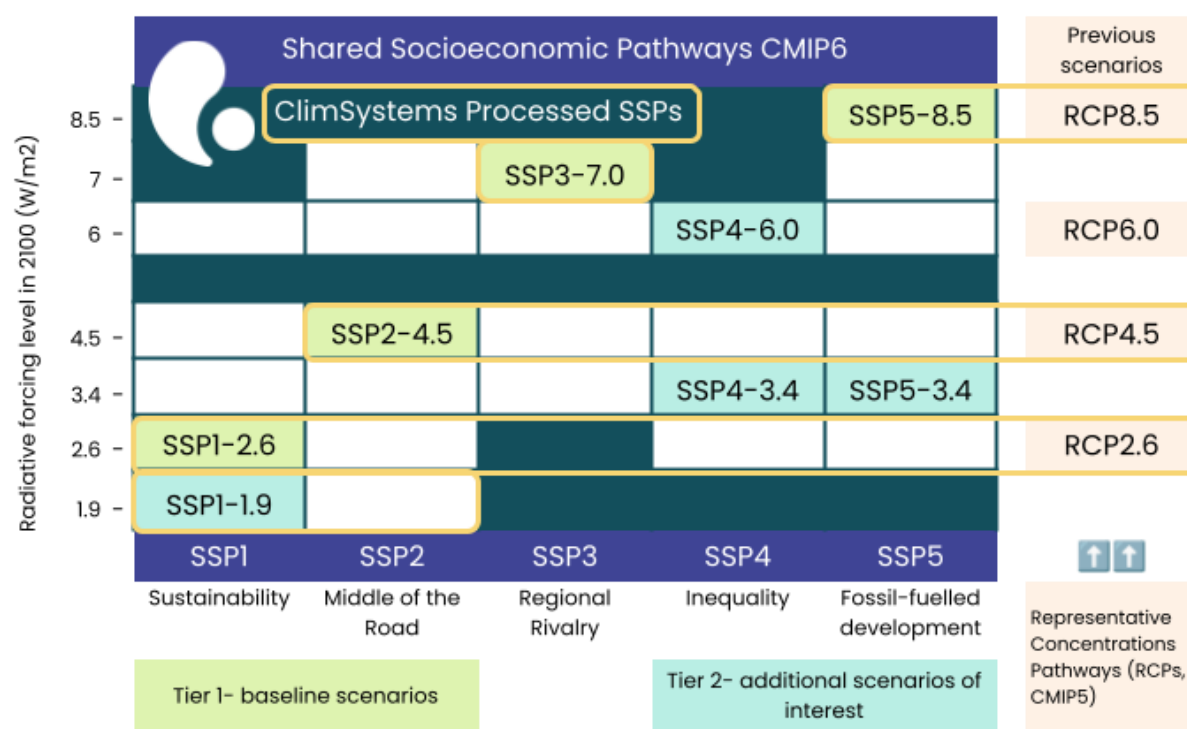


Figure 4: Equivalence SSPs (CMIP6) and RCPs (CMIP5)

Source: ClimaSystems. SSPs and RCPs

2.2 Set up of GIS environment



In order to centralize all the geographic data collected, processed and produced as part of this study, as well as to share it with the Client, a GIS environment was set up. For this purpose, it was decided to use the QGIS Desktop tool. It contains all the necessary data to create meaningful maps for understanding the climate situation. The main types of data include climate indicators, topography (DEM), hydrography (rivers and water resources), and geographic information (administrative limits). These data are primarily in raster and vector formats, and QGIS offers many tools for working with these kinds of data. Its use in this project is justified by its free availability on the web (open-source software), its ability to centralize the georeferenced data, and to process spatial data efficiently.

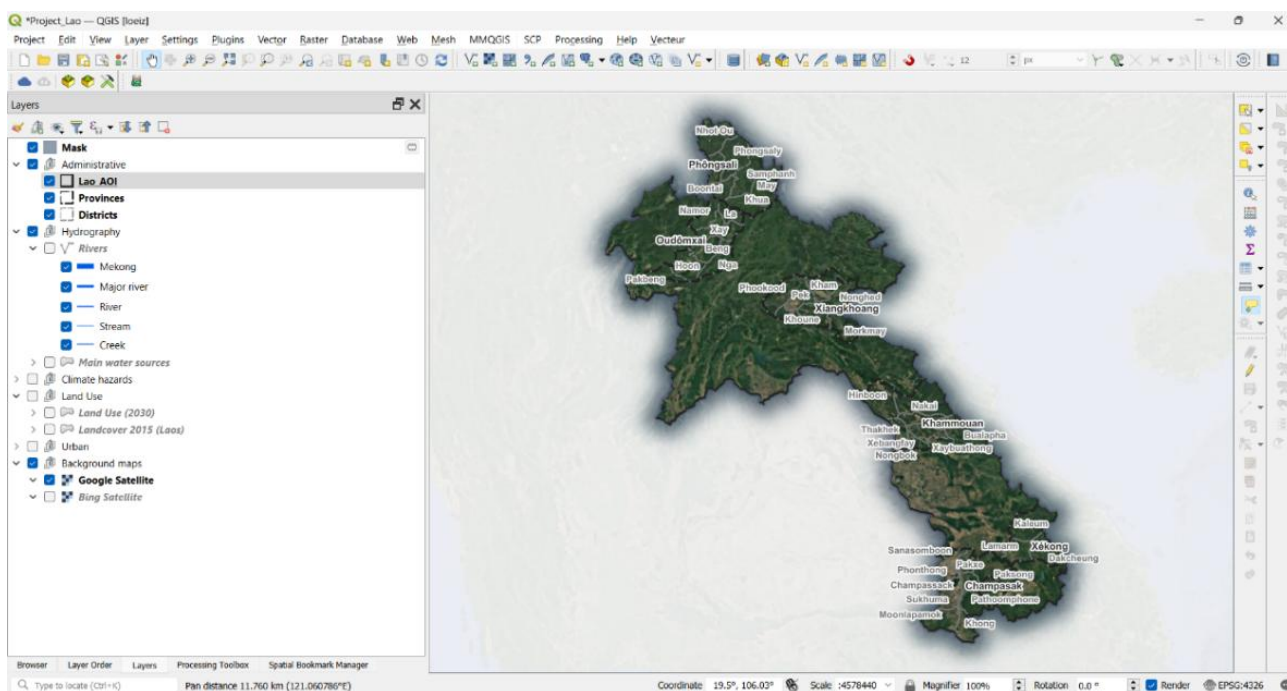


Figure 5: Overview of the GIS built with QGIS

Source: Internal production (consultant modeling environment)

2.3 Introduction of Klim tool

K'lim tool is an advanced Python-based tool, developed in-house by Groupe Huit, designed to perform in-depth analyses of past and future climate conditions, including the derivation of climate indicators, the analysis of extreme events, and the analysis of seasonal cycles.

While the Klim tool enables advanced climate data analysis, its use can be adapted to different levels of technical capacity. At a minimum, the analysis can rely on a set of basic indicators" including annual averages or cumulative values, as well as monthly means and seasonal variations over time. These indicators can provide a sufficient basis to characterize key climate trends and inform hazard analysis. More advanced analyses, such as the derivation of extreme event indicators or more complex climate diagnostics, require higher levels of expertise in climate data processing and interpretation. This distinction ensures that the methodology can be applied flexibly, allowing users with varying technical capacities to implement the approach while maintaining analytical consistency.

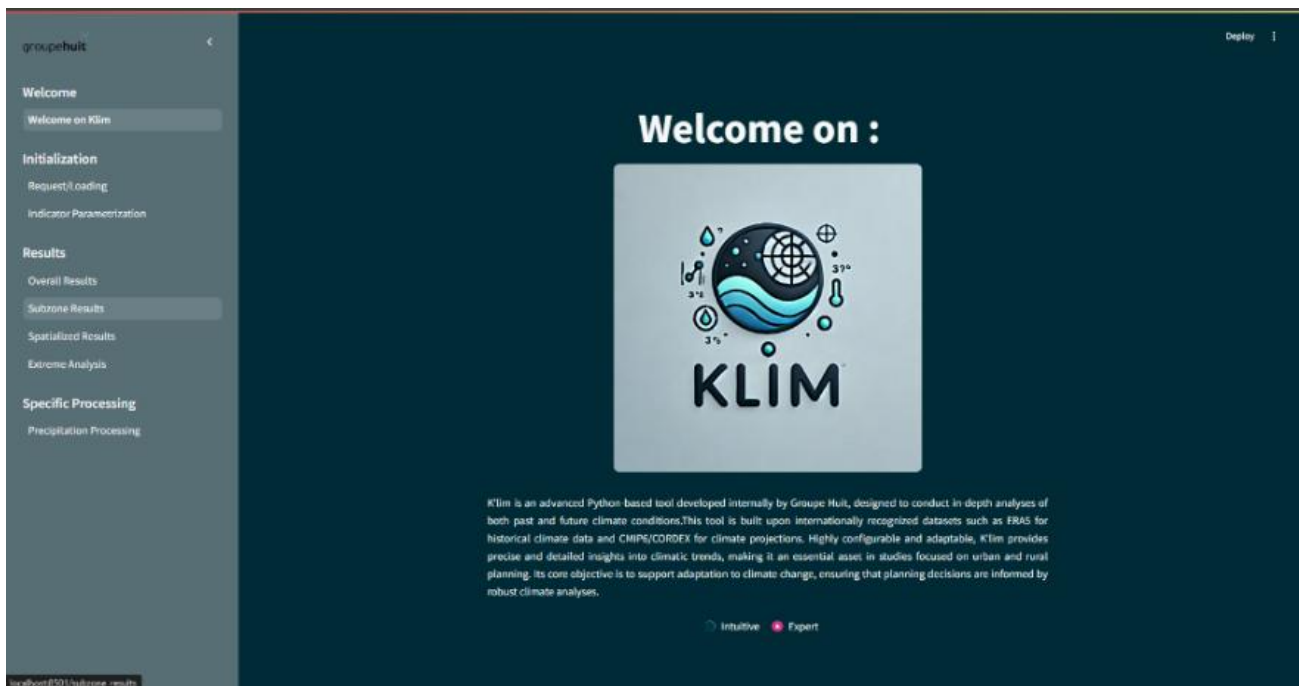


Figure 6: Overview of the K'lim Tool

Source: Internal production (consultant modeling environment)

2.3.1 Input data

K'lim Tool is based on internationally recognized climate data, such as ERA5-Land for historical climate data and CMIP6 for climate projections.

ERA5 is a climate database produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) as part of the Copernicus Climate Change Service (C3S) program. It is a climate reanalysis: a historical reconstruction of the global climate by combining observations (satellites, ground stations, radiosondes...) with a numerical weather prediction model. This produces consistent, complete and regular estimates of atmospheric and surface conditions

ERA5-Land is a database derived from ERA5, specially optimized to describe conditions on the earth's surface. It provides more detailed information on soil and surface hydrology (e.g. soil moisture, surface temperature, snow, evapotranspiration, etc.). Its improved spatial resolution: around 9 km (0.1° x 0.1° grid), compared with 0.25° for ERA5. This provides a more detailed description of local variations, which is highly useful for agriculture, water management and climate risk studies.

With regard to projected data, the data available through the tool are all derived from models developed as part of the 6th IPCC report (AR6), and more specifically as part of CMIP6 (the latest generation of coupled ocean-atmosphere models). All models developed within the framework of AR6 and presenting sufficient resolution are available through the tool, for all available SSPs. These correspond to scenarios for the evolution of anthropogenic CO2 emissions between 2015 and 2100. The SSPs are characterized by a first number (1 to 5) corresponding to an increasing scale of "compliance" with the objectives of the Paris COP21 agreements (number 1 being the most "virtuous"), and a second group of numbers corresponding to the "radiative forcing" (W/m2) over the period.

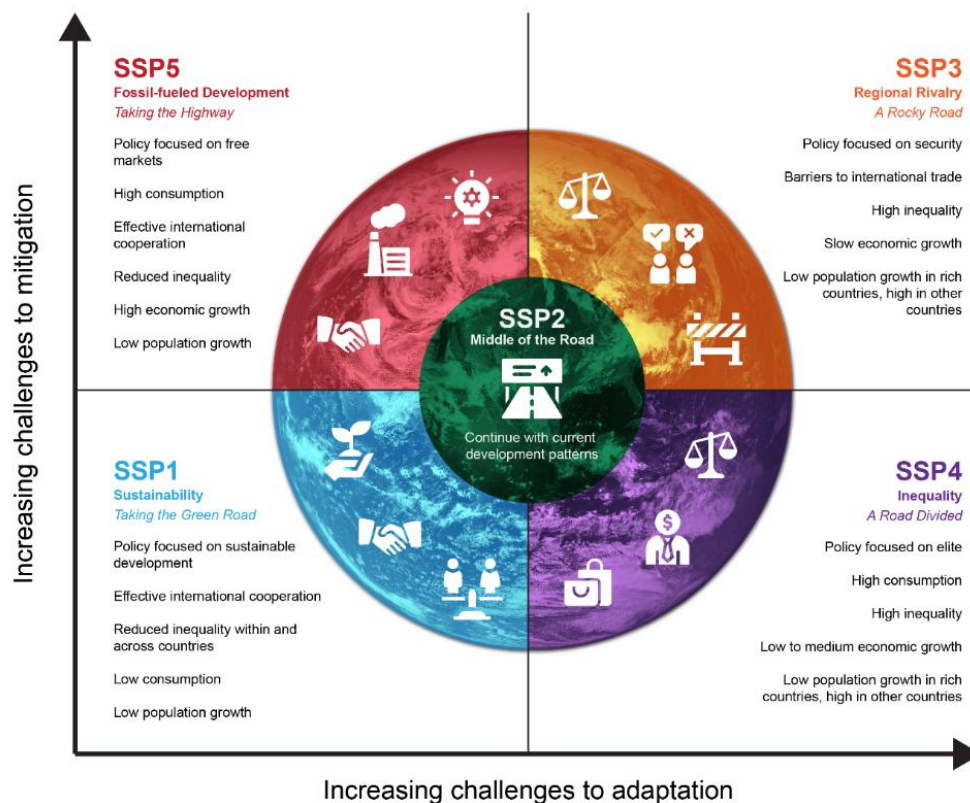


Figure 7: Overview of the different SSPs in IPCC AR6

Source: climatedata.ca

Note that the data to be processed can also be customized using Python APIs, for example to integrate high-resolution regional climate models (RCMs) such as CORDEX.

2.3.2 Tool features

Highly configurable and adaptable, K'lim Tool provides precise, detailed information on climate trends, making it an essential asset in studies focusing on urban and rural planning. Its main objective is to support adaptation to climate change, by ensuring that planning decisions are based on sound climate analyses.

It exploits powerful APIs to extract climate data from reputable sources such as the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA) and performs advanced statistical processing of this data at different temporal resolutions, from hourly to daily scales.

The tool offers the following detailed functionalities:

1. Extraction of past and future daily climate data based on a user-supplied area of interest. The user can choose:
2. The period to be extracted, between 1950 and 2100,
3. The SSP(s) to be extracted,
4. Daily variables to be extracted from among the following: Cumulative precipitation, average, minimum and maximum temperature, specific/relative humidity, average wind at 10 m above ground level, short- and long-wave solar radiation.

5. Calculation of average climate statistics over the area of interest for the selected variables and derivation of annual and then decadal climate indicators based on the extracted variables.
6. Import a sub-zoning and calculate average climate statistics for each sub-zone for selected variables and previously defined climate indicators,
7. Calculation of spatialized indicators over the entire area of interest and interpolation on a user-defined grid,
8. Analysis of extreme events using stationary or non-stationary GEV statistical adjustments, particularly useful for analyzing temperature and precipitation extremes and their frequency of occurrence and evolution over time.
9. Analysis of seasonal cycles, e.g. extraction and analysis of rainy season duration and characteristics in the past and in the future.

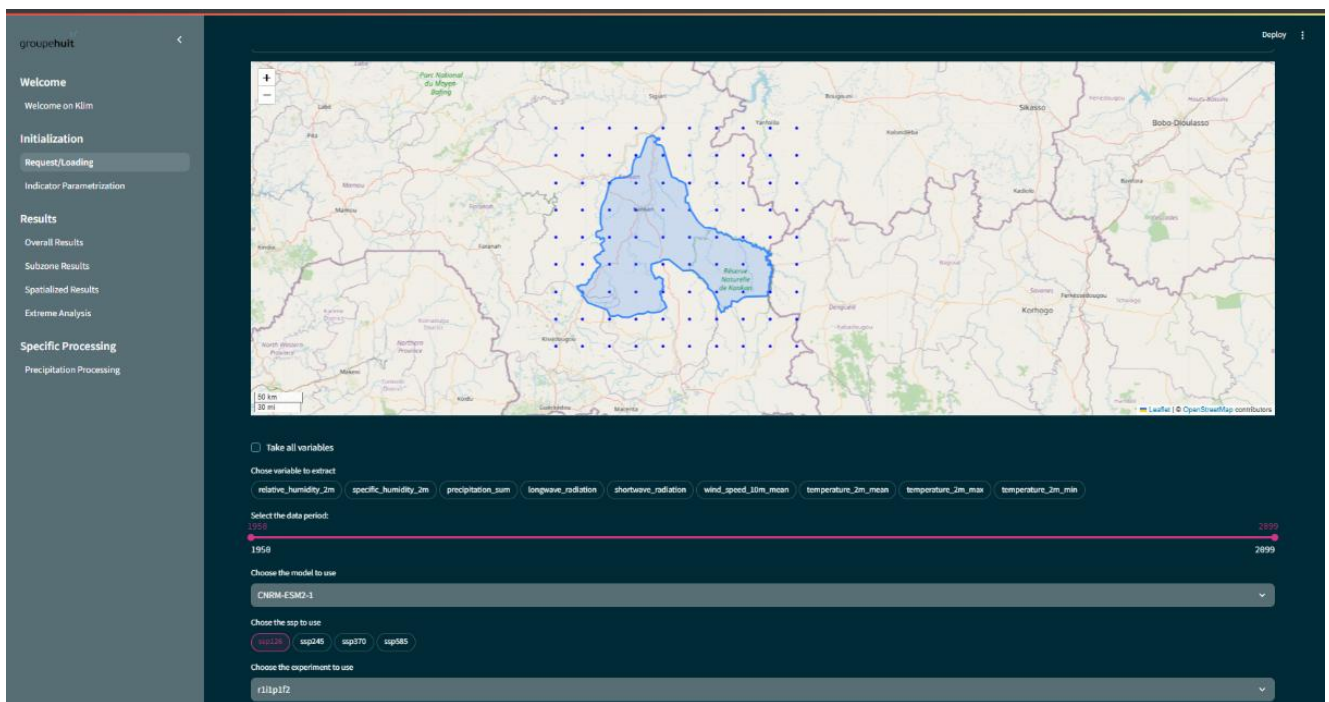


Figure 8: View of the data extraction tool

Source: Internal production (consultant modeling environment)

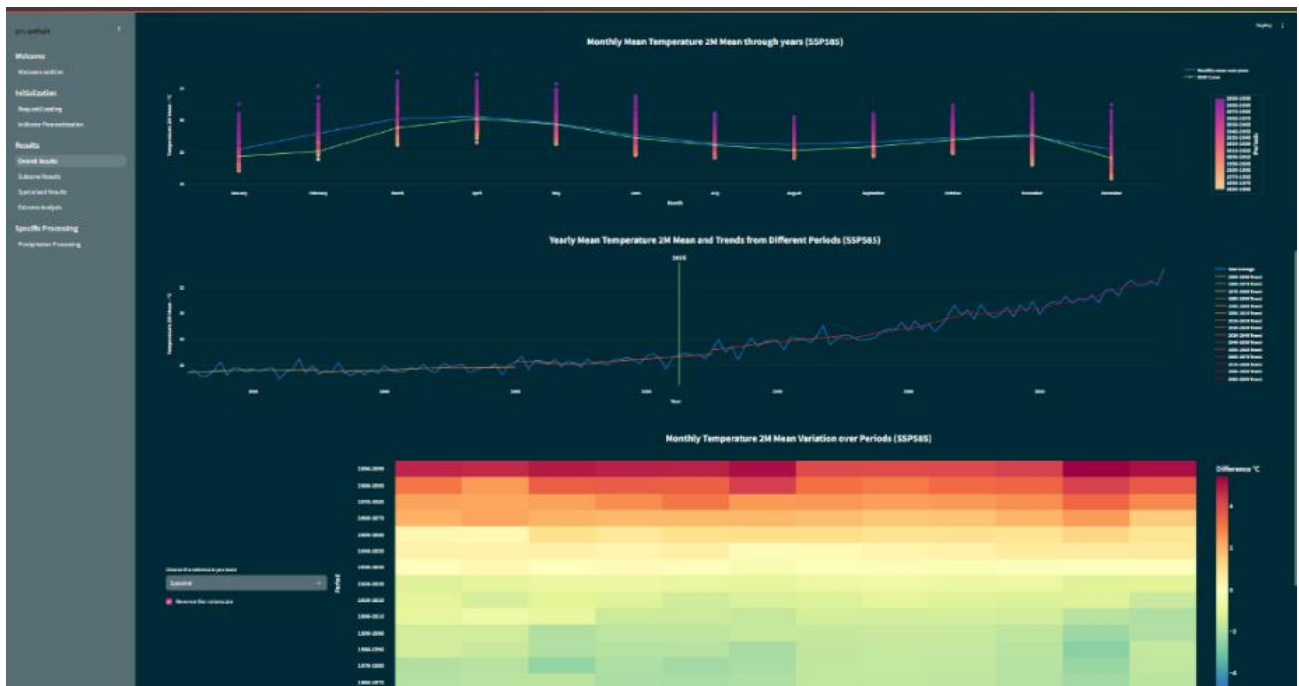


Figure 9: Examples of average statistics for an area of interest

Source: Internal production (consultant modeling environment)

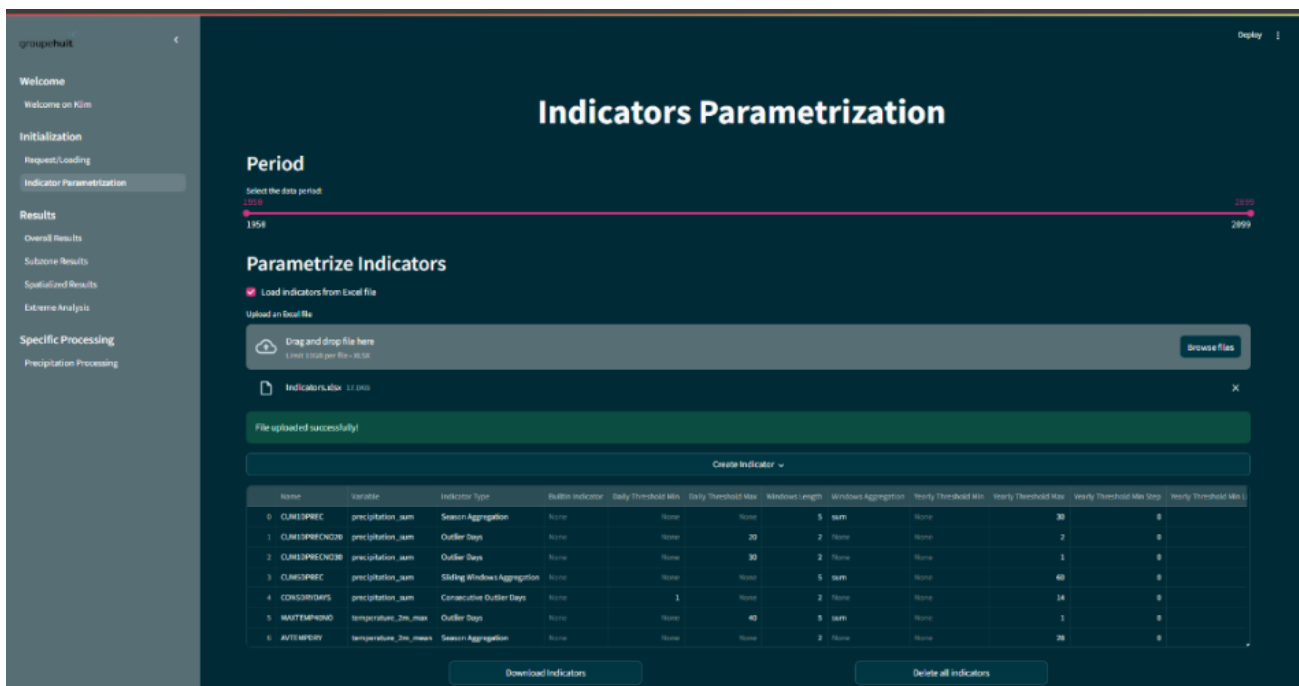


Figure 10: View of the climate indicator definition tool

Source: Internal production (consultant modeling environment)

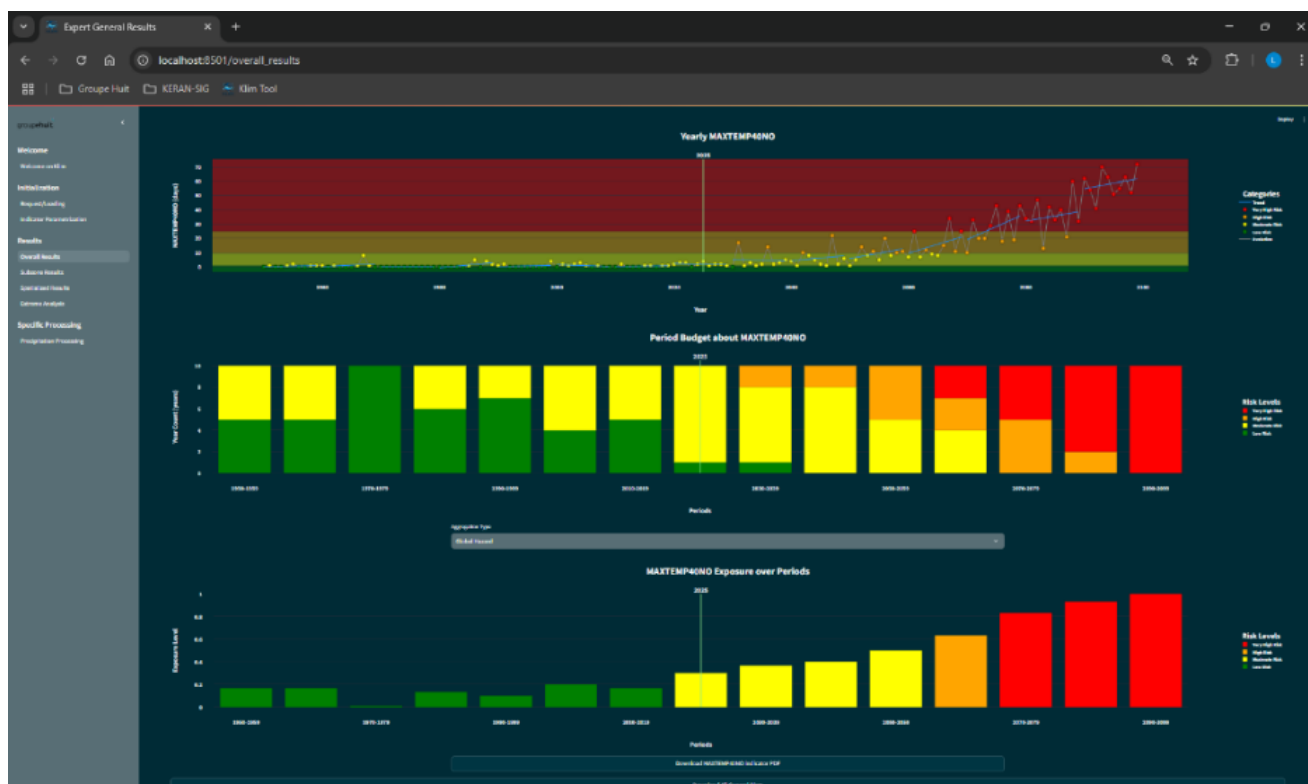


Figure 11: Visualization of indicators at the scale of the area of interest

Source: Internal production (consultant modeling environment)

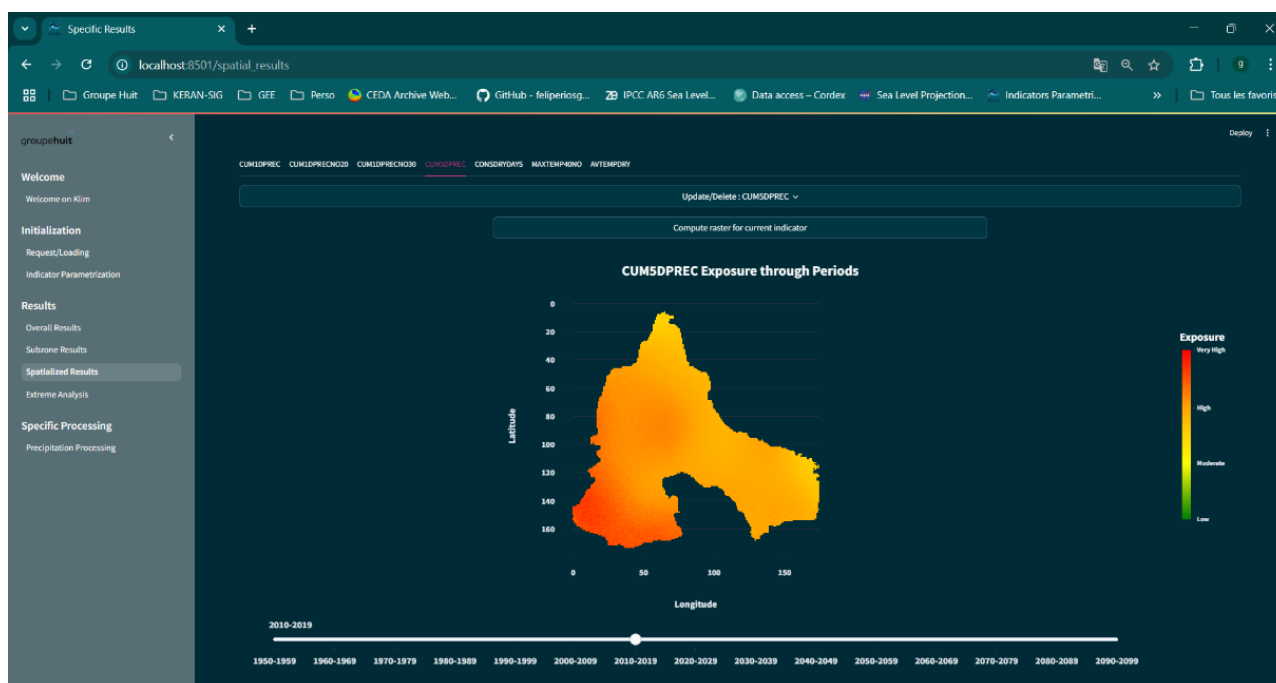


Figure 12: Visualization of spatialized indicators

Source: Internal production (consultant modeling environment)



Figure 13: Example of seasonal analysis - rainy season extraction
Source: Internal production (consultant modeling environment)

2.4 Data Collection

2.4.1 Climatic Data



In order to perform the analysis, the following data were collected through the use of **K'lim tool**. To be noted that the methodology applied in this CRVA can be replicated using alternative data processing workflows, provided that input data are consistent and of sufficient quality. The Klim tool is used as a practical means to process and analyze climate datasets, but similar outputs can be generated using other tools or platforms depending on data availability, technical capacity, and institutional context.

The following parameters were extracted, on the entire Laos area with a 0.25-degree resolution, on the period 1950-2100:

- Daily Cumulated Precipitation (mm)
- Water availability is a key determinant of agricultural productivity.
- Changes in precipitation patterns (intensity, duration, and frequency) can influence soil moisture levels, irrigation needs, and crop yields.
- Extreme rainfall can lead to flooding and soil erosion, while prolonged dry spells contribute to drought conditions that threaten agribusiness sustainability.
- Mean and Maximum Daily Temperature (°C)
- Temperature directly affects plant growth, evapotranspiration rates, and soil moisture retention.
- High temperatures can lead to heat stress in crops and livestock, reducing productivity and increasing water requirements.
- Maximum temperature is particularly relevant for assessing heatwave impacts, which can cause crop failure and affect livestock health.
- Daily Mean Relative Humidity (%)
- Humidity influences plant transpiration rates, disease prevalence, and pest activity.

- Lower humidity levels can increase evapotranspiration, leading to greater water loss from soil and plants, thereby intensifying drought effects.
- High humidity can promote fungal diseases in crops, affecting yield quality and storage conditions for harvested produce.
- Daily Shortwave Radiation (W/m^2)
- Solar radiation is a key driver of photosynthesis, determining crop growth rates and biomass production.
- Changes in radiation patterns can affect crop phenology (growth stages), influencing planting and harvesting schedules.
- Excessive solar radiation, combined with high temperatures, can lead to excessive evapotranspiration, increasing irrigation demands

2.4.2 Other Data

Additional data was collected through the use of specific APIs and use of ArcGIS Rest Services (K4D website²⁷ and other resources):

²⁷ Source: <https://en.data.k4d.la/>

2.4.3 Sectoral Focus Group Discussions

Targeted FGDs and consultations were conducted with technical representatives from key ministries and agencies overseeing agriculture and forestry, urban development and transport, and water resources. These participatory discussions displayed in Table 2 helped to capture qualitative insights from sectoral stakeholders and to contextualize climate vulnerability and adaptive capacity.

The following points were discussed:

- ▶ **Data Gaps & Systemic Limitations:** Challenges with real-time data access, coordination, internet coverage, and outdated forecasting tools.
- ▶ **Sector-specific Risks:** Floods and droughts affecting agriculture and infrastructure; disease outbreaks (e.g., dengue) during wet seasons.
- ▶ **Local Response & Resilience Constraints:** Irrigation shortages, reliance on outdated maps and reports, and weakened infrastructure preparedness.
- ▶ **Institutional Adaptation Actions:** Emergency warnings, technical training, inter-ministerial coordination, and agro-climatic services are active but fragmented.
- ▶ **Gender & Inclusion Concerns:** Women, elderly, and persons with disabilities often excluded from response planning; efforts underway to build inclusive strategies.

Table 2: Summary of the FGDs conducted

Date & Time	Ministry	Department	Participants
15 May 2025 AM	Ministry of Natural Resources and Environment (MONRE)	Department of Meteorology and Hydrology (DMH)	Total: 8 participants
16 May 2025 PM	Ministry of Natural Resources and Environment (MONRE)	Department of Water Resources (DWR)	Total: 9 participants
20 May 2025 AM	Ministry of Public Works and Transport (MPWT)	Department of Planning and Finance Department of Waterways Department of Transport Institute of Civil Engineering and Transport Department of Housing and Urban Planning	Total: 15 participants
20 May 2025 PM	Ministry of Agriculture and Forest (MAF)	Department of Planning and Cooperation Department of Forestry Department of Agriculture Land Management Department of Irrigation National Agriculture and Forestry Research Institute	Total: 14 participants

The qualitative insights collected through FGDs were systematically integrated into the analytical framework of the CRVA. In particular, FGD discussions informed the identification and validation of key hazard profiles (e.g. recurrent flooding in river basins, drought impacts on agriculture, wildfire risks in forested areas – see Annex 3 – Sectoral FGDs Summary), as well as sector-specific exposure patterns and vulnerability drivers, including institutional, technical, and financial constraints (see Annex 5 – Consolidated Vulnerability Questionnaire Results). These inputs were used to refine the assessment of sensitivity and adaptive capacity by highlighting critical issues such as data gaps, limited technical capacity, coordination challenges, and reliance on external project-based support. Furthermore, FGD findings provided essential context for interpreting quantitative results and identifying risk hotspots, ensuring that the analysis reflects operational realities across sectors.

3 CLIMATE FEATURES AND PROJECTIONS

3.1 Climate in Lao PDR

Lao PDR, a landlocked country in the Mekong Basin, is experiencing accelerating climate variability and long-term shifts in key climate parameters due to global warming. Its tropical monsoon climate is characterized by distinct wet and dry seasons, with most of the annual precipitation concentrated between May and October.

Over the past decades, observational records show rising mean temperatures, increased frequency of extreme heat days, and erratic rainfall patterns. Climate models project that average annual temperatures in Laos could increase by 1.5°C to 2.5°C by mid-century under moderate emissions scenarios and potentially exceed 3°C under high-emissions pathways (RCP8.5 / SSP5-8.5). These trends are already manifesting through more frequent and intense heatwaves, especially in lowland and urban areas, alongside longer and more severe dry spells that challenge rainfed agriculture.

Rainfall variability is expected to intensify, with both an increase in heavy rainfall events leading to flash floods, particularly in urbanized provinces like Vientiane, Savannakhet, and Champasak, and prolonged dry periods impacting water availability in upland areas such as Xiengkhouang and Phongsaly provinces. Seasonal shifts may disrupt the agricultural calendar, leading to maladapted planting and harvest periods unless climate-smart adjustments are made.

Furthermore, changes in precipitation and temperature regimes pose critical risks to biodiversity, particularly in forest ecosystems that serve as natural carbon sinks and climate buffers. As the climate warms, evapotranspiration rates will rise, intensifying soil moisture deficits and degrading both agricultural and forest lands unless soil conservation and reforestation strategies are scaled. Hydrological extremes, including riverine flooding from the Mekong and its tributaries, are expected to become more frequent due to both upstream hydropower development and altered rainfall-runoff dynamics.

Overall, Laos faces a complex climate future shaped by a convergence of slow-onset changes and sudden climate shocks. These risks necessitate transformative adaptation planning, a transition to sustainable land use, and climate-resilient infrastructure investments aligned with both mitigation and adaptation imperatives.

Figure 14 presents the historical evolution of climate zones in Lao PDR based on the Köppen-Geiger classification, across four time periods: 1901–1930, 1931–1960, 1961–1990, and 1991–2020.

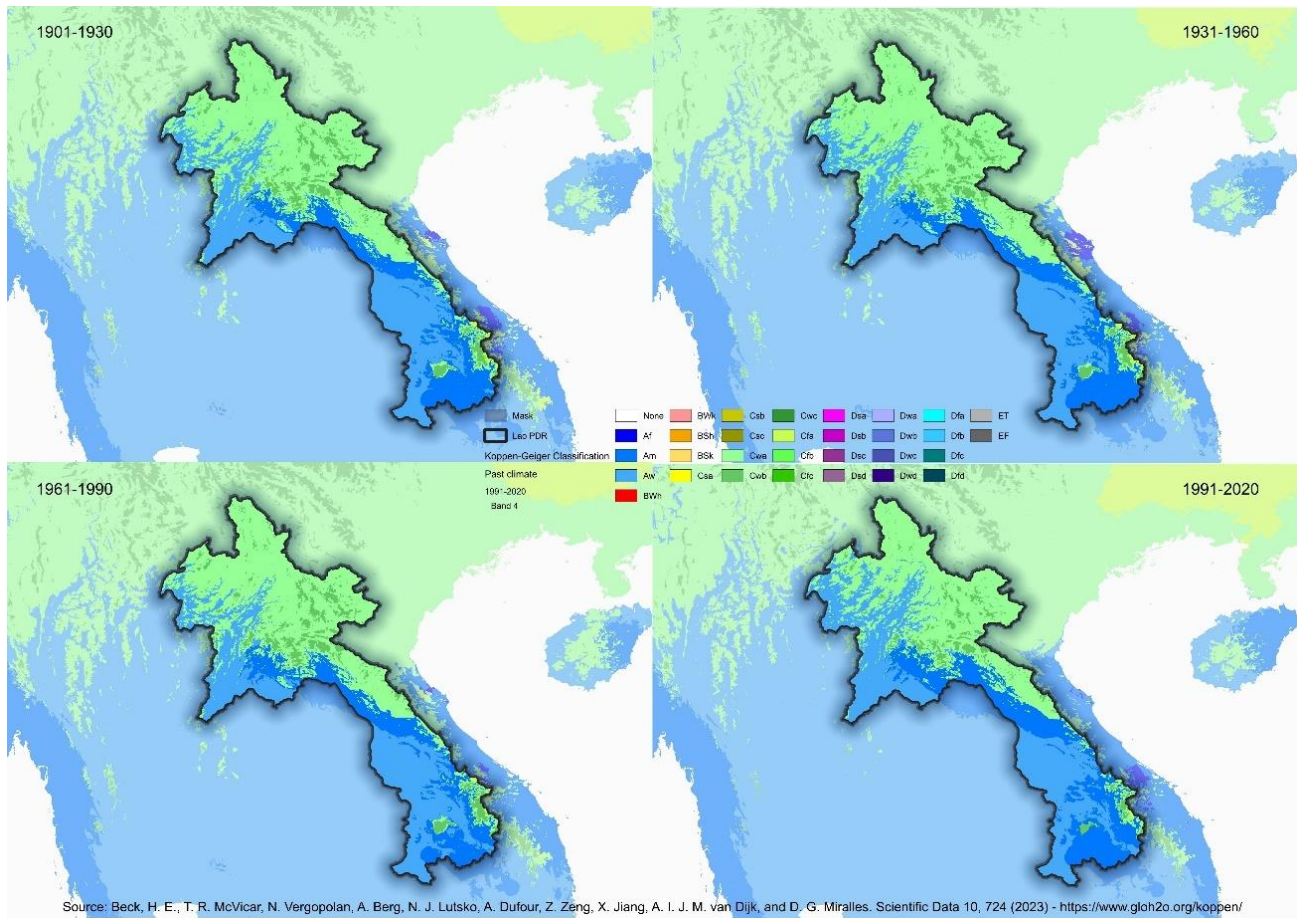


Figure 14: Overview of Köppen-Geiger classification in past situation
Source: Climate Change knowledge Portal, Lao PDR Profile, World Bank

Over time, this map reveals a gradual expansion of tropical savanna climate (Aw, in light blue) across most of the country. While the northern mountainous regions remained largely under the warm temperature with dry winter (Cwa and Cwb), the central part of the country is under a tropical monsoon climate (Am) which involves much more precipitation than Cwa or Cwb. The south is split into two categories, the upper part in Aw and lower part in Am. This trend indicates a historical warming and drying tendency, especially in southern Lao PDR.

Figure 15 now illustrates future projections of climate zones in Lao PDR under two Shared Socioeconomic Pathways (SSPs):

- SSP2-4.5 (intermediate scenario), and
- SSP5-8.5 (high emissions scenario), for two future periods: 2041–2070 and 2071–2100.

In both scenarios, the dominance of the tropical savanna (Aw) climate intensifies, progressively covering almost the entire country. Under SSP5-8.5, this shift is more pronounced and occurs more rapidly.

Highland areas that previously retained warm temperate (Cwa and Cwb in green on the map) conditions also change to tropical savanna (Aw in blue light) by the end of the century, particularly under SSP5-8.5. The main change between warm temperate and tropical savanna is the rise of temperature, and the decrease of precipitation. Therefore, this will automatically have impacts on the different sectors of the study that will be discussed later in the report. This reflects increasing temperature and changing rainfall patterns, which are likely to impact agriculture, water resources, and ecosystems throughout Lao PDR.

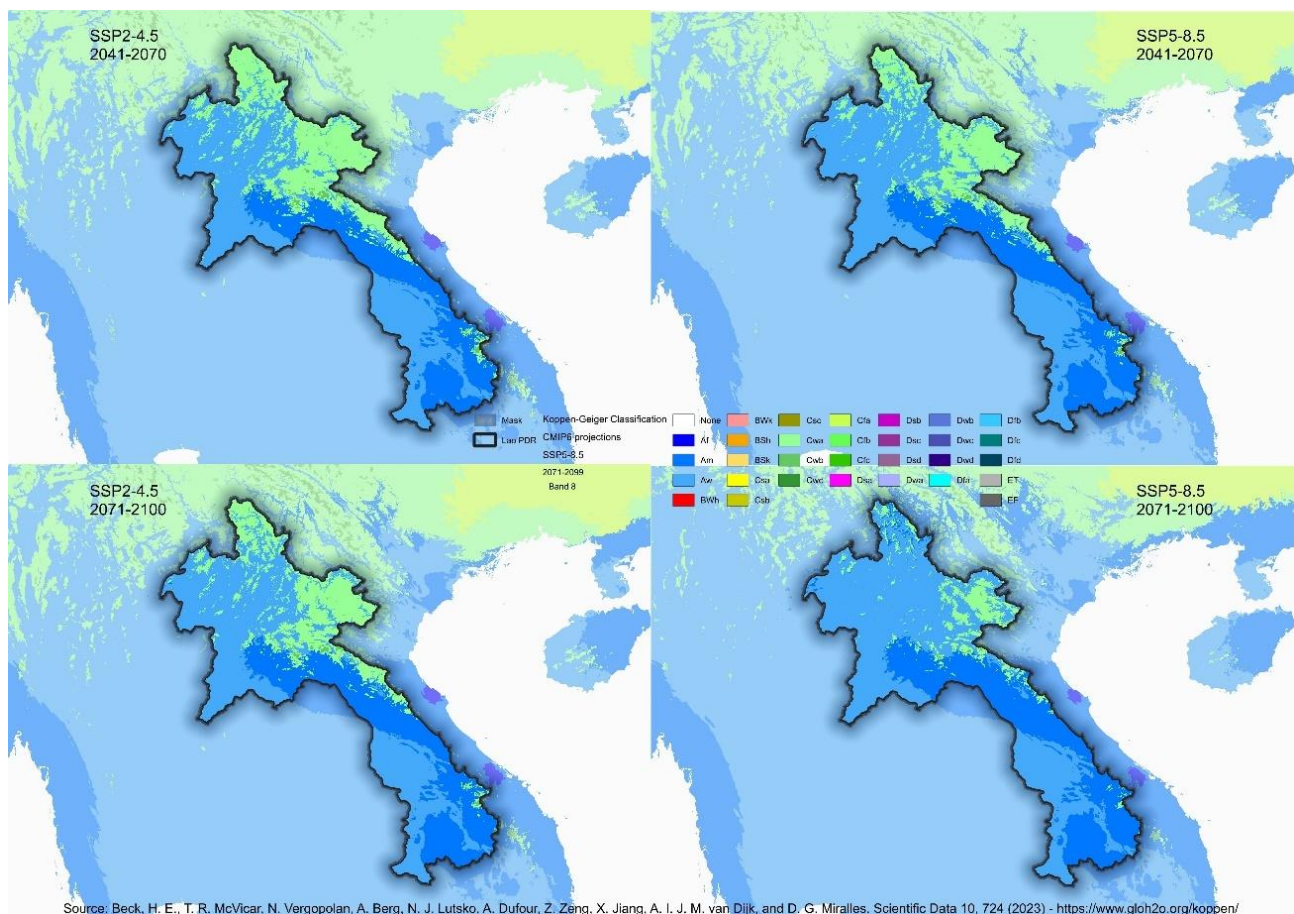


Figure 15: Overview of Köppen-Geiger classification in future situation as per SSP2-4.5 and SSP5-8.5

Source: Climate Change knowledge Portal, Lao PDR Profile, World Bank

3.2 Analysis of physical parameters (historical, trends and projections)

3.2.1 Climatic variables

All the graphs presented in this section have been generated using the K'lim tool, providing a comprehensive analysis of climatic trends and projections. The dataset spans an extensive period from 1950 to 2099, offering both historical context and future projections. It is important to note that the data from 1950 to 2014 are based on observed real-world measurements, while the data from 2015 onwards represent projected values under two distinct climate scenarios: SSP2-4.5 and SSP5-8.5.

3.2.1.1 Relative Humidity

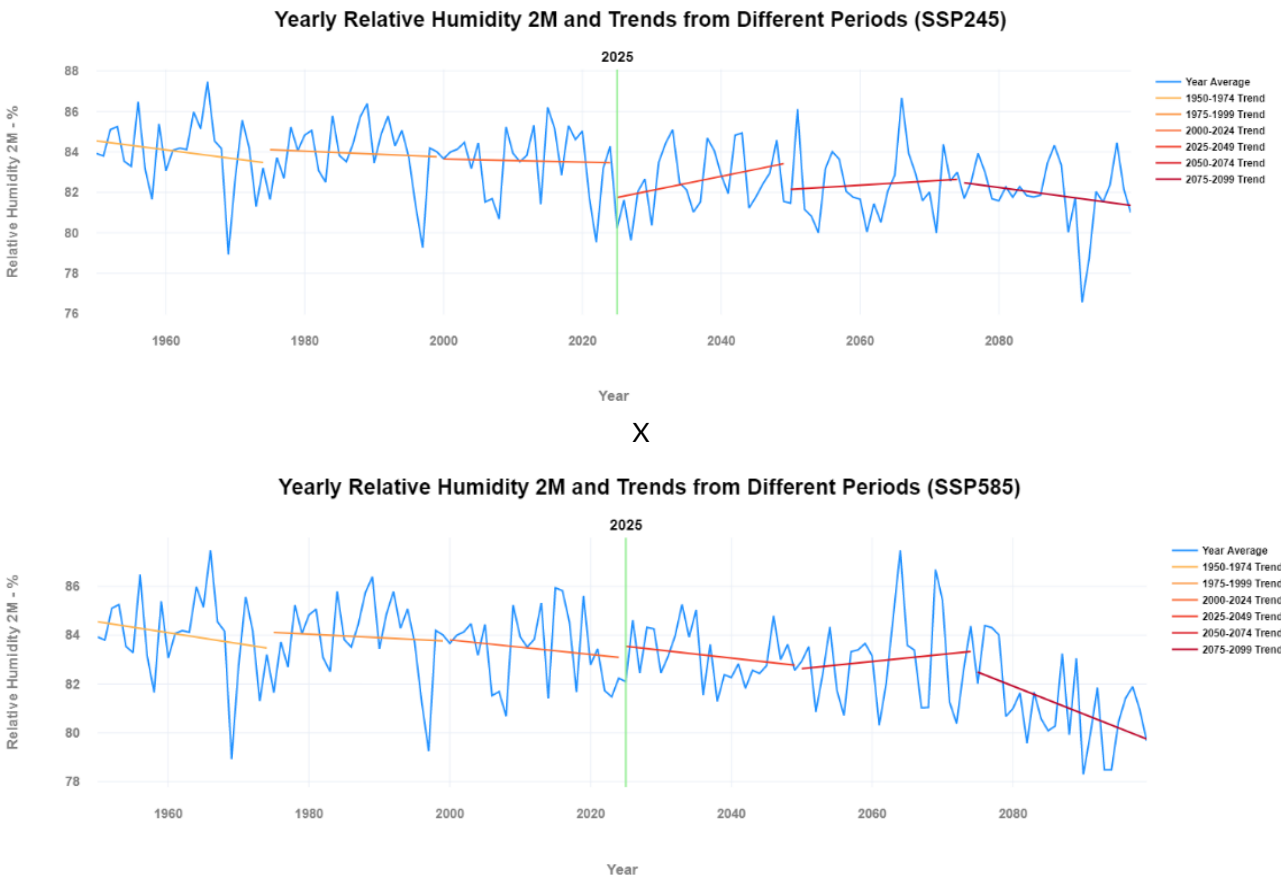


Figure 16 – Annual relative humidity average evolutions and trends from 1950 to 2099 with both SSP2-4.5 and SSP5-8.5

Source: Climate Change knowledge Portal, Lao PDR Profile, World Bank

Historical data reveals that relative humidity levels in Laos have remained stable over past decades, showing little variation across different time periods. This stability is observed consistently in both climate scenarios during the historical period. However, projections indicate a significant shift in this trend beginning around 2025. From this point onward, both scenarios show a clear decreasing trend in relative humidity, though with notable differences in magnitude and rate of change, especially at the end of the century.

Under the moderate emissions scenario (SSP2-4.5), the decline in relative humidity is gradual and relatively contained, suggesting a more manageable adaptation challenge. In contrast, the high emissions scenario (SSP5-

8.5) presents a more alarming picture, with a steeper and more pronounced decrease in relative humidity levels, starting around 2075. This accelerated decline under SSP5-8.5 scenario indicates potentially more severe impacts on various sectors, particularly agriculture, water resources, and ecosystems that are sensitive to humidity changes.

The projected decrease in relative humidity has several important implications. Lower humidity levels can lead to increased evapotranspiration rates, potentially exacerbating water stress for vegetation and crops. This trend may also contribute to more frequent and intense drought conditions, particularly in regions already experiencing water scarcity.

3.2.1.2 Precipitations

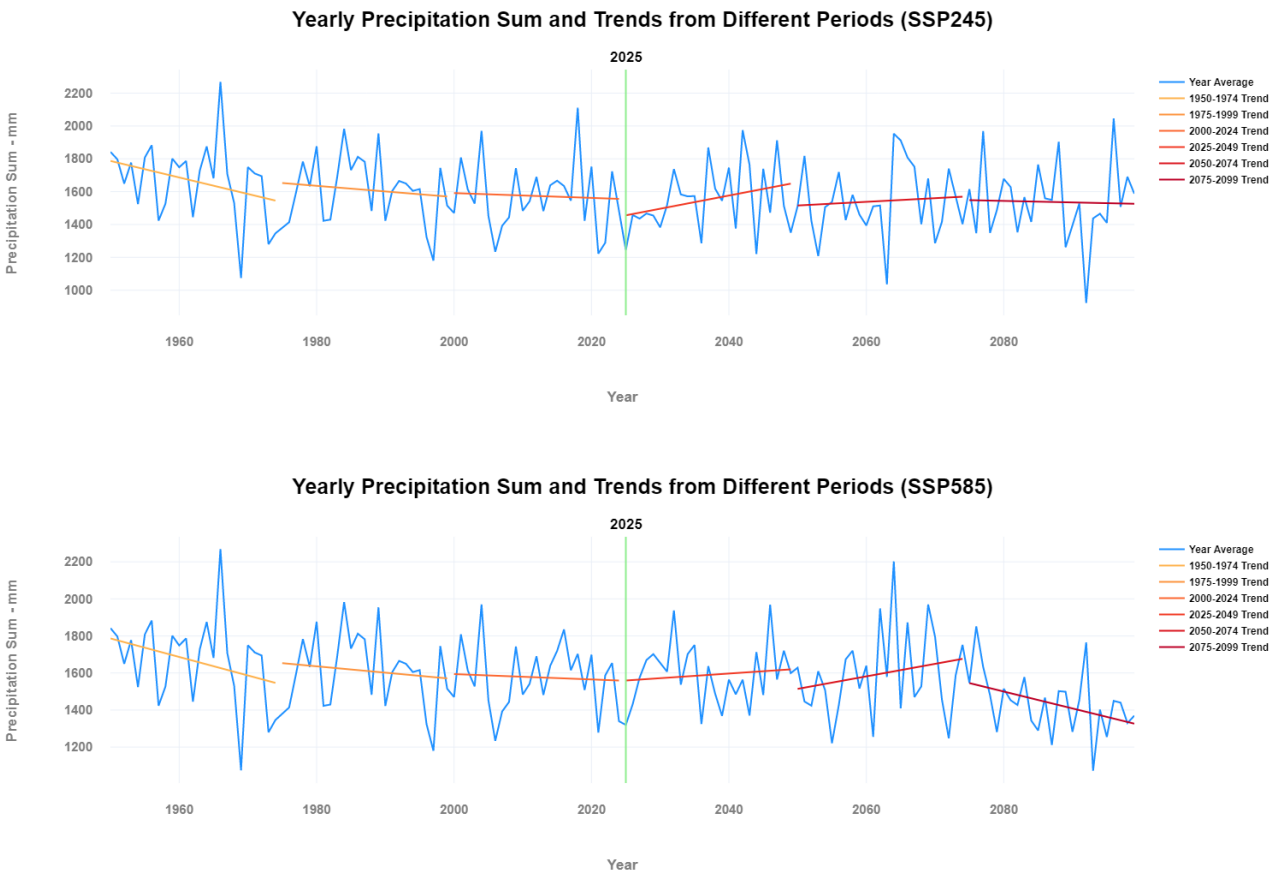


Figure 17 – Annual precipitation evolutions and trends from 1950 to 2099 with both SSP2-4.5 and SSP5-8.5

Source: Climate Change knowledge Portal, Lao PDR Profile, World Bank

Historical precipitation data from 1950 to the present shows a gradual decline in annual rainfall, decreasing from approximately 1800 mm/year to 1600 mm/year. This downward trend represents a reduction of about 200 mm over the historical period, indicating a slow but steady decrease in precipitation.

Looking ahead, climate projections under both scenarios show similar trends until the last quarter of the 21st century. However, significant divergences emerge in the long-term projections.

Under the moderate emissions scenario (SSP2-4.5), precipitation levels remain relatively stable throughout most of the century, maintaining an average of around 1600 mm/year. Toward the end of the century, a slight

decreasing trend becomes apparent, with precipitation levels dropping by approximately 100 mm/year. While this represents a reduction, the change is relatively modest compared to historical variations.

In contrast, the high emissions scenario (SSP5-8.5) presents a more complex and concerning picture. Following the initial decline, precipitation levels begin to increase again after 2025, reaching about 1700 mm/year by 2075. However, this temporary increase is followed by a sharp decline in the latter part of the century. The precipitation levels drop significantly, with a steep negative slope that results in annual precipitation of only about 1300 mm/year by the end of the century. This represents a substantial decrease of 400 mm/year from the mid-century average.

A significant decrease in annual precipitation, particularly as projected under the SSP5-8.5 scenario, would have substantial consequences for Laos' natural systems and socio-economic sectors. Reduced rainfall could lead to decreased water availability, affecting both surface water and groundwater resources. This water scarcity would likely impact agricultural productivity, potentially reducing crop yields and threatening food security, especially for rain-fed agriculture which constitutes a significant portion of Laos' farming systems.

3.2.1.3 Temperature

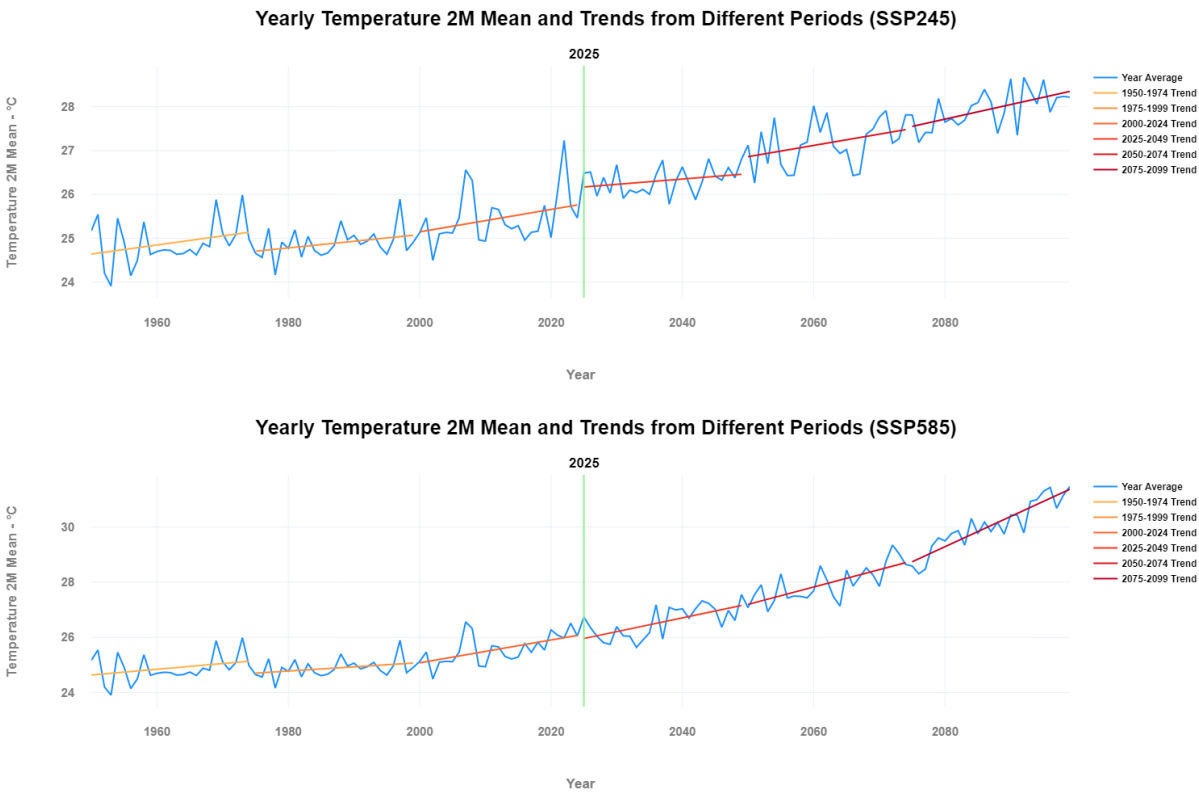


Figure 18- Annual temperature evolutions and trends from 1950 to 2099 with both SSP2-4.5 and SSP5-8.5
Source: Climate Change knowledge Portal, Lao PDR Profile, World Bank

Historical data reveals a clear upward trend in annual mean temperatures in Laos, with an observed increase of approximately +1°C from 1950 to 2025 across both climate scenarios. This warming trend is projected to continue beyond 2025, though with significant differences between the two scenarios.

Under the high emissions scenario (SSP5-8.5), the rate of temperature increases markedly. By the end of the century, the mean annual temperatures are projected to reach approximately 31°C, representing a substantial

+5°C increase from the 1950 baseline. This constitutes a 20% rise in temperature, which would have profound implications for both natural ecosystems and human systems in Laos.

Even under the more moderate emissions scenario (SSP2-4.5), the temperature increase remains concerning. Projections indicate that by 2099, the mean annual temperatures could reach nearly 29°C. While this represents a less dramatic increase than under SSP5-8.5, it still signifies a substantial warming trend that warrants serious attention from policymakers and planners.

The projected temperature increases under both scenarios present significant challenges for Laos. Such warming trends could exacerbate heat stress, affect agricultural productivity, alter ecosystem dynamics, and increase energy demands for cooling. The more pronounced warming under SSP5-8.5 particularly highlights the critical importance of global and national efforts to reduce greenhouse gas emissions and implement effective climate adaptation strategies.

3.2.2 Derived climatic indicators

3.2.2.1 Defining indicators

In order to assess the level of hazard under past and future conditions, a list of indicators to be found in Annex 1 has been defined, together with calculation methodologies and associated risks.

Each indicator is calculated as follows:

1. Extraction of the annual (or seasonal) variable required to calculate the indicator.
2. Comparison of each annual value with the defined thresholds and assignment of the corresponding hazard level:
 - 1 = Low if the annual value is below (or above, for SPEI06AP) the first threshold,
 - 2 = Moderate if the annual value is between the first and second thresholds,
 - 3 = High if the annual value is between the second and third thresholds,
 - 4 = Very high if the annual value exceeds the third threshold.
3. Assessment of the level of exposure for each hazard and each decade as follows: For each decade, calculate the number of years corresponding to each exposure level (1 to 4).
4. Calculation of an overall exposure score per decade using the following formula (factors 1/30 and 1/3 are used to normalize the value on a scale from 0 to 100%):

$$EXP = \frac{1}{30} \times (NUMYEAR_1 \times 1 + NUMYEAR_2 \times 2 + NUMYEAR_3 \times 3 + NUMYEAR_4 \times 4) - \frac{1}{3}$$

For each indicator, assessment of the level of exposure per decade:

1. $0 \leq EXP < 25\% \rightarrow$ Low exposure,
2. $25\% \leq EXP < 50\% \rightarrow$ Moderate exposure,
3. $50\% \leq EXP < 75\% \rightarrow$ High exposure,
4. $EXP \geq 75\% \rightarrow$ Very high exposure.

4 HAZARD AND EXPOSURE ASSESSMENT

4.1 General approach

A climatic hazard is an event, or combination of climatic events, which has potentially harmful outcomes. The objective is to identify the key climate-related hazards relevant to each sector, analyze corresponding climate parameters, and determine the extent to which these hazards pose risks to the study areas.

The first step involved selecting the primary climate hazards, such as droughts, heatwaves, flooding (pluvial and riverine), tropical storms, and landslides. Each hazard is linked to specific climate parameters (e.g., precipitation, temperature, wind speed) that serve as proxies for assessing hazard dynamics and trends under changing climate conditions. Next, the analysis evaluates the spatial and temporal likelihood of occurrence of each hazard in both current and projected future climate conditions, using reference scenarios (SSP2-4.5 and SSP5-8.5) for two horizons (2041–2070 and 2071–2100). Climate projections are based on regional downscaled models, as detailed in the Climate Context section.

This hazard characterization is then used to develop an exposure profile for each targeted sector (Agriculture & Forestry, Urban Development & Transport, and Water Resources). The exposure assessment considers both the frequency and severity of each hazard, to determine the level of threat posed to assets, systems, and populations in the study area. At this stage, the analysis focuses on a sectoral characterization of exposure based on hazard patterns and sector-specific sensitivities, rather than a fully spatialized overlay of hazard maps with detailed asset- or population-level datasets. While such spatially explicit analyses would allow for a more granular assessment of impacts, they require comprehensive and harmonized geospatial data. Nevertheless, this approach provides a robust and policy-relevant basis for identifying priority risks at the sectoral level, and can be further refined in future work with more detailed data.

4.2 Hazards identification

Over the past three decades, Lao PDR has experienced an increasingly diverse range of climate-related hazards. These events have not only caused widespread human and economic losses. This hazard screening synthesizes major historical events and scientific evidence across key hazard categories. Lao PDR is highly susceptible to climate change especially flood and drought. Over the last decade, annual economic loss and damage from disaster events, especially flood and drought, had almost quadrupled from about \$94 million in 2009, to \$200 million in 2011 and \$371.5 million in 2018, which was equivalent to 2.1% of the country's projected 2018 GDP, and 10.2% of its 2018 budget²⁸

As previously mentioned, the consultant will primarily focus on the report 'Lao PDR Provincial Storyline-based Climate Risk, Vulnerability and Adaptation Assessment' for the hazard analysis. However, as per the Terms of Reference, special attention will be given to both drought and flooding but will also approach landslides as well as emerging hazards such extreme heat events and wildfires.

As requested by GGGI, the analysis presented in the “Lao PDR Provincial Storyline-based Climate Risk, Vulnerability and Adaptation Assessment” report will be complemented by a mapping analysis using Klim tool as presented in the methodology, proposing a cross-analyze the results from both approaches to ensure consistency and enhance the robustness of the findings.

²⁸ NDC Implementation Plan 2024

Floods

These events are caused by tropical storms and monsoons and can also take the form of flash flooding, including damage to dams. They are the most frequent and destructive hazards for the Lao PDR and caused 37% of hazard-related deaths, 85% of hazard-related injuries, and 77% of recorded economic losses during 1990–2018. The low-lying floodplains of the Mekong River and its tributaries are the most exposed areas of the country to flooding. Floods cause the outbreak of diseases, including acute diarrheal disease, dengue fever, and malaria, and adversely impact rice production, with significant consequences for rural livelihoods and food security. Women are disproportionately affected by floods. For example, floods in 2018 increased women's workloads and the risk of experiencing GBV in temporary shelters and camps (UNDDR, 2019).

Tropical storms

Storms are strongest during the monsoon season and most adversely affect low-lying floodplain areas, including their production of key crops such as rice. During 1990–2018, storms were responsible for 10% of the country's recorded hazard-related economic losses. Climate change is predicted to exacerbate storms by increasing annual rainfall by an estimated 7% in the region (UNDDR, 2019).

HAZARDS

Droughts

Droughts affected 9% of the population during 1990–2018 (UNDDR, 2019). Droughts can result in water shortages, which represent an emerging risk for the Lao PDR agriculture sector and a particular concern for subsistence farmers. Droughts impact health outcomes and hydroelectric power generation and can contribute to increases in pollution, forced migration, and the prevalence of diseases. The impacts of droughts are predicted to significantly worsen in the southern regions of Lao PDR in the coming years.

Landslides

These are often correlated with high precipitation due to floods and storms, and result in significant losses of lives, property, and agricultural production. Landslides threaten an estimated 5.24% of the country's terrain, mainly in the southeast and central regions which are characterized by steep topography and particular soil conditions (UNDDR, 2019).

Heat waves

Laos has seen increasingly severe heatwave events in recent years. In April 2023, Sainyabuli reached a record 42.9 °C, followed by Luang Prabang hitting 43.5 °C on May 6, with Vientiane reaching 42.5 °C, each breaking historical highs (World Weather Attribution, 2023). When high temperature are combined with high humidity, it worsens the consequences of heatwaves not only for cities but also for human bodies. Perceived as "silent killers" heatwaves are often overlooked in disaster reporting and therefore numbers on affected people and casualties across Southeast Asia are lacking. However, according to the WHO heat-related medical conditions will inevitably increase due to heatwaves in Lao PDR and regarding losses, Parsons et al. (2022), for example, estimate that globally, annual labor productivity losses driven by humid heat can amount to roughly US\$2.1 trillion (in constant 2017 US dollars adjusted for purchasing power parity).

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Key climate hazards to be considered in the present study and related key climate parameters and impacts are presented in Table 3.

Table 3: Climate hazards and related impacts and key parameters

Hazard	Impact	Climate Parameters
Sector 1: Agriculture & Forestry		
Droughts	Crop failure, soil degradation, water scarcity, animal heat stress, biodiversity loss	Precipitation, Temperature
Heatwaves	Heat stress on crops/livestock, reduced yield, animal heat stress, soil degradation, biodiversity loss	Temperature
Flooding (pluvial and river)	Soil erosion, crop loss, seed washout, Damage to farmland, crop loss, nutrient leaching	Precipitation
Landslides	Loss of arable land, forest degradation,	Precipitation
Sector 2: Urban Development & Transport		
Droughts	Water shortages, disruption in urban services, pressure on urban green areas	Precipitation, Temperature
Heatwaves	Heat stress for vulnerable populations, infrastructure strain (e.g., roads, buildings), increased energy demand	Temperature
Urban flooding	Damage to infrastructure, traffic disruption, drainage system overload, water contamination	Precipitation, Rainfall intensity
Landslides	Road blockage, damage to infrastructure, safety risks in hilly urban settlements	Precipitation, soil saturation
Sector 3: Water Resources		
Droughts	Reduced river flow and reservoir levels, irrigation water shortage, degraded water quality	Precipitation, Temperature
Heatwaves	Increased evaporation, reduced surface water availability, water quality issues	Temperature
Flooding	Contamination of water sources, infrastructure damage (dams, canals), service disruption	Precipitation, River discharge
Landslides	Blockage of water courses, sedimentation of reservoirs and irrigation systems	Precipitation, Soil saturation

In order to assess the level of hazard under past and future conditions, a list of indicators has been defined, together with calculation methodologies and associated risks. These indicators are computed along with threshold values to each key climate parameter in order to determine above which value of key parameter the corresponding hazard event begins to occur.

- **DROUGHTS:** Two primary types of droughts may affect Lao PDR, meteorological (usually associated with a precipitation deficit) and hydrological (usually associated with a deficit in surface and subsurface water flow, potentially originating in the region's wider river basins). The following analysis of droughts considers mainly the impact on agriculture yields. The typical threshold for hydrological drought, commonly found in scientific literature²⁹ and water management guidelines, is around 30 days without sufficient precipitation (below 1 mm/day). This basis threshold has been adapted towards a drought stress index to consider context specific water needs, soil moisture availability, etc. For agriculture yields, it is considered after ~7 consecutive dry days, soil moisture depletes, evapotranspiration exceeds supply, crops face stomatal closure, yield loss.

²⁹ https://link.springer.com/referenceworkentry/10.1007/978-3-319-71063-1_68-1

- **EXTREME HEAT:** The WMO defines a heatwave as five or more consecutive days during which the daily maximum temperature surpasses the average maximum temperature by 5°C or more.⁵ Such a definition must be crossed with other parameters which reflects which peak temperature can be reached annually. Therefore, heatwaves were analyzed with heat stress index

- Characterization of maximal annual daily surface temperature, with thresholds which set for different impact on sectors (yield stress, livestock stress, fish stock stress, water resources stress, etc.)
- Characterization of annual maximum number of consecutive days with daily maximum temperature above average daily maximum temperature.

Minimum recurrence interval of both thresholds is retained as likelihood occurrence for characterization of related heatwave hazard.

Heat stress is variable per targeted impact: agriculture yields, livestock, fish stock, forest biodiversity, water quality, human health in urban environments, etc.

- **Agriculture yields:** When temperatures exceed approximately 36°C, many crops begin to suffer heat stress, leading to reduced photosynthesis, flower abortion, and limited grain filling, ultimately reducing yields.
- **Livestock:** Animals are sensitive to heat and may stop feeding when the Temperature-Humidity Index (THI) exceeds 28, resulting in productivity losses.
- **Fish stock:** When air temperatures exceed 32°C, water bodies can warm to 28–29°C, reducing oxygen solubility while simultaneously increasing fish metabolic demand, threatening aquatic life.
- **Forest biodiversity:** In the analysis it has been considered that 03 or more consecutive days above 35°C are associated with tree hydraulic failure, leaf scorching, understory mortality, and biodiversity loss, particularly in sensitive forest ecosystems.
- **Water resources:** A Coefficient of Variation (CV) greater than 20–30% in annual groundwater recharge indicates high inter-annual variability, suggesting unstable recharge patterns. This level of variability poses a risk to aquifer sustainability, particularly during dry seasons, and is therefore used as a threshold to characterize areas with high exposure to groundwater-related stress.
- **Human health:** Nighttime temperatures above 25°C, especially when occurring more than 10 nights per year, are linked to increased mortality rates, urban tree degradation, and a worsening urban heat island effect, compromising public health and urban livability.

- **RIVER FLOODING:** Research suggests that a 5-day cumulative rainfall threshold can be used to assess the risk of river flooding. Several studies³⁰ indicate that a threshold of 50 mm over 5 days at the scale of the river sub catchment is a realistic threshold to define river flooding event. In the analysis, it has been considered that dams and levees are designed for ~50–100 mm over 5 days and above that, spillways activated, floodplain inundation, infrastructure at risk.

- **PLUVIAL FLOODING:** Research suggests that a 1-day cumulative rainfall threshold can be used to assess the risk of urban pluvial flooding. Several studies³¹ indicate that a threshold of 11 to 20 mm over 5 days at the scale of the river sub catchment is a realistic threshold to define pluvial flooding event. As some provinces in Lao PDR are subject to high intense rainfall events, we proposed a threshold of 25 mm in order not to over assess pluvial flooding hazard.

In urban settings, drainage systems are typically designed to handle 25–50 mm/day of rainfall. Rainfall above 50 mm/day generally causes surface pooling, while above 75 mm/day can overwhelm drainage infrastructure, leading to road and basement flooding. Additionally, urban cleanup and sanitation systems tend to become strained after 5 to 10 heavy rain events per year. Exceeding this number risks

³⁰ <https://www.sciencedirect.com/science/article/pii/S0022169421011069>

³¹ <https://hess.copernicus.org/preprints/hess-2017-751/hess-2017-751.pdf>

overwhelming waste management, sanitation services, and road debris removal, compounding the impacts of flooding.

- **LANDSLIDES:** In Lao PDR, landslides are primarily triggered by intense or prolonged rainfall, especially in mountainous areas where slopes are unstable and vegetation cover is degraded. Daily precipitation is therefore the key variable in assessing landslide risk.

To support this analysis, a Soil Quality Index was calculated based on the relationship between rainfall and potential evapotranspiration (PET). Specifically, it considers that when PET exceeds precipitation for more than 20% of days, it leads to soil degradation processes such as crusting, reduced biological activity, erosion, compaction, and declining fertility. These factors significantly increase the vulnerability of soils to landslides.

Table 4: Identified indicators and derived variables

Sectors	Sub-categories	Indicators	Definition	Variable
Agriculture & Forestry	Agriculture yields	Heat Stress Index	Annual number of days when HeatIndex exceeds a critical threshold the crop during the growing season	HeatIndex (derived from maximum daily temperature and mean daily relative humidity)
		Drought Stress Index	Annual maximum number of consecutive dry days (precipitation < 1mm)	Daily precipitation
	Livestock	Heat Stress Index	Annual number of days THI exceeds critical limits for animal	Temperature Humidity Index (derived from max daily t° and mean daily relative humidity)
	Fish stock	Heat Stress Index	Annual number of days with Tmax > 30°C (proxy for hot water)	Maximum daily temperature
	Soil Quality	Soil Quality Index	Annual number of days with climatic water deficit (PET – Precipitation > 0)	Potential Evapotranspiration (derived from max daily t°) and daily precipitation
	Forest & Biodiversity	Heat Stress	Events/Years where Tmax > threshold for ≥ 3 consecutive days	Maximum daily temperature
Water resources management	Water Quality	Heat stress index	Annual max temperature	Maximum daily temperature
	River & Reservoir flows	Flood stress Index	Maximum 5-day cumulated precipitation	Daily precipitation
	Groundwater management	Precipitation groundwater index	Cumulated precipitation	Daily precipitation
Urban Development & Transport	Infrastructures Urban ecosystems Urban clean up Water infrastructure Hydraulic infra	Flood stress Index	Maximum 5-day cumulated precipitation	Daily precipitation
		Run off stress Index	Maximum daily precipitation	Daily precipitation
		Urban clean up stress	Number of days with precipitation >25mm	Daily precipitation
		Night heat stress	Number of nights with Tmin > 25°C	Minimum daily temperature

The context specific daily thresholds are synthesized in Table 5:

Table 5: Indicators context specific daily thresholds

		Daily threshold	Low	Moderate	High	Very high
Heat Stress Index for agriculture crops	Annual number of days when HeatIndex exceeds a critical threshold the crop during the growing season	HI > 36°C	< 5 days	5-10 days	10-20 days	>20 days
Drought Stress Index	Annual maximum number of consecutive dry days (precipitation < 1mm)	Precipitation <1mm	< 7 days	7-14 days	14-21 days	>21 days
Heat Stress Index for Livestock	Annual number of days THI exceeds critical limits for animal	THI >28°C	<10 days	10-20 days	20-30 days	>30 days
Heat Stress for fish stock	Annual number of days with Tmax >30°C (proxy for hot water)	Max T° >32°C	<10 days	10-20 days	20-30 days	>30 days
Soil Quality Index	Annual number of days with climatic water deficit (PET – Precipitation >0)	CWD > 0	<20%	20-30%	30-40%	>40%
Heat Stress Index (forest biodiversity)	Events/Years where Tmax > threshold for ≥ 3 consecutive days	Max T° > 35°C	0-1 events	2-3 events	4-5 events	>5 events
Run off stress Index	Maximum daily precipitation		<25mm	25-50mm	50-75mm	>75 mm
River Flooding stress Index	Maximum 5-day cumulated precipitation		<100mm	100-150 mm	150-200 mm	>200mm
Precipitation groundwater index	Cumulated precipitation		>1500mm	1250-1500 mm	1000-1250mm	<1000mm
Heat Stress Index (Water quality)	Annual max temperature		<35°C	35-40°C	40-45°C	>45°C
Urban clean up stress	Number of days with precipitation >25mm		<2days	2-5days	5-10 days	>10 days
Night heat stress	Number of nights with Tmin > 25°C	Min T°>25°C	<5 nights	5-10 nights	10-20 nights	>20 nights

See detailed table in Annex 1

4.3 Hazard screening

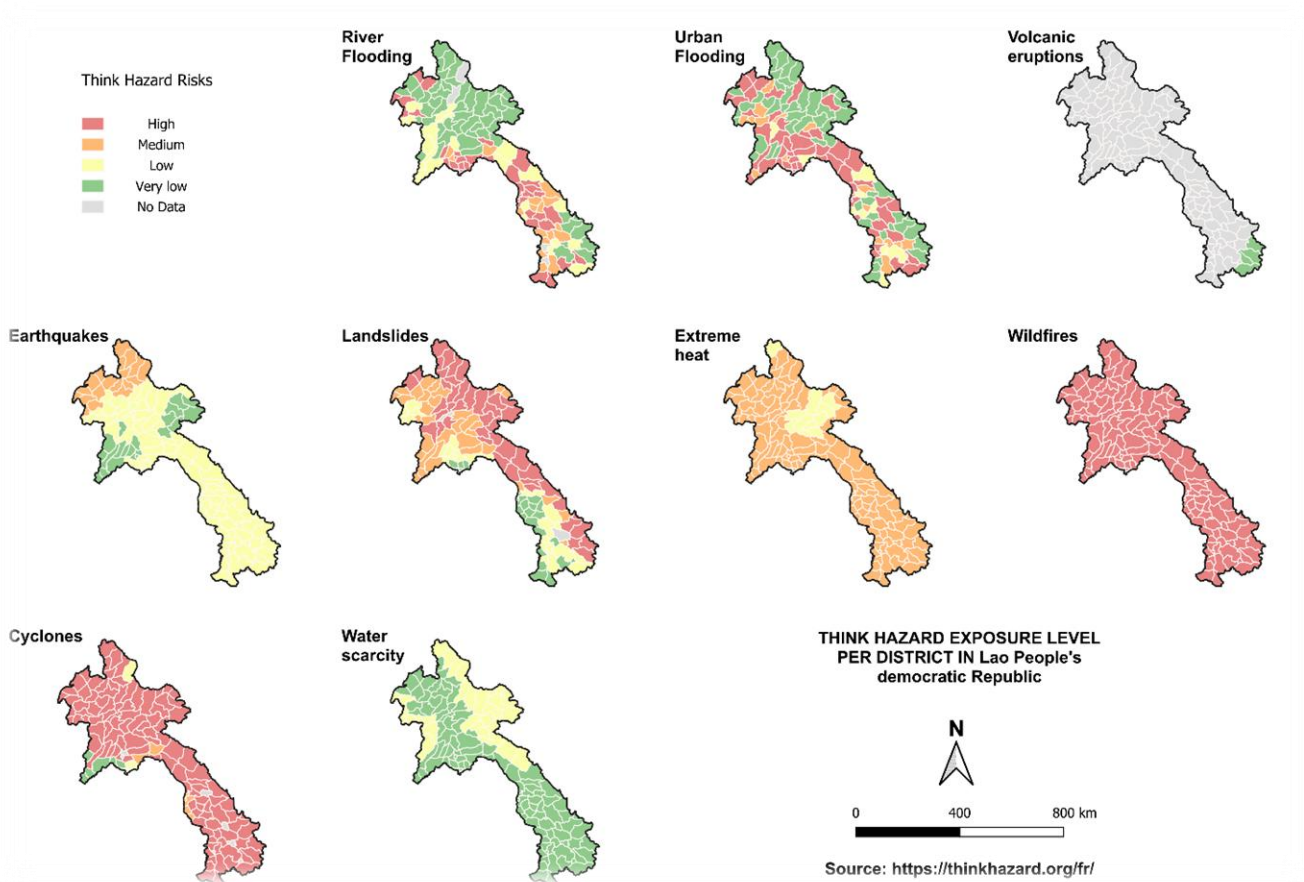


Figure 19 - Think Hazard Risk Screening

Source : <https://thinkhazard.org/fr/>

The following risk assessments for Laos, based on Think Hazard data³² and the National Risk Profile of Lao PDR developed by the UNDP ³³, should be interpreted with caution, as they reflect current climate-related vulnerabilities. The analysis highlights several key patterns that warrant further investigation and careful interpretation.

For riverine and urban flooding, the maps show heightened vulnerability in central Laos, with additional urban flood risks dispersed across the country, indicating susceptibility in these areas. Interestingly, landslide risks are concentrated in the northeastern region, with no apparent correlation to flood-prone zones.

Extreme heat poses a moderate to high risk nationwide, reflecting widespread exposure to rising temperatures. Wildfire risk is more difficult to interpret, as the entire country is classified as high risk.

Water scarcity currently poses a generally low risk, except in certain northern regions where moderate levels are observed. This spatial variation underscores the importance of region-specific water resource management strategies.

³² Global Facility for Disaster Reduction and Recovery (GFDRR). (n.d.). ThinkHazard Retrieved from: <https://www.thinkhazard.org/en/>

³³ Asian Disaster Preparedness Center (ADPC). (2010). *Developing a National Risk Profile of Lao PDR: Part 1 - Hazard Assessment*. Vientiane: ADPC. Retrieved from https://data.laos.opendevlopmentmekong.net/library_record/developing-a-national-risk-profile-of-lao-pdr-part-1-hazard-assessment

While these assessments offer valuable initial insights, they should be complemented with detailed local studies that incorporate geological, topographical, and localized climate data. Such enhanced analysis will support more targeted adaptation and mitigation strategies, particularly in the most vulnerable regions identified.

4.4 Hazard & exposure assessment

4.4.1 Extreme heat events

4.4.1.1 Agriculture and Forestry

The Heat Index (HI), which combines air temperature and relative humidity to determine perceived temperature, has significant implications for agriculture in Laos. While primarily designed for human comfort and health, the underlying factors of the Heat Index—high temperatures and humidity—can profoundly impact plant health and agricultural productivity.

HEAT_AG (Heat Stress – Crops)

- ▶ **Definition:** Days with HI >36°C during growing season
- ▶ **Impact:** Feed intake declines, animal stress

Province	Exposure Rating
Champasak	Very High (>20 days)
Khammouane	High (10–20 days)
Xekong	High (10–20 days)
Oudomxay	Moderate (5–10 days)
Xiengkhouang	Low (<5 days)
Phongsaly	Low (<5 days)

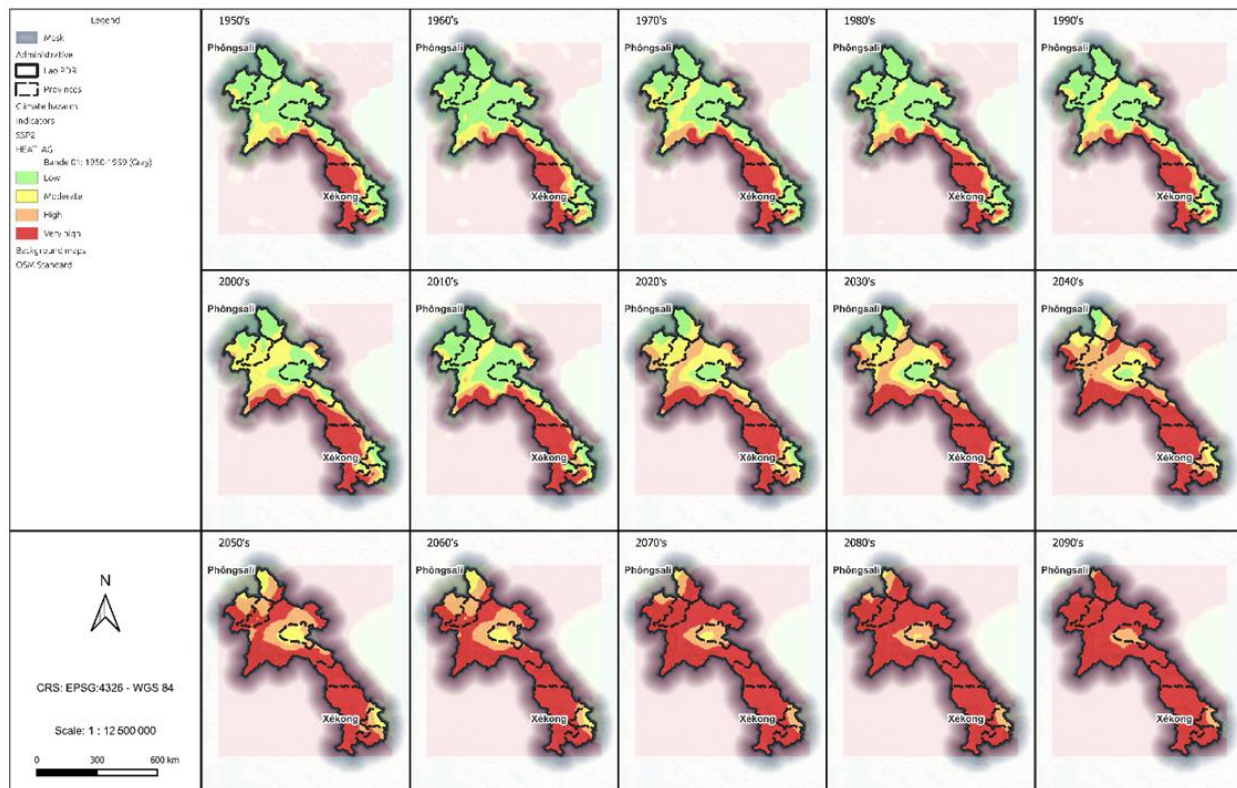
**Sector 1: Agriculture & Forestry**
Overview of past and future evolution of Agriculture Heat Stress Index up to 2100 as per SSP2-4.5

Figure 20 - Evolution of HEAT_AG indicator from 1950 to 2099 with SSP2-4.5

Source: Internal production (consultant modeling environment)

In 1950, only the southern border with Thailand experienced significantly high Heat Index values. Over time, this trend has steadily worsened and is projected to continue deteriorating. By 2100, the entire country is expected to face very high Heat Index values, indicating more than 20 days per year with a Heat Index exceeding 36°C. This trend is consistent across both scenarios, SSP2-4.5 and SSP5-8.5, with the latter scenario experiencing a more rapid deterioration.

Elevated HI values can have severe consequences for agriculture and forestry in Laos. High temperatures and humidity can induce heat stress in crops, leading to reduced photosynthesis, impaired growth, and increased susceptibility to diseases. This stress is particularly detrimental to sensitive crops such as potatoes, tomatoes, and tea, resulting in significantly lower yields and degraded quality. Warm, humid conditions favor the proliferation and the development of diseases, further compromising crop health, and impacting directly the yield.

The rising Heat Index may necessitate changes in agricultural practices, including the adoption of heat-resistant crop varieties, altered planting schedules, and improved irrigation techniques. Farmers may need to relocate crops to more suitable climates, which could disrupt traditional farming systems and local economies.

In forestry, increased heat and humidity can stress forest ecosystems, leading to reduced growth rates, increased susceptibility to diseases, and higher mortality rates among tree species. This results in degraded forest health and reduced biodiversity.

Elevated temperatures can also increase the risk of wildfires, devastate forest areas and lead to loss of habitat, reduced carbon sequestration, and long-term ecological damage.

The degradation of forest health can impair the provision of ecosystem services, such as water regulation, soil stabilization, and habitat for wildlife. It further impacts agricultural productivity and environmental sustainability.

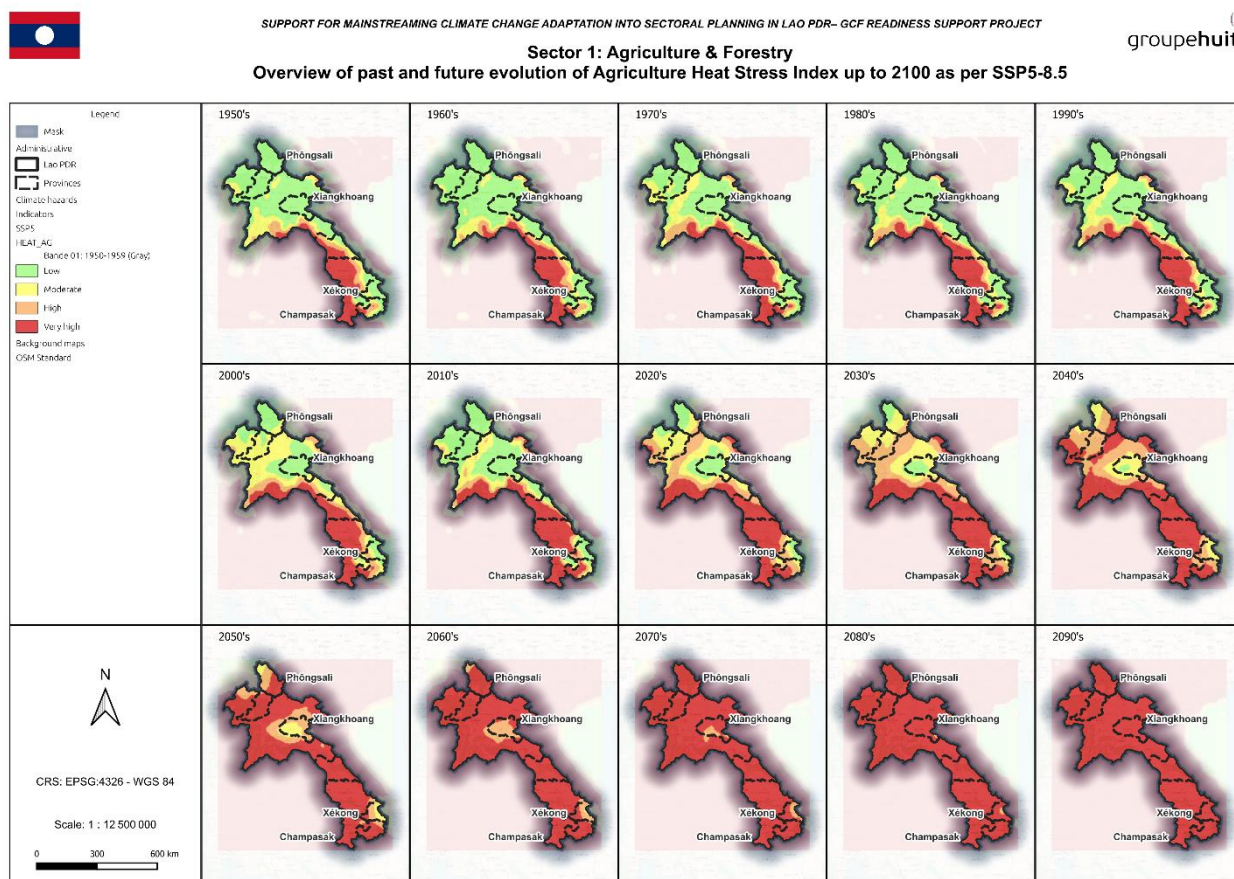


Figure 20 - Evolution of HEAT_AG indicator from 1950 to 2099 with SSP5-8.5

Source: Internal production (consultant modeling environment)

4.4.1.2 Urban Development and Transport

HEAT_NIGHT_URB is a crucial indicator in urban development, as it focuses on the human perception of climate conditions. This indicator measures the Heat Stress Index at night by counting the number of days in a year when the minimum temperature exceeds 25°C. Understanding and monitoring HEAT_NIGHT_URB is essential for assessing the impacts of nighttime warming on urban areas and their inhabitants.

HEAT_NIGHT_URB (Urban Night Heat)

- **Definition:** Nights with $T_{min} > 25^{\circ}\text{C}$
- **Impact:** Human/ecosystem stress

Province	Exposure Rating
Champasak	Very High
Khammouane	High
Xekong	High
Oudomxay	Moderate
Xiengkhouang	Low
PhongsalyPhongsaly	Low

Sector 2: Urban development & transport
Overview of past and future evolution of Night Heat Stress Index up to 2100 as per SSP2-4.5

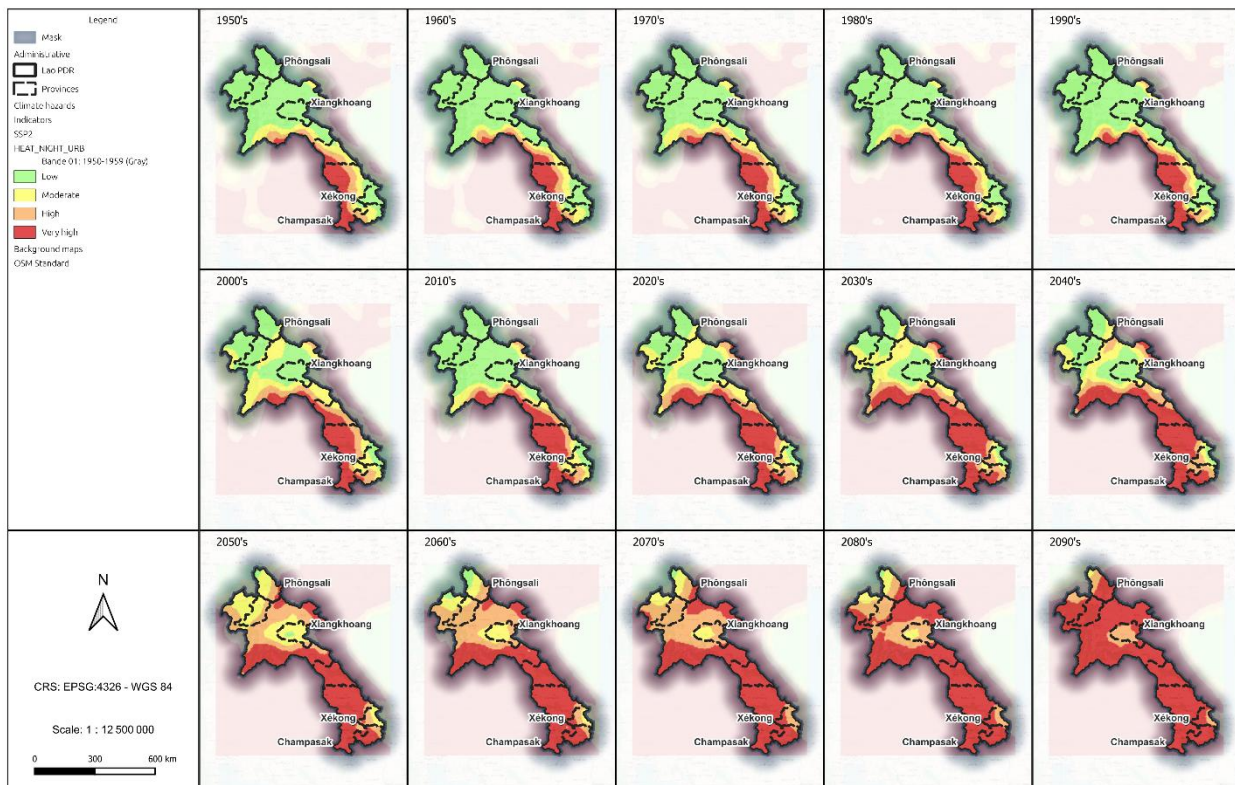


Figure 21 - Evolution of HEAT_NIGHT_URB indicator from 1950 to 2099 with SSP2-4.5

Source: Internal production (consultant modeling environment)

In 1950, Northern and Eastern Laos experienced relatively low nighttime heat stress, with less than 5 nights per year above 25°C. In contrast, the southern and eastern regions were already experiencing more than 20 nights per year with temperatures exceeding this threshold. Unfortunately, this trend has worsened over time and is projected to continue deteriorating. By the end of 2090, the entire country, including the previously less affected northern and eastern regions, is expected to face a significant increase in the number of nights with temperatures above 25°C. Under the SSP5-8.5 scenario, this trend follows a similar pattern but with a steeper slope, indicating a more rapid deterioration.

Nighttime warming is a critical issue as it initiates a cascade of problems. Primarily, it exacerbates the urban heat island phenomenon, leading to a decrease in air quality. One common response to mitigate this effect is the increased use of fans and air conditioning, which, paradoxically, worsens the situation by increasing electricity consumption and further contributing to temperature rise. This creates a vicious cycle of escalating temperatures and energy use.

Moreover, higher nighttime temperatures have a direct impact on labour productivity, as excessive heat can impair physical and cognitive performance. Additionally, elevated temperatures accelerate the degradation of urban infrastructure, such as buildings and roads, compromising their longevity and sustainability.

Given these far-reaching consequences, it is imperative to implement measures to limit the increase in the Heat Stress Index at night. Addressing this issue requires a multifaceted approach, including urban planning strategies that promote cooling, energy-efficient building designs, and sustainable infrastructure development.

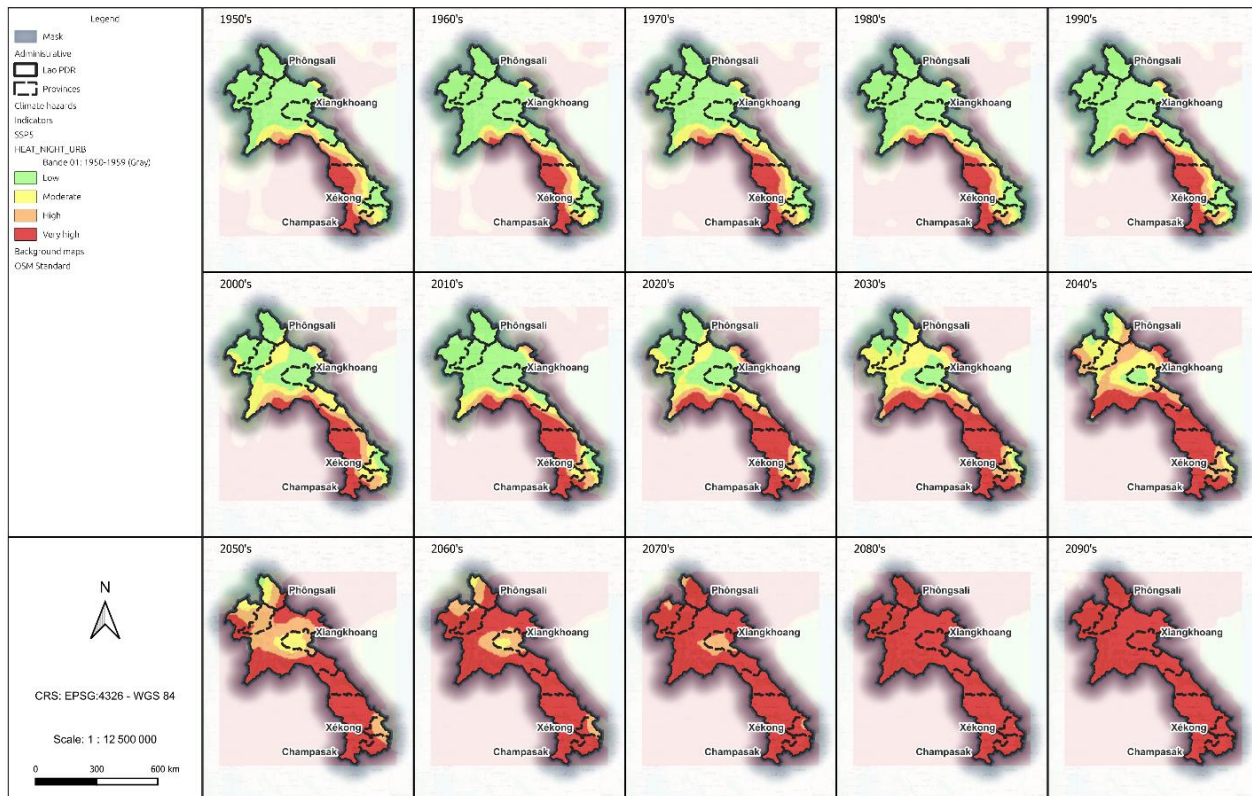
**Sector 2: Urban development & transport**
Overview of past and future evolution of Night Heat Stress Index up to 2100 as per SSP5-8.5

Figure 22 - Evolution of HEAT_NIGHT_URB indicator from 1950 to 2099 with SSP5-8.5

Source: Internal production (consultant modeling environment)

4.4.1.3 Water Resources

The HEAT_WA indicator serves as an excellent metric for assessing water quality impacts from thermal stress. This indicator specifically captures annual maximum temperature values, which are particularly relevant for evaluating heat-related water quality effects.

Historical data from 1950 reveals a distinct southwest-to-northeast gradient in water quality stress across Laos. This spatial pattern has persisted to the present day, with the southwestern regions consistently exhibiting high risk levels while northeastern areas maintain low to moderate risk profiles. Future projections indicate a significant deterioration of this pattern under both climate scenarios. By 2100, under the moderate emissions scenario (SSP2-4.5), areas of very high risk are expected to expand from the southwest to cover approximately half of the country. The situation becomes substantially more severe under the high emissions scenario (SSP5-8.5), where projections show nearly the entire country experiencing very high exposure (indicated by red shading) by the end of the century.

Rising temperatures will particularly affect Laos' surface water resources, which are crucial for agriculture and rural communities. The Mekong River and its tributaries, vital for transportation and irrigation, will face increased algal blooms that could disrupt navigation and require costly treatment for agricultural use. Reservoirs may experience more frequent harmful algal blooms, increasing water treatment costs for urban centers like Vientiane that rely on these surface water sources. The Nam Ngum and other key reservoirs may see reduced storage capacity due to increased evaporation rates, exacerbating seasonal water shortages.

Laos' groundwater resources, which serve as critical dry-season water sources, will face multiple threats from rising temperatures. Increased evaporation rates may reduce groundwater recharge, particularly in the limestone karst regions of northern Laos where aquifers are already vulnerable. Higher temperatures could also increase the concentration of naturally occurring contaminants like arsenic and fluoride in groundwater, requiring additional treatment for safe consumption. Rural communities relying on shallow wells may face challenges as these water sources become more vulnerable to both quality degradation and quantity reduction.

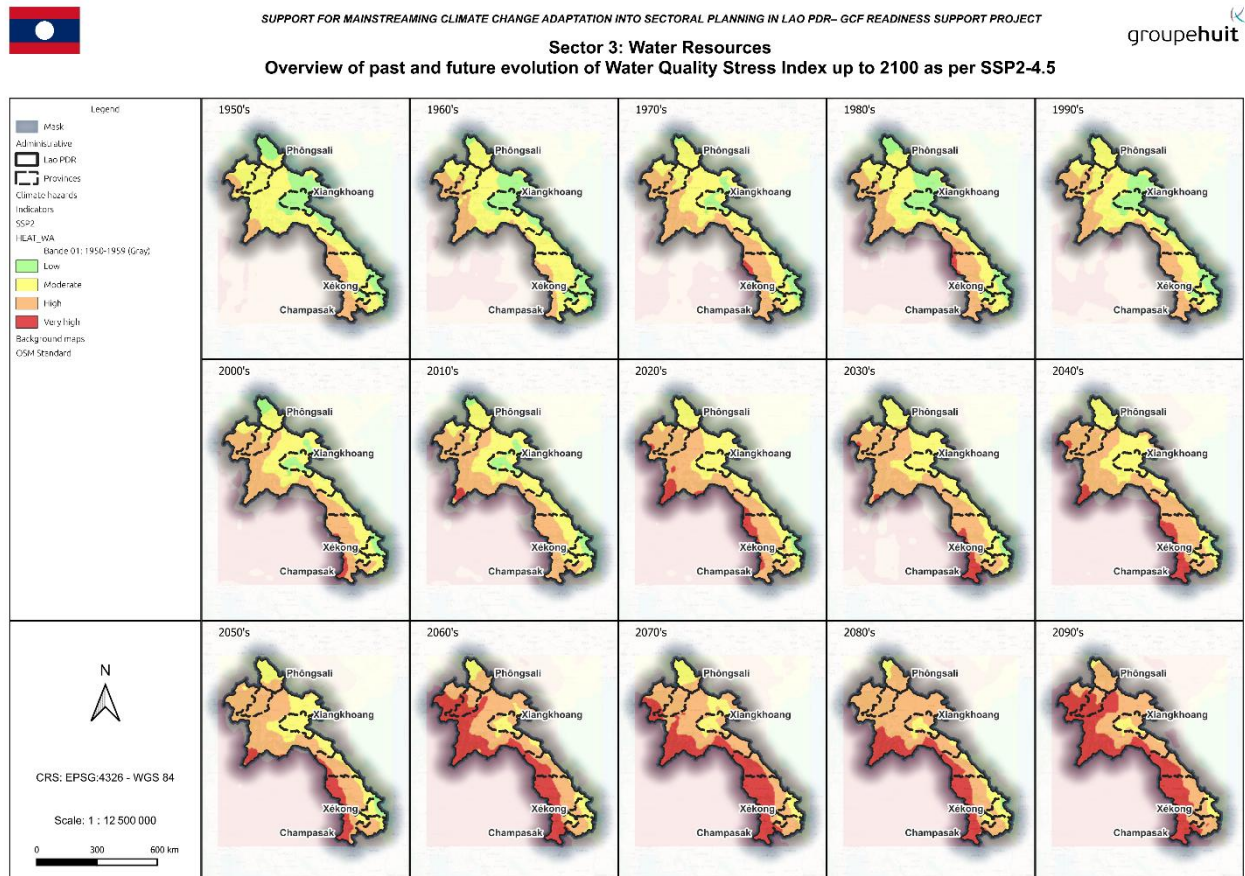


Figure 23 - Evolution of HEAT_WA indicator from 1950 to 2099 with SSP2-4.5
Source: Internal production (consultant modeling environment)



Sector 3: Water Resources
Overview of past and future evolution of Water Quality Stress Index up to 2100 as per SSP5-8.5

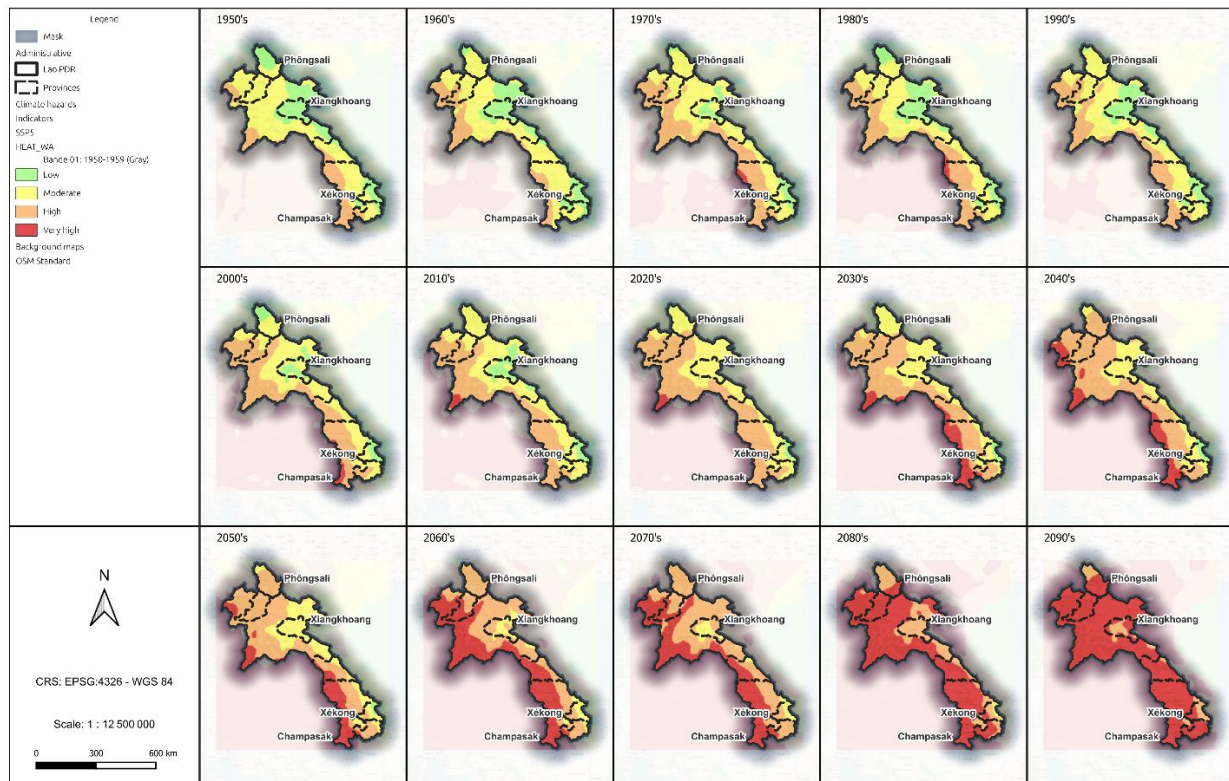


Figure 24 - Evolution of HEAT_WA indicator from 1950 to 2099 with SSP5-8.5

Source: Internal production (consultant modeling environment)

4.4.2 Droughts

4.4.2.1 Agriculture and Forestry

The DROUGHT_AG indicator provides crucial insights for agricultural and forestry sectors by measuring the maximum number of consecutive dry days in a year during growing season for most of the crops (April to October). This metric is particularly valuable for assessing drought stress on crops and forest ecosystems, as extended dry periods can significantly impact plant growth, soil moisture availability, and overall ecosystem health.

DROUGHT_AG (Drought Stress – Crops)

- **Definition:** Max consecutive dry days <1mm rainfall.
- **Impact:** Soil moisture depletion, yield loss.

Province	Exposure Rating
Champasak	Very High (>21 days)
Khammouane	High (14–21 days)
Xekong	High (14–21 days)
Oudomxay	Moderate (7–14 days)
Xiengkhouang	Moderate (7–14 days)
Phongsaly	Low (<7 days)



Sector 1: Agriculture & Forestry
Overview of past and future evolution of Agriculture Drought Stress Index up to 2100 as per SSP2-4.5

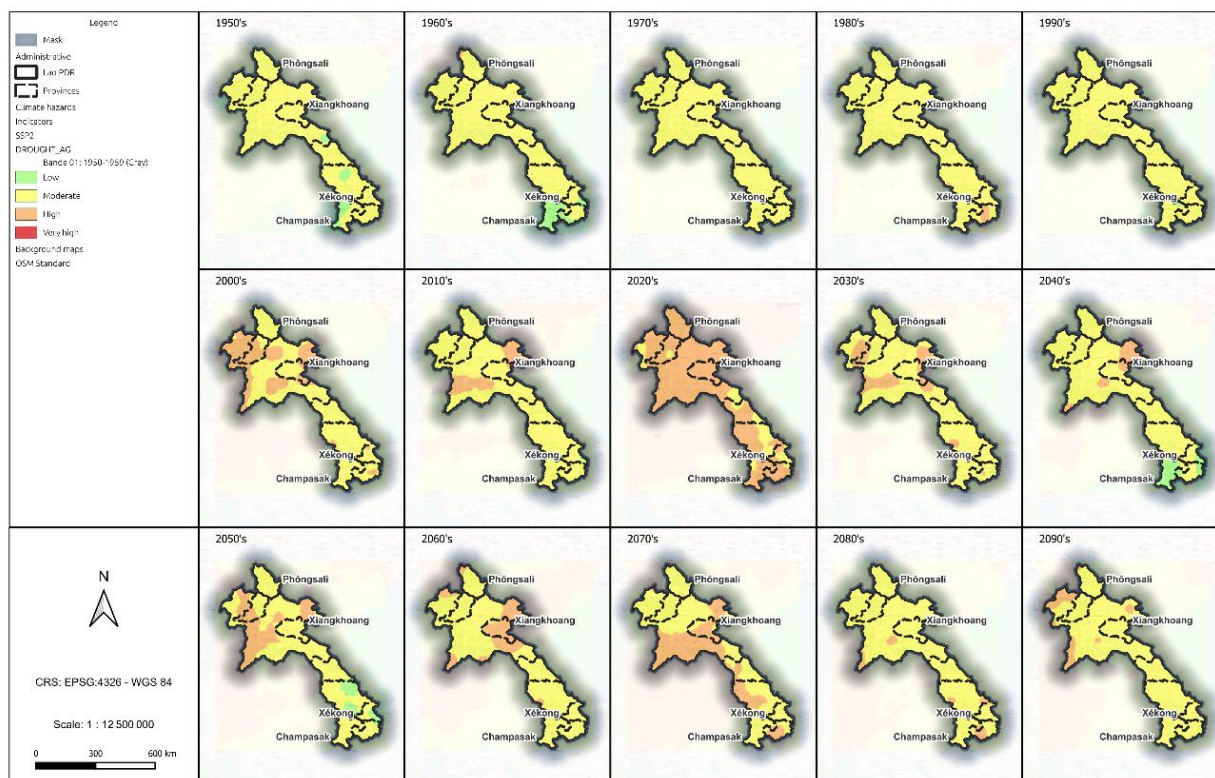


Figure 25 - Evolution of DROUGHT_AG indicator from 1950 to 2099 with SSP2-4.5

Source: Internal production (consultant modeling environment)

In 1950, the entire country experienced moderate drought conditions, as indicated by yellow mainly covering. Future projections show divergent pathways: under the SSP2-4.5 scenario, drought risk increases to high levels by 2025 before improving to moderate exposure by 2100, while the SSP5-8.5 scenario shows moderate risk in 2025 worsening to high risk by 2100. Notably, both scenarios show oscillations between moderate and high exposure levels throughout the century, consistently centered around 14 consecutive dry days per year.

The persistent drought patterns revealed by the DROUGHT_AG indicator create challenges for both agricultural and forestry systems in Laos. The recurring 14-day dry periods annually stress the country's natural resource base through multiple interconnected impacts. These consecutive dry days reduce soil moisture availability during critical growth stages for both crops and forest species, which can have some consequences.

For agricultural systems, the regular drought conditions particularly affect rain-fed crops during vulnerable development phases, leading to reduced yields and increased production risks. The dry periods coincide with critical water demand periods for major crops like rice, maize, and vegetables, stressing both subsistence and commercial farming operations. At the same time, forest ecosystems face elevated vulnerabilities as the consistent moisture stress weakens tree species and increases forest fire risks. The drought conditions create ideal circumstances for pest outbreaks that can damage both agricultural crops and forest stands, compounding the stress on rural livelihoods that depend on both sectors.



Sector 1: Agriculture & Forestry
Overview of past and future evolution of Agriculture Drought Stress Index up to 2100 as per SSP5-8.5

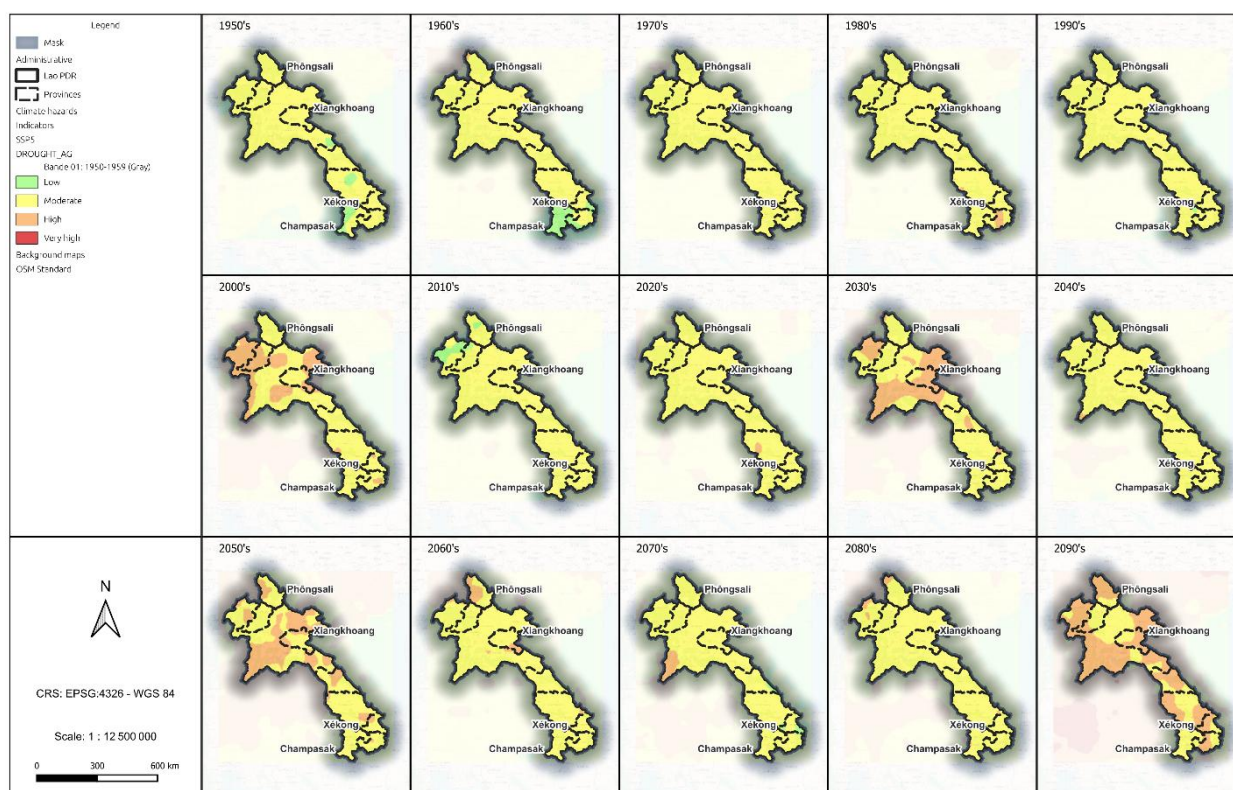


Figure 26 - Evolution of DROUGHT_AG indicator from 1950 to 2099 with SSP5-8.5

Source: Internal production (consultant modeling environment)

4.4.2.2 Urban Development and Transport

The precedent indicator is quite relevant as well for urban development and transport. The persistent moderate drought conditions indicated by the DROUGHT_AG indicator create challenges for urban development in Laos, particularly affecting the country's rapidly growing cities. As reservoirs and groundwater sources deplete during extended dry periods, municipalities can face water supply challenges that strain already limited urban infrastructure. Laos made progress towards the MDG targets for water and sanitation. By 2015, an estimated 76% of Laotians had access to "improved" water sources (water not taken directly from natural flows), though this figure hid significant disparities. For example, in 2011-2012, around 70% of the total population had access to improved drinking water, but the rural-urban gap remained³⁴. Even with "improved" sources, water quality was often a concern; a 2017 survey found that over 80% of water samples at the household and source level were positive for E.coli bacteria, indicating fecal contamination³⁵. Rural-Urban Disparity Remains: Despite efforts, significant disparities persist. As of recent data (around 2021), while 84% of people in Laos had basic water services at home, only 18% had access to a "safely managed" water supply that meets daily needs for drinking, sanitation, and hygiene³⁶. The situation is particularly dire in rural areas, where only 78.3% of people

³⁴ World Vision International. (2014, December 10). "My home got clean water!" | Laos. Retrieved from <https://www.wvi.org/laos/article/my-home-got-clean-water>

³⁵ UNICEF. (2018, June). Lao People's Democratic Republic - Water, Sanitation and Hygiene (WASH) Thematic Report 2018 - Grant No SC149903. Retrieved from <https://open.unicef.org/sites/transparency/files/2020-06/LaoPDR-TP6-2018.pdf>

³⁶ Laotian Times. (2024, April 30). Rural Laos Struggles with Dwindling Water Resources Amidst Climate Change. Retrieved from <https://laotiantimes.com/2024/04/30/rural-laos-struggles-with-dwindling-water-resources-amidst-climate-change/>

drink from improved water sources, compared to 96.7% in urban settings³⁷. The situation during the dry season, in Vientiane capital is significant proved that many communities face challenges for water shortage from water supply system, and many households applied ground water system to solve the situation.

For Laos' transportation sector, the recurring drought patterns could present significant operational challenges. Regarding inland waterway transport, the Mekong River as the country's largest river and a major natural transport corridor, it plays a vital role in the movement of goods and people, particularly in remote and rural areas where road and rail infrastructure remains limited. For this landlocked nation, the Mekong provides essential access to regional and international markets through connections with neighboring countries such as Thailand, Cambodia, and Vietnam. It supports the transport of bulk goods, agricultural products, and fuel, making it a critical component of the national logistics network. However, the navigability of the Mekong River is significantly influenced by seasonal variations, with low water levels during the dry season, such as those recorded in 2019 and 2020, posing substantial challenges for vessel movement. According to the Mekong River Commission³⁸, over the past three years, flows along the Mekong mainstream have declined to levels not observed in over six decades. River flows are shaped by a combination of factors, including the total annual water storage across the basin, the size of the upstream catchment, the volume of stored water at the onset of the wet season, and the timing and intensity of the Southeast Asian monsoon. According to the Mekong River Commission (2022), since 2019, wet season flows (June to October) have been consistently below the 2008–2017 average, and dry season flows (November to May) were exceptionally low in 2020. During the 2019–2021 period (identified by the Commission as "drought years") the peak flow period was also shortened, shifting from the usual June–October window to a truncated July–October timeframe. The reduced water flows and lower water levels in the Mekong River and its tributaries observed these last years severely restrict navigation capabilities, directly impacting the barge traffic that transports essential goods to landlocked Laos. For instance, around Vientiane in 2019, some villages have seen the height level of the Mekong River passing from 8 meters to 1 meter depth, which mandatorily induce challenges in the use of the river in terms of transportation but not only³⁹. These navigation restrictions increase transportation costs and create supply chain delays that affect urban markets. On land, the extended dry conditions exacerbate dust accumulation on Laos' road network, particularly affecting the largely unpaved rural-urban corridors that are vital for domestic commerce. The increased dust creates visibility hazards and accelerates road surface degradation, placing additional maintenance burdens on limited municipal budgets while disrupting key transport routes. Within urban areas, the drought conditions worsen air quality through increased dust and particulate pollution, creating health hazards and reducing visibility for urban transportation systems.

4.4.2.3 Water Resources

PRECIP_GR_WA is a crucial indicator of Groundwater Stress, providing insights into the changes in groundwater levels over time. Monitoring this indicator is essential for understanding the sustainability of water resources and the potential impacts on various sectors, including agriculture, urban development, and ecosystems.

³⁷ UNICEF. (2018, June). *Lao People's Democratic Republic - Water, Sanitation and Hygiene (WASH) Thematic Report 2018 - Grant No SC149903*. Retrieved from <https://open.unicef.org/sites/transparency/files/2020-06/LaoPDR-TP6-2018.pdf>

³⁸ Mekong River Commission, *Mekong Low Flow and Drought Conditions in 2019–2021: Hydrological Conditions in the Lower Mekong River Basin*, Technical Report, January 2022. Available at: <https://www.mrcmekong.org/wp-content/uploads/2024/08/LowFlowReport20192021.pdf>

³⁹ United Nations Office for the Coordination of Humanitarian Affairs (OCHA) (July, 2019) *Rural Laotians Suffer as Drought in Mekong Region Worsens*. Retrieved from: [Rural Laotians Suffer as Drought in Mekong Region Worsens - Lao People's Democratic Republic \(the\) | ReliefWeb](#)

PRECIP_GW (Groundwater Precipitation Index)

- **Definition:** Annual cumulative precipitation
- **Impact:** Recharge reliability

Province	Exposure Rating
Champasak	High (<1000mm)
Khammouane	Moderate
Xekong	High
Oudomxay	Moderate
Xiengkhouang	Moderate
Phongsaly	Low (>1500mm)



SUPPORT FOR MAINSTREAMING CLIMATE CHANGE ADAPTATION INTO SECTORAL PLANNING IN LAO PDR- GCF READINESS SUPPORT PROJECT



Sector 3: Water Resources Overview of past and future evolution of Groundwater Stress Index up to 2100 as per SSP2-4.5

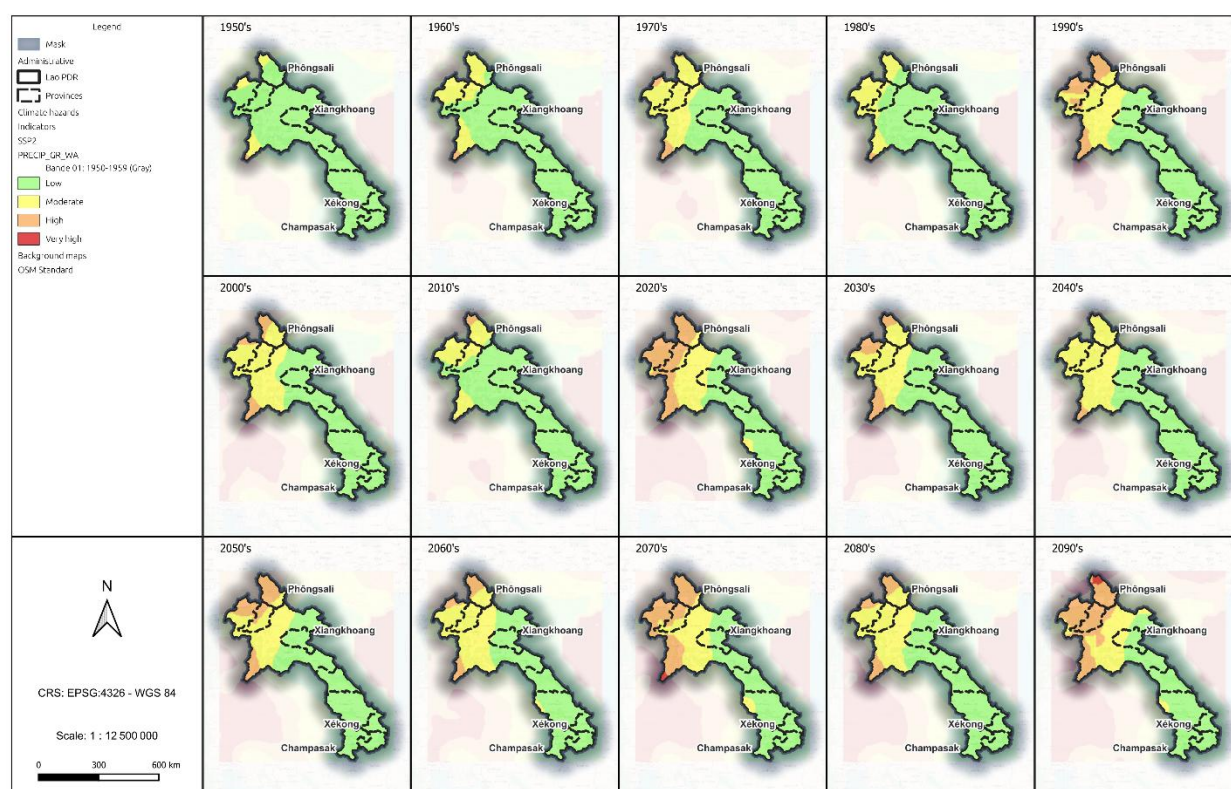


Figure 27 - Evolution of PRECIP_GR_WA indicator from 1950 to 2099 with SSP2-4.5

Source: Internal production (consultant modeling environment)

In 1950, Laos experienced relatively low groundwater stress, with no specific stress observed across most of the country except for some isolated zones. However, the situation has changed significantly in recent decades. Notably, the northern region has seen a marked increase in groundwater stress, indicated by orange zones on the stress map. This coloration signifies that groundwater recharge rates have diminished over time, leading to reduced groundwater availability.

Groundwater in Laos is primarily sourced from aquifers systems serving as key sources for domestic water supply and agricultural irrigation. Nationally, groundwater recharge is heavily dependent on rainfall, with around 80% occurring during the wet season⁴⁰. These aquifers are typically recharged by local infiltration of rainwater and, to a lesser extent, by surface water interactions. The increasing stress observed, particularly in the northern provinces, may be attributed to a combination of reduced seasonal recharge and increasing extraction pressure for domestic and agricultural use.

Looking ahead, the groundwater stress situation is projected to worsen, although moderately. Under the SSP2-4.5 scenario, the northern region is expected to remain predominantly orange, with some areas turning red, particularly in the very northern part of the country. This indicates a further reduction in groundwater recharge rates. Under the more severe SSP5-8.5 scenario, the southern part of the northern region is also expected to experience increased stress, with more areas turning red.

The lack of annual groundwater recharge poses significant challenges for Laos, with far-reaching implications across various sectors. As groundwater recharge rates decline, water tables are expected to drop, making groundwater access increasingly difficult and costly. This situation will particularly affect agriculture, as farmers may struggle to meet the water demands of their crops, leading to reduced productivity and potential economic losses.

Urban areas will also face heightened water scarcity, as decreased groundwater availability strains water supply systems and intensifies competition for water resources among different users.

These potential issues are particularly critical for the northern region, where the risk of groundwater stress is stronger. The lack of water resources in this region can have cascading effects, disrupting various sectors and hindering socio-economic development.

⁴⁰ Viossanges, M., Pavelic, P., Rebelo, L.-M., Lacombe, G., & Sotoukee, T. (2018). Regional Mapping of Groundwater Resources in Data-Scarce Regions: The Case of Laos. *Hydrology*, 5(1), 2. <https://doi.org/10.3390/hydrology5010002>

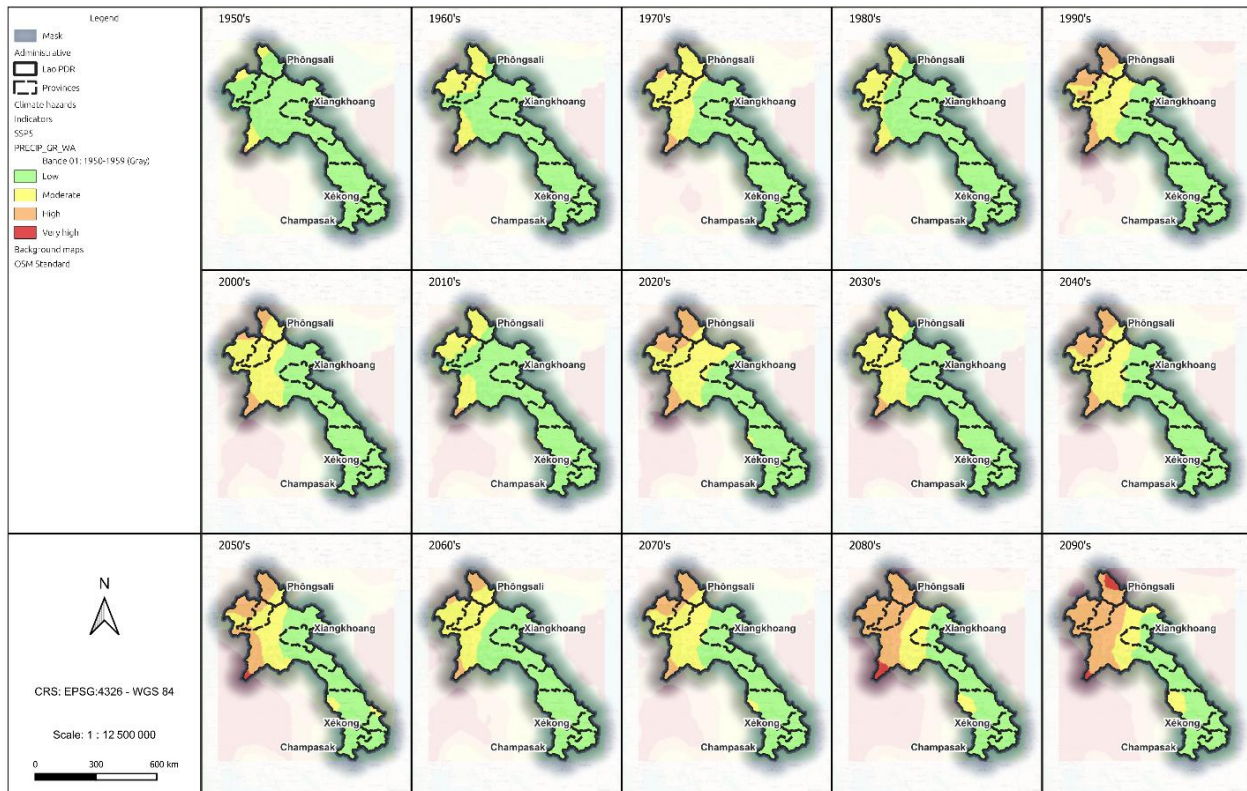
**Sector 3: Water Resources**
Overview of past and future evolution of Groundwater Stress Index up to 2100 as per SSP5-8.5

Figure 28 - Evolution of PRECIP_GR_WA indicator from 1950 to 2099 with SSP5-8.5

Source: Internal production (consultant modeling environment)

4.4.3 Floods

The flood risk indicators presented in this analysis, including FLOOD_WA and RUNOFF_URB, provide valuable insights into potential flood hazards in Laos. However, it is essential to approach these indicators with a clear understanding of their scope and limitations. These indicators primarily focus on precipitation patterns and do not account for the multitude of factors that influence actual flood risk and impacts.

The risk assessments based on these indicators should be considered as preliminary evaluations rather than definitive predictions of flood occurrences. Several critical factors that significantly influence flood risk are not incorporated into these indicators, like soil characteristics, drainage systems, land use, topography, vegetation cover, etc.

Given these limitations, the flood risk levels presented should be interpreted with caution. The actual flood risk in any given area can be either higher or lower than indicated by these indicators, depending on the complex interplay of local factors. For example, areas with high precipitation but permeable soils and effective drainage may experience lower flood risks than suggested by the indicators. Conversely, regions with moderate precipitation but impermeable surfaces and inadequate drainage may face higher flood risks than indicated.

4.4.3.1 Agriculture and Forestry

The FLOOD_WA indicator is particularly useful for interpreting flood risks resulting from consecutive rainy days. This indicator calculates the sum of precipitation over five consecutive days and then identifies the maximum value for the year, making it an effective tool for capturing heavy rain events.

From 1950 to 2099, the spatial distribution of flood risk in Laos has demonstrated remarkable consistency, exhibiting only minor variations across different time periods. This stability persists even when comparing different climate scenarios, as the SSP5-8.5 scenario shows negligible differences from the SSP2-4.5 scenario in terms of flood risk patterns. Consequently, the analysis of flood risk in Laos is primarily geographically determined rather than temporally dependent.

In the northern regions of the country, flood risk varies from low to moderate, depending on specific local conditions. The southern part of Laos presents a more complex picture, with distinct risk patterns observed in different areas. The western region, bordering Thailand, experiences moderate to high flood risk, while the eastern region, adjacent to Vietnam, faces very high flood risk. This geographical differentiation in flood risk highlights the need for region-specific adaptation and mitigation strategies.

Heavy rainfall events within a very short period can have dramatic consequences for crops and forestry. In agriculture, intense rainfall can lead to waterlogging, soil erosion, and nutrient leaching, which can damage crops and reduce yields. Flooding can also destroy crops and infrastructure, leading to economic losses for farmers. The risk is particularly high in low-lying areas and regions with poor drainage systems, where water can accumulate and cause significant damage.

For forestry, heavy rainfall and flooding can result in soil saturation, which can stress trees and increase their susceptibility to diseases. Flooding can also cause physical damage to trees, leading to reduced forest health and biodiversity. In addition, landslides triggered by heavy rainfall can destroy forest habitats, leading to loss of biodiversity and ecological imbalance.



Sector 1: Agriculture & Forestry
Overview of past and future evolution of River Flooding Stress Index up to 2100 as per SSP2-4.5

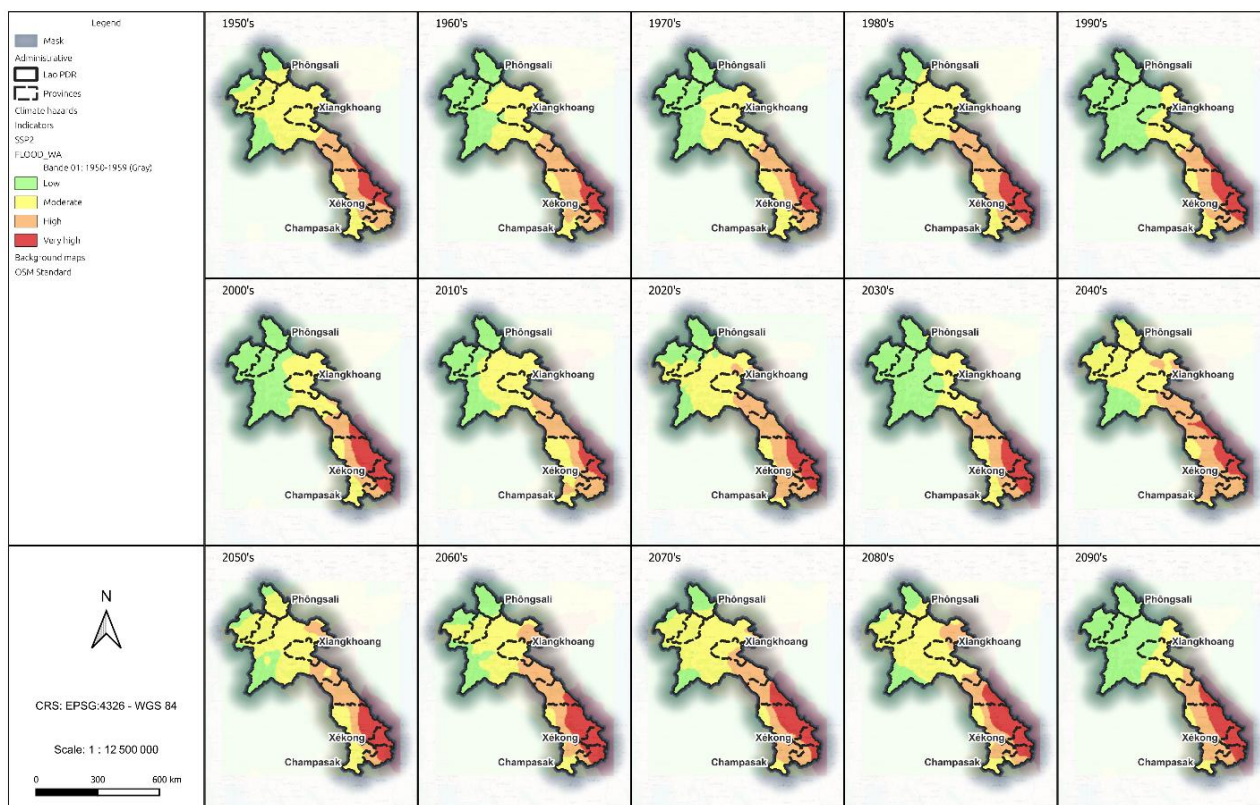


Figure 29 - Evolution of FLOOD_WA indicator from 1950 to 2099 with SSP2-4.5

Source: Internal production (consultant modeling environment)



Sector 1: Agriculture & Forestry
Overview of past and future evolution of River Flooding Stress Index up to 2100 as per SSP5-8.5

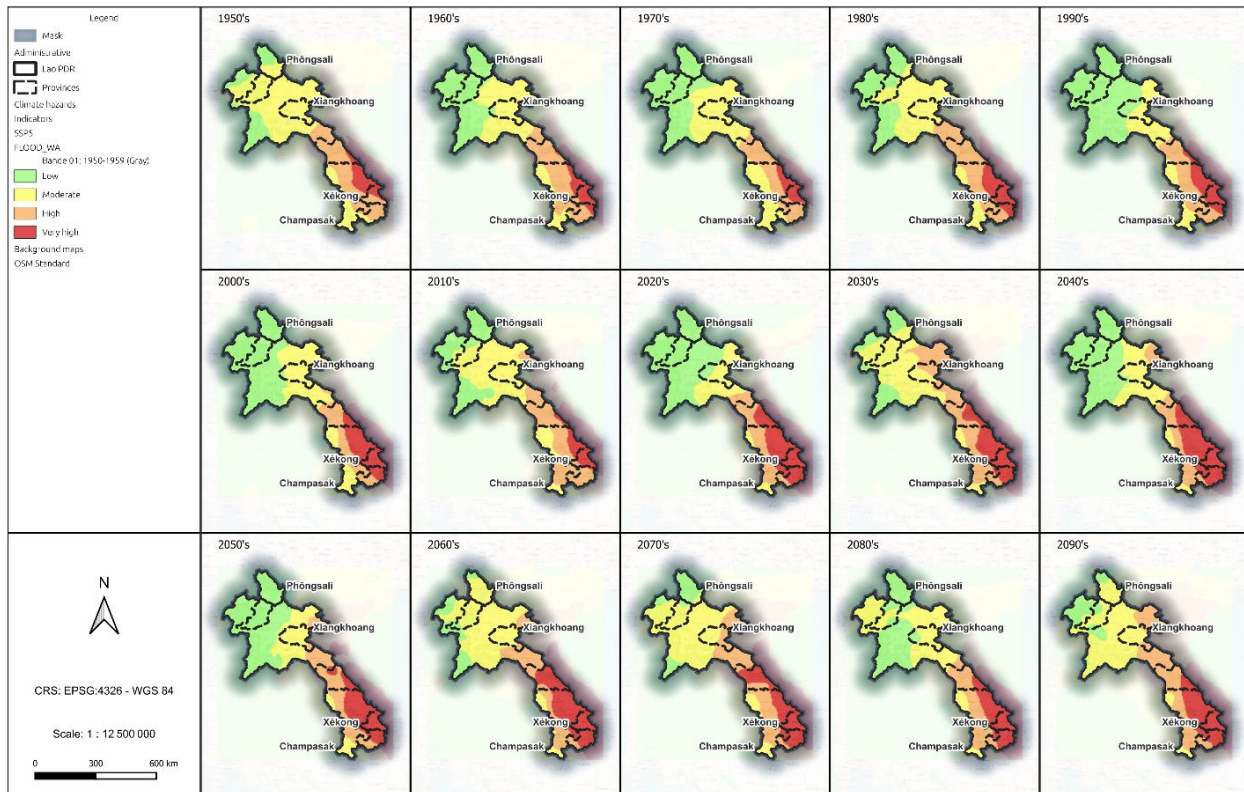


Figure 30 - Evolution of FLOOD_WA indicator from 1950 to 2099 with SSP5-8.5

Source: Internal production (consultant modeling environment)

4.4.3.2 Urban Development and Transport

RUNOFF_URB is an indicator that evaluates the risk of water runoff in urban areas, specifically focusing on the potential for flash floods. This indicator is constructed by identifying the maximum single-day rainfall event for each year, unlike the previous FLOOD_WA indicator which considers five consecutive days. By examining intense precipitation over a single day, RUNOFF_URB effectively assesses the risk of flash floods that can occur in urban environments due to sudden, heavy rainfall.

RUNOFF_URB (Urban Precipitation – Max Daily)

- **Definition:** Daily rain >75mm
- **Impact:** Flash flooding

Province	Exposure Rating
Champasak	Very High
Khammouane	Very High
Xekong	High
Oudomxay	High
Xiengkhouang	Moderate
Phongsaly	High

The distribution of RUNOFF_URB risk has remained relatively steady over time, with only minor variations observed between different periods. This temporal consistency mirrors the patterns seen in the FLOOD_WA indicator, which is logical given that both indicators are related to precipitation extremes. Geographically, the risk distribution follows a similar pattern to that observed with FLOOD_WA. In the northern region of Laos, cities face a moderate risk of flash floods. The southern region, however, presents a more complex picture with distinct risk patterns. The western part of southern Laos experiences high to extreme risk of flash floods, while the eastern part is particularly threatened, showing extreme risk across the entire area.

Flash floods in urban areas can cause substantial damage to infrastructure and disrupt daily life. A notable example occurred in June 2021 when Tropical Storm Koguma brought heavy rainfall to parts of northern and central Laos, including Vientiane Capital. The sudden influx of water overwhelmed drainage systems, resulting in widespread street flooding and disruptions to transport and electricity services. According to authorities, roughly 5,300 vehicles were damaged, 11 schools were affected, and five bridges across the country were wrecked. The storm destroyed 25 roadways and around 169 ha of plowland was severely damaged and an unknown number of cattle and poultry perished as rivers broke their banks, including in Nam Houng in Xayaboury Province, and Nam Song in Vang Vieng District of Vientiane Province. In Xayaboury, the worst-affected area, the damage alone was estimated at 9.77 million dollars or 94 billion Lao kip. This example illustrates the broader economic and social impacts of such events. Public services, including water supply, electricity, and communication networks, can be affected, leading to service outages and further complicating emergency response efforts. The contamination of water supplies due to flooded sewage systems poses health risks, increasing the likelihood of waterborne diseases. Businesses may face interruptions, leading to economic losses and affecting the livelihoods of urban residents. The extreme risk observed in eastern southern Laos is particularly concerning, as it indicates that urban areas in this region are highly vulnerable to these impacts.



Sector 2: Urban development & transport
Overview of past and future evolution of Urban Runoff Stress Index up to 2100 as per SSP2-4.5

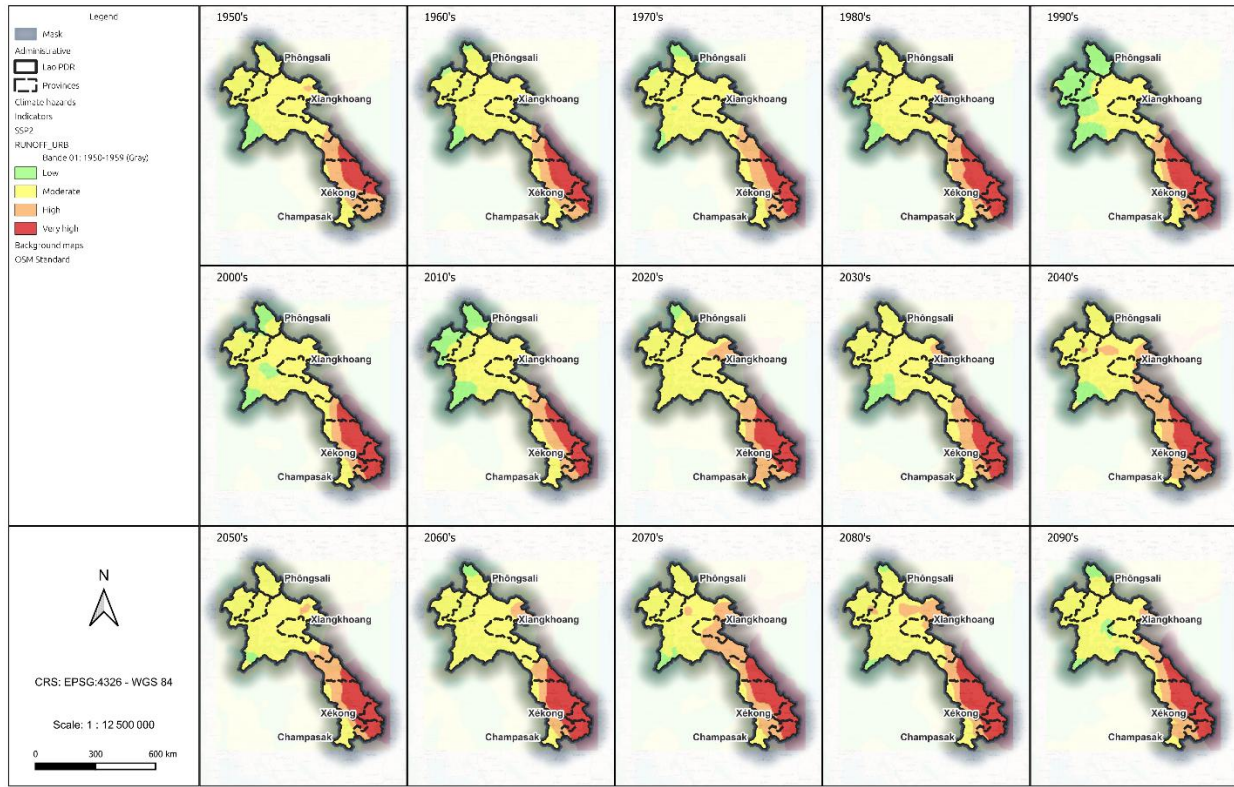


Figure 31 - Evolution of RUNOFF_URB indicator from 1950 to 2099 with SSP2-4.5

Source: Internal production (consultant modeling environment)



Sector 2: Urban development & transport
Overview of past and future evolution of Urban Runoff Stress Index up to 2100 as per SSP5-8.5

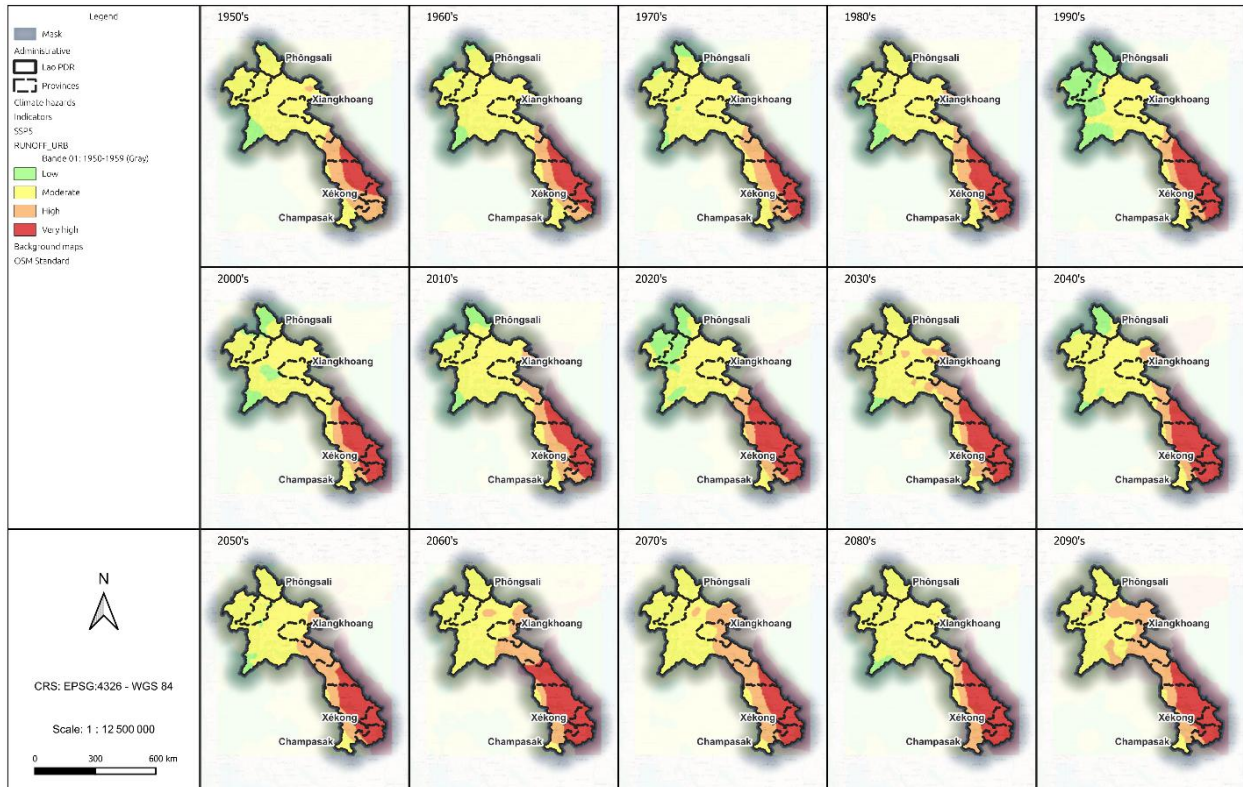


Figure 32 - Evolution of RUNOFF_URB indicator from 1950 to 2099 with SSP5-8.5

Source: Internal production (consultant modeling environment)

4.4.3.3 Water Resources

The FLOOD_WA (indicator is particularly useful for interpreting flood risks resulting from consecutive rainy days. This indicator calculates the sum of precipitation over five consecutive days and then identifies the maximum value for the year, making it an effective tool for capturing heavy rain events.

FLOOD_WA (Flood Stress Index – River systems)

- **Definition:** 5-day total rain >200mm
- **Impact:** Floodplain, levee risk

Province	Exposure Rating
Champasak	Very High
Khammouane	High
Xekong	High
Oudomxay	Moderate
Xiengkhouang	Low
Phongsaly	Moderate

From 1950 to 2099, the spatial distribution of flood risk in Laos has demonstrated remarkable consistency, exhibiting only minor variations across different time periods. This stability persists even when comparing different climate scenarios, as the SSP5-8.5 scenario shows negligible differences from the SSP2-4.5 scenario in terms of flood risk patterns. Consequently, the analysis of flood risk in Laos is primarily geographically determined rather than temporally dependent.

Floods can have significant and multifaceted impacts on water resources, presenting both challenges and opportunities for water management. While floods are often associated with immediate dangers such as property damage and loss of life, their effects on water resources can be equally profound and long-lasting. One of the primary risks is the contamination of water supplies, as floodwaters can carry pollutants, sediments, and pathogens from various sources, including agricultural runoff, industrial sites, and overflowing sewage systems. This contamination can compromise the safety of drinking water sources, leading to health risks and requiring extensive treatment before the water can be safely consumed.

Additionally, floods can damage water infrastructure, such as treatment plants, distribution networks, and storage facilities, disrupting the supply of clean water to communities and exacerbating water scarcity issues. The physical force of floodwater can also alter river channels and aquatic habitats, affecting the availability and quality of water resources for both human use and ecosystems.

Furthermore, while floods can replenish groundwater reserves and surface water bodies, the sudden influx of large volumes of water can also lead to waterlogging, soil erosion, and sedimentation, which can negatively impact water storage capacity and water quality. These complex interactions highlight the need for comprehensive water resource management strategies that consider both the risks and potential benefits of flooding events.

The data presented in these tables are derived from country-wide mean climatic variables, which provide a national overview of various indicators. It is important to note that these indicators represent smooth, average values across the entire country and do not account for regional specificities or local variations. This approach offers a broad understanding of climatic trends and risks at the national level but may not accurately reflect the conditions or vulnerabilities of specific regions within the country.

4.4.4 Landslides

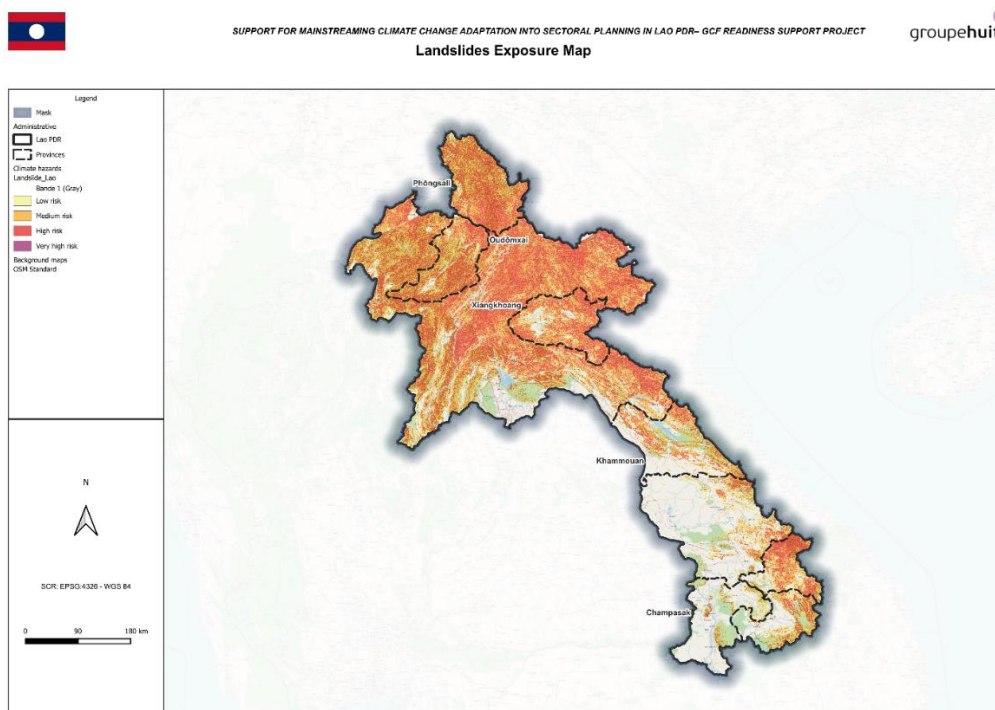


Figure 33 - Landslide Hazard Screening Map in Laos

Source: Internal production (consultant modeling environment)

The landslide risk map presented in figure 34 was generated using a multi-parameter approach incorporating geological bedrock data, soil texture information, and a high-resolution Digital Elevation Model (DEM). The analysis combined lithological characteristics, pedological properties, and topographical features to assess slope stability and landslide susceptibility across Laos. This integrated methodology provides a comprehensive evaluation of the physical factors contributing to landslide potential.

The resulting risk distribution reveals distinct spatial patterns, with particularly elevated landslide risks concentrated in northern Laos and the eastern regions of the country. These areas exhibit geological and topographical conditions that make them more susceptible to mass wasting events. The map clearly delineates these high-risk zones (mainly northern and central provinces and Xekong province in the South), which should be prioritized for landslide monitoring, mitigation planning, and land use management strategies.

4.4.4.1 Agriculture and Forestry

Landslides pose significant threats to Laos' agriculture and forestry sectors. In agricultural areas, landslides can destroy croplands, impacting food security and livelihoods, especially for smallholder farmers who constitute the majority of the agricultural workforce in Laos⁴¹. Landslides also bury fertile soil under debris, and damage irrigation infrastructure, leading to reduced productivity and potential food security concerns. The loss of arable land can be particularly devastating for subsistence farmers who rely on small plots for their livelihoods.

⁴¹ FAO. (2024, May 30). *The future of agriculture in Lao People's Democratic Republic: Green growth and food security for all*. Retrieved from <https://www.fao.org/lao-people-democratic-republic/news/detail-events/en/c/1698414/>

For instance, in August 2023, heavy rainfall led to widespread flooding and landslides affecting 10 provinces. The Center for Agricultural Statistics reported that 31,482 hectares of agricultural land were affected by flooding, with 2,281 hectares severely damaged⁴².

Another report from August 2024 indicated that floods, often accompanied by landslides, inundated 1,685.87 hectares across Xayaboury Province, with 593.03 hectares either destroyed or expected to suffer extensive damage, including paddy fields, maize, and cassava⁴³.

In forestry, landslides can cause extensive damage to timber resources, disrupt forest ecosystems, and increase soil erosion that may take decades to recover. In Laos, forest loss from landslide is not recorded so far, however the loss of forest cover exacerbates landslide risks, creating a negative feedback loop where deforestation makes land more vulnerable to landslides, which in turn further damages forest ecosystems⁴⁴. The destruction of forest areas can also lead to habitat loss for wildlife and reduced biodiversity.

4.4.4.2 Urban Development and Transport

Landslides present serious risks to infrastructure and human settlements. In urban and peri-urban areas, landslides can destroy buildings, damage critical infrastructure such as water and sewage systems, and disrupt power and communication networks. The displacement of communities due to landslide risks can lead to social and economic disruptions. Regarding transport, landslides frequently damage road networks, particularly in mountainous regions where many of Laos' transport corridors are located⁴⁵. This can isolate communities, disrupt supply chains, and increase transportation costs. Landslides may also damage bridges and other critical transport infrastructure, requiring costly repairs and maintenance. The cumulative effect can be significant economic losses and impede development in affected regions.

4.4.4.3 Water Resources

It can have complex impacts on water resources. While they may temporarily create new water bodies by damming rivers, these are often unstable and can fail catastrophically. More commonly, landslides increase sediment loads in rivers and reservoirs, reducing water quality and potentially damaging hydropower infrastructure which is crucial for Laos' energy sector. The sedimentation can also affect aquatic ecosystems and fisheries. Landslides may alter natural drainage patterns, potentially increasing flood risks in some areas while creating water shortages in others. In mountainous regions, landslides can damage water supply infrastructure, leading to disruptions in water availability for both urban and rural communities.

4.4.5 Comparison between internal results and national data

To ensure coherence and relevance, we have presented the results and findings from both national datasets and the provincial climate analysis previously conducted in Lao PDR. As the purpose of this CRVA report is to serve as a solid foundation and provide key inputs for the development of sectoral guidelines and adaptation plans, it is essential to align closely with existing national assessments—particularly the NAP developed with UNEP support and the Lao PDR Provincial Storyline-based CRVA. The table below synthesizes the main nationally

⁴² AFSIS. (2023, September 13). *Flooding and Landslides in 10 Provinces in Lao PDR*. ASEAN Food Security Information System. Retrieved from <https://apftsis.org/news-events/news138>

⁴³ AFSIS. (2024, August 24). *Transboundary Flooding & Landslides in Lao PDR and Thailand on 24 August 2024*. ASEAN Food Security Information System. Retrieved from <https://apftsis.org/news-events/news173>

⁴⁴ WB. (2020). *Lao PDR Forest Note: Toward Sustainable Forest Landscapes for Green Growth, Jobs and Resilience*

⁴⁵ Global Transport Knowledge Partnership (GTKP). *Landslide impacts on the road network of Lao PDR and the feasibility of implementing a slope management programme* (SEACAP 21-002). Retrieved July 4, 2025, from <https://www.gtkp.com/knowledge/landslide-impacts-on-the-road-network-of-lao-pdr-and-the-feasibility-of-implementing-a-slope-management-programme-seacap-21-002/>

projected hazards, along with the key sector-specific hazards and their respective impacts. As evidenced by the analysis above, our findings are largely consistent with those of prior national and provincial assessments.

Therefore, the main hazards identified across our analysis, the NAP-UNEP, and the Provincial Storyline-based CRVA include:

1. Floodings (riverine, flash, and urban)
2. Droughts
3. Heatwaves and rising temperatures
4. Landslides and erosion

Table 6: Hazard and Impact Assessment Comparison with national data

Hazards assessment Comparison						
	NAP-UNEP hazard assessment			Lao PDR Provincial Storyline-based CRVA hazard assessment		
Sector	Projected Hazards in Lao PDR	Main Sector-Specific Hazards	Key Impacts on the Sector	Projected Hazards in Lao PDR	Main Sector-Specific Hazards	Key Impacts on the Sector
Agriculture & Forestry	- Increased temperature and heatwaves - More frequent and intense floodings - Prolonged droughts	- Flooding - Droughts - Temperature rise - Rainfall variability - Forest fires	- Crop failures, especially rice and maize - Livestock and fishery losses - Food insecurity - Reduced forest regeneration - Increased pests and fire risk	- Heavier monsoon rainfall & extreme river flows →flash/riverine/urban floods - Longer dry seasons & rainfall deficits → more frequent, prolonged droughts	- Floods & flash-floods - Droughts & longer dry spells - Heatwaves & rising mean temps - Rainfall variability - Storms & associated landslides	- Crop losses (rice ↓ 5–20% by 2040s) and livestock/fish mortalities - Reduced soil moisture, forest regeneration and increased fire/pest outbreaks - Food-insecure households rise; rural incomes and biodiversity decline

Urban Development & Transport	- Rainfall variability - Storms and typhoons - Forest fires and pest outbreaks	- Flooding (pluvial & fluvial) - Storms - Heatwaves - Erosion	- Infrastructure damage (roads, bridges, drainage) - Heat stress and health risks - Displacement and housing loss - Economic disruption	- Rising mean and extreme temperatures → heatwaves & hot spells - Greater rainfall variability (erratic onset, intensity swings) - Stronger tropical storms & associated landslides/erosion	- Floods (pluvial, fluvial) & storm surges - Landslides/erosion - Heatwaves	- Damage/closure of roads, bridges, drainage and riverside ports – up to one-fifth of road network hit in major typhoon years - Higher maintenance costs, disrupted trade and essential services - Urban heat stress affecting health and labor productivity, especially in informal settlements
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Hazards assessment Comparison						
	NAP-UNEP hazard assessment			Lao PDR Provincial Storyline-based CRVA hazard assessment		
Sector	Projected Hazards in Lao PDR	Main Sector-Specific Hazards	Key Impacts on the Sector	Projected Hazards in Lao PDR	Main Sector-Specific Hazards	Key Impacts on the Sector
Water Resources		- Rainfall variability - Droughts - Flooding - Temperature rise	- Reduced irrigation water - Declining water quality - Groundwater depletion - Hydropower instability - Water conflicts		- Increase extreme rainfall floods - Prolonged droughts & hotter dry seasons - Temperature-driven evaporation rise	- Flood damage to dams, irrigation networks and water-supply assets; degraded water quality - Reduced dry-season flows, groundwater depletion and conflict over allocations - Hydropower generation instability threatening energy security

4.4.6 Synthesis of sectoral hazard assessment

Table 7: Exposure assessment synthesis

Hazards	Categories	Severity of hazard	Provinces with the highest severity of hazards
Sector 1: Agriculture & Forestry			
Droughts	Agriculture yields	Moderate/High	Phongsaly Oudomxay
	Livestock	Moderate	
	Fish stock	Moderate	
	Soil Quality	Moderate	
	Forest Biodiversity	Moderate/High	
Heatwaves	Agriculture yields	Very High	Champasak Khammouane
	Livestock	High	
	Fish stock	High/Very High	
	Soil Quality	Moderate/High	
	Forest Biodiversity	Very High	
Flooding	Agriculture yields	Moderate/High	Xekong Khammouane
	Livestock	Moderate	
	Fish stock	Moderate / High	
	Soil Quality	Moderate/High	
	Forest Biodiversity	Moderate	
Landslides	Agriculture yields	Moderate/High	Phongsaly Oudomxay
	Livestock	Moderate	
	Fish stock	Moderate	
	Soil Quality	High	
	Forest Biodiversity	Moderate/High	
Sector 2: Urban Environment and Transport			
Droughts	Urban infrastructure	Moderate	Phongsaly Oudomxay
	Urban ecosystems	Moderate/High	
	Urban clean-up	High	
	Hydraulic infrastructure	Moderate/High	
Heatwaves	Urban infrastructure	High/Very High	Champasak Khammouane
	Urban ecosystems	High/Very High	
	Urban clean-up	High/Very High	
	Hydraulic infrastructure	High/Very High	
Flooding	Urban infrastructure	Moderate/High	Xekong Khammouane
	Urban ecosystems	Moderate/High	
	Urban clean-up	Moderate/Very High	
	Hydraulic infrastructure	Moderate/High	
Landslides	Urban infrastructure	Moderate/High	Phongsaly Oudomxay
	Urban ecosystems	Moderate/High	
	Urban clean-up	High	
	Hydraulic infrastructure	Moderate/High	
Sector 3: Water Resources			Phongsaly
Droughts	River & reservoir flows	Low/Moderate	

	Hydraulic infrastructure	Low/Moderate	Oudomxay
	Water quality	Low/Moderate	
	Groundwater management	Low/Moderate	
Heatwaves	River & reservoir flows	High/Very High	Champasak Khammouane (Oudomxay)
	Hydraulic infrastructure	High	
	Water quality	High/Very High	
	Groundwater management	High/Very High	
Flooding	River & reservoir flows	Low/Moderate	Xekong Khammouane
	Hydraulic infrastructure	Low/Moderate	
	Water quality	Low/Moderate	
	Groundwater management	Low/Moderate	
Landslides	River & reservoir flows	High/Very High	Phongsaly Oudomxay
	Hydraulic infrastructure	High	
	Water quality	Very High	
	Groundwater management	Moderate/Very High	

5 VULNERABILITY ASSESSMENT

5.1 General approach

The vulnerability captures the propensity or predisposition of exposed units (system, species or asset) to be adversely affected by identified climate-related hazards.

The vulnerability refers to the physical predisposition of human beings, infrastructure, and environment to be affected by hazards due to a lack of resistance and predisposition to suffer harm as a consequence of intrinsic and context conditions making it plausible that such systems once impacted will collapse or experience major harm and damage due to the influence of a hazard event. Vulnerability has two components: (i) sensitivity which is determined by factors that directly affect the consequences of a hazard, and (ii) capacity which refers to the ability of systems and people to prepare for and respond to current and future climate impacts. The vulnerability thus encompasses both the adaptive capacity (susceptibility) and intrinsic sensitivity (or lack of resilience). Besides, vulnerability has various variables: physical, ecological, social, economic, cultural and institutional, that will be considered for each sector. GEDSI considerations and related factors of vulnerability as well as ongoing projects and initiatives, will be also considered.

The levels of vulnerability will be primarily determined based on the analyzed sectoral reports, and the “Lao PDR provincial storyline-based climate risk, vulnerability and adaptation assessment” report. The level of vulnerability will also be discussed and confirmed during the sectoral Focus Group Discussions and the CRVA Consultation workshop.

The analysis was completed by qualitative insights from key sectoral actors to contextualize climate vulnerability and adaptive capacity across provinces and sectors captured during the Focus Group Discussions and the structured discussions around key dimensions of vulnerability:

- Exposure & Risk Perception
- Sensitivity & Adaptive Capacity
- Institutional Capacity
- Social Inclusion (GEDSI)
- Observed Impacts

These qualitative findings helped complement quantitative indicators, helping define grounded vulnerability scores and shape realistic, inclusive adaptation pathways in the CRVA.

So, for each sector and categories determined, we will describe and evaluate 2 types of vulnerabilities: environmental and socio-economic in alignment with the “Lao PDR provincial storyline-based climate risk, vulnerability and adaptation assessment” methodology.

It is important to note that the consultant proposes to detail the sensitivity factors and adaptive capacities in order to identify the strengths on which to build a robust adaptation strategy (which is not part of the “Lao PDR provincial storyline-based climate risk, vulnerability and adaptation assessment” methodology).

The vulnerability assessment framework and the initial elements of vulnerability analysis based on the methodology of the 'Lao PDR Provincial Storyline-based Climate Risk, Vulnerability and Adaptation Assessment' document are provided below and will be completed during the CRVA completion through the analysis of sectoral documents. These vulnerabilities and adaptive capacities will be discussed and supplemented during the Focus Group Discussions and CRVA Consultation Workshop.

The vulnerability analysis involves:

- ▶ A description for each category of sensitive factors and adaptive capacities, informed by the literature review and discussions with local stakeholders.
- ▶ Determining a level of vulnerability based on the level of sensitivity/adaptive capacity through a scoring system, relying on the consultant's expertise and, most importantly, discussions with stakeholders from each sector. In line with the proposed scoring, a risk level (low-medium-high) and a specific color-coded system (green-orange-red) will be associated.

5.2 Lao PDR national context

Lao PDR's geographical vulnerability is compounded by socioeconomic fragility, with 80% of its 7.5 million inhabitants reliant on climate-sensitive agriculture (World Bank, 2021). The country ranks 142/181 on the ND-GAIN Index due to intersecting political, geographical, and developmental challenges (University of Notre Dame, 2020). Observed climate trends reveal alarming accelerations: temperatures near Vientiane rose 1.03°C between 1900-1917 and 2000-2017, while precipitation intensity increased 13.5% since 1953 (World Bank Climate Portal, 2021). CMIP6 projections under SSP5-8.5 indicate a 4.1°C temperature rise by 2090 and a 25% reduction in dry-season rainfall, creating a hydrological "scissors effect"⁴⁶ of intensified floods and droughts (IPCC, 2023). These changes threaten the Mekong Basin's ecological stability, where 72% of rice cultivation is rain-fed and thus acutely exposed to monsoon variability (FAO, 2022).

Building on the findings of the provincial storyline-based Climate Risk, Vulnerability, and Adaptation Assessment conducted in Lao PDR, and incorporating the insights gathered during the Focus Group Discussions, the vulnerability assessment will be further developed and presented on a sector-by-sector basis. To support the development of targeted adaptation measures in the next steps of the project, the analysis will break down each sector's vulnerabilities by identifying key sensitivity and adaptive capacity factors, and by indicating whether these vulnerabilities are mainly environmental or socio-economic.

It is important to remember that vulnerability to climate change is not experienced equally across populations. Gender, disability, ethnicity, age, and socio-economic status all intersect to shape individuals' and groups' capacity to cope with and adapt to climate risks. In Lao PDR, women, persons with disabilities, ethnic minorities, and other marginalized groups often face structural barriers to accessing information, resources, and decision-making processes, which heightens their vulnerability. Limited participation in governance, lower income levels, and reduced mobility can restrict adaptive capacity and increase exposure to hazards. GEDSI considerations have been integrated into sensitive factors during the vulnerability assessment in order to that adaptation strategies that will be developed at the latter stages of the project will be inclusive, equitable, and responsive to the differentiated needs of at-risk populations, ultimately contributing to more resilient communities.

5.3 Agriculture and Forestry

The sector of Agriculture and Forestry is exposed to climate hazards like floods, droughts, wildfires, and soil degradation, which impact agriculture, forestry ecosystems, and local livelihoods. While strategic plans and international collaborations exist, there is a heavy dependence on external support, limited disaster preparedness, and insufficient technical and financial capacity. Institutions like MAE, Department of Forestry,

⁴⁶ "Climate change can lead to more intense and frequent extreme weather events. This means an area might experience longer and more severe droughts, followed by shorter but more intense rainfall events that cause flooding. The "scissors effect" here is the growing contrast between prolonged periods of water deficit and sudden, overwhelming surpluses, making water management increasingly challenging. For Further detail check IPCC, 2023.

and NAFRI have initiated climate-smart agriculture, reforestation, and simulation modeling for climate change⁴⁷ (such as soil suitability model, Agro-Ecological Zoning. (AEZ)⁴⁸, or crop model after 2015), but implementation remains constrained.

5.3.1 Sensitivity factors (or vulnerabilities)

Environmental Vulnerabilities

- ▶ **Rainfall variability and climate extremes:**
 - Heavy reliance on rainfed farming systems increases vulnerability to rainfall variability, monsoon shifts, delayed onset of rainy seasons, and prolonged droughts.
 - Altered rainfall and temperature patterns reduce the reliability of water supply for crops and forest ecosystems, affecting yields and distribution of species.
- ▶ **Heat stress:**
 - Crops experience significant physiological stress when exposed to sustained temperatures above 36°C, especially during flowering and grain-filling stages, reducing rice and maize yields by 15–20% under RCP8.5.
 - Forestry ecosystems suffer from hydraulic failure during heatwaves (>35°C for three or more days), compromising tree health and regeneration.
- ▶ **Drought stress:**
 - Consecutive dry days (>21 days) in southern Lao PDR deplete soil moisture, reduce plant photosynthesis (stomatal closure), and threaten rainfed agriculture.
 - Droughts impair hydrological cycles, particularly affecting irrigation and aquifer recharge.
- ▶ **Flooding and extreme rainfall:**
 - Heavy rain causes erosion, landslides, and crop damage, especially in upland areas.
 - Floods can destroy agricultural plots and contribute to sedimentation and nutrient loss.
- ▶ **Soil degradation and erosion:**
 - Shorter fallow periods, intensified land use, and poor land management accelerate soil nutrient depletion, crusting, and erosion, and reducing agricultural productivity.
 - Floodwater and deforestation further exacerbate sediment transport and land degradation.
- ▶ **Deforestation and forest ecosystem fragility:**
 - Conversion to monocultures (e.g. rubber, banana), grazing, and slash-and-burn practices reduce forest cover and biodiversity.
 - Southern evergreen forests are particularly vulnerable to climate disturbances.
- ▶ **Pests and diseases:** Rising temperatures and humidity favor pest and weed outbreaks, reducing productivity and increasing reliance on chemical inputs.
- ▶ **Aquatic ecosystem degradation:**
 - Elevated water temperatures (>32°C) reduce oxygen levels, causing fish kills.
 - Nutrient runoff (phosphorus, nitrogen) leads to eutrophication and aquatic biodiversity loss.
 - Dams and hydropower projects disrupt sediment flow and fish habitats downstream.

⁴⁷ Annex 3_Sectoral FGDs summary

⁴⁸ Land Resources Information Management System (n.d.). Agro-Ecological Zoning (AEZ) [Data module]. LRIMS portal. Available at: <https://lrims-dalam.net/?thematic=aez>

Socio-Economic Vulnerabilities

- ▶ **Land access and tenure insecurity:**
 - Weak or unclear land rights, especially for ethnic minorities and women, result in unsustainable practices like shifting cultivation.
 - Land concessions to investors displace local farmers, and unexploded ordnance (UXO) limits usable land.
- ▶ **Economic dependence and low diversification:**
 - Farmers often rely on monocultures with high price volatility (e.g. rubber), making them vulnerable to shocks.
 - COVID-19 and global price fluctuations have reduced farm incomes and market access.
- ▶ **Limited infrastructure and resources:**
 - Inadequate irrigation systems reduce water access during droughts and floods.
 - Poor connectivity, limited extension services, and lack of input or equipment reduce adaptive options for smallholder farmers.
- ▶ **Low technical and institutional capacity:**
 - Limited knowledge, data collection, and early warning systems hamper timely and informed responses.
 - Disaster response is often reactive rather than anticipatory.
- ▶ **Demographic and social challenges:**
 - Youth migration reduces the rural labor force.
 - Women and ethnic minorities face higher vulnerability due to lower access to resources, decision-making, and education.
 - Language barriers and exclusion from governance limit the effectiveness of adaptation efforts.
- ▶ **Market dependency and globalization risks:** High reliance on export crops and imported agricultural input increases vulnerability to international supply and price shocks.
- ▶ **Urban expansion and land pressure:** Population growth and urbanization increase land use competition, reducing available space for farming and forests.

5.3.2 Adaptive capacity factors

Environmental Capacities

- ▶ **Climate-Smart Agriculture (CSA):**
 - Implementation of drought-tolerant rice varieties, integrated agroforestry systems, and diversified crops in Climate-Smart Villages have enhanced resilience. In this regard, in Lao two pilot villages: Ekxang and Pailom are following a CSA strategy, including drought-resistant crops, agroforestry systems, water storage infrastructure, and alternate wetting and drying (AWD) for rice, enabling water-efficient and diversified cropping systems.
 - Development of models for soil, water, and fertilizer management in drought-prone areas is underway.
- ▶ **Ecosystem-Based Adaptation (EbA):** Restoration of degraded watersheds and reforestation efforts, especially in northern regions, reduce landslide risk, enhance biodiversity, and sequester CO₂ (0.8 MtCO₂e/year).
- ▶ **Forest and land management:**
 - Strengthening forest zoning and sustainable land-use planning supports ecosystem resilience.
 - Agroforestry and soil conservation practices stabilize slopes, improve water retention, and enhance carbon sequestration.

- ▶ **Simulation and early warning tools:** The National Agriculture and Forestry Research Institute (NAFRI) uses climate models to predict droughts and rainfall variability, improving agricultural preparedness.
- ▶ **Biodiversity conservation:** Efforts to implement the National Biodiversity Strategy (though currently only 58% implemented) contribute to the maintenance of ecosystem services and genetic diversity.

Socio-Economic Capacities

- ▶ **Policy and strategic frameworks:**
 - National Adaptation Plan (NAP) and former Ministry of Agriculture and Forestry (MAF) -now Ministry of Agriculture and Environment (MAE) - strategies (e.g. vision to 2035) provide long-term orientation for adaptive responses.
 - Policies promote agroecological inputs, seed exchange networks, and subsidies for sustainable farming practices.
- ▶ **International collaboration and funding:** Partnerships with FAO, UNDP, WFP, and the World Bank support technical assistance and financial resources for adaptation.
- ▶ **Community participation and gender inclusion:**
 - Engagement of local communities ensures cultural relevance and effectiveness of adaptation actions.
 - Promoting women's participation strengthens resilience outcomes.
- ▶ **Education and extension services:**
 - Training programs, farmer field schools, and knowledge transfer initiatives (e.g. CSA village models) enhance local adaptive skills.
- ▶ **Livelihood diversification and financial tools:**
 - Promotion of mixed farming systems (pulses, legumes, tubers) reduces risk exposure.
 - Ongoing efforts include feasibility studies for agricultural insurance, microfinance, and the creation of an Emergency Reserve Fund for Agricultural Disasters.
- ▶ **Infrastructure improvement:**
 - Investments in irrigation and rural roads can reduce exposure to floods and drought impacts and improve market access.

5.4 Urban Development and Transport

The urban and transport sectors face **floods, landslides, erosion, and infrastructure damage** due to outdated planning, poor drainage systems, and insufficient maintenance budgets. Despite some progress in pilot projects and training, the sector is constrained by outdated tools, limited staff capacity, and reliance on external funding.

5.4.1 Sensitivity factors (or vulnerabilities)

Environmental Vulnerabilities

- ▶ **Increased Flood Risk and Poor Drainage Systems:** Urban areas face frequent flash floods due to outdated or undersized drainage systems, especially during rainfall events exceeding 75mm/day. This affects major cities like Vientiane, Savannakhet, and Champasak and results in economic losses and heightening public health risks.
- ▶ **Urban Heat Stress:** The urban heat island effect raises nighttime temperatures by up to 3–5°C in cities, increasing heat-related illnesses and energy demands for cooling.
- ▶ **Vulnerability of Transport Infrastructure to Extreme Events:**

- The road network is highly exposed to floods, erosion, and landslides, particularly due to non-standard design and low maintenance. Mountainous terrain further amplifies landslide risks, while unpaved roads are often impassable during monsoons.
 - Rail lines often traverse areas prone to flash flooding, slope instability, and erosion, particularly during extreme rainfall, which may lead to washouts, ground heaves, or slope failure. These conditions pose serious threats to rail operations, safety, and connectivity. For example, on July 23, 2025, all passenger train services on the LCR were suspended due to Typhoon Wipha, which brought heavy rainfall, strong winds, and elevated risks of landslides and rockfalls along the railway route⁴⁹. Again, on August 25–26, 2025, the railway was suspended as Typhoon Kajiki approached northern Laos, prompting authorities to halt services in the interest of passenger safety⁵⁰.
- **Proximity to Rivers and Climate Hazards:** Urban development along the Mekong River increases exposure to flooding and erosion. Changes in rainfall and river flow patterns disrupt both water-based transport and ecosystem functions.

Socio-Economic Vulnerabilities

- **Outdated Urban Planning and Weak Management Systems:** Many urban development plans date back to the 1990s, misaligned with current climate risks. Urban management services remain underdeveloped, delaying effective responses to climate events.
- **Manual and Fragmented Data Systems:** The lack of digitalized, centralized urban planning and risk data limits informed decision-making and slows climate adaptation efforts.
- **Limited Financial and Institutional Capacity:** Inadequate long-term funding hinders infrastructure upgrades and the scaling-up of climate-resilient projects.
- **Urban-Rural and Gender Inequalities:** Rapid urbanization deepens regional disparities, leaving rural transport systems underserved. Women face mobility constraints due to socio-cultural norms, and urbanization-induced land use changes reduce inclusive access to housing and services.
- **Exposure of Critical Infrastructure:**
- Schools, hospitals, households, and government buildings are often located in hazard-prone areas, lacking flood-proofing or emergency protocols.
 - People and their property owners, who live under the poverty line are more vulnerable to climate change on floods, storms, heat and landslides.
 - Climate-related hazards account for an estimated 14% of transport infrastructure loss annually, with roads bearing 85% of the burden and railways absorbing a substantial share⁵¹. The national rail network, including the Lao-China Railway (LCR), plays a central role in Lao PDR's ambition to become a land-linked hub of ASEAN. However, the system is also exposed to climate hazards such as floods, landslides, and soil erosion along embankments. Heavy rainfall events increase risks of track flooding and slope failures, which can disrupt both passenger and freight services. In addition, extreme heat may affect track stability and rail operations, posing challenges for maintenance and safety. Disruptions to key corridors, whether from poor drainage in urban areas or climate hazards along rail routes, can have significant socio-economic implications such as delayed freight transport, increased logistics costs, and reduced competitiveness for cross-border trade that need to be assessed.

⁴⁹ Chanlivong, K. (2025, July 23). *Widespread flooding hits Laos in an early monsoon season*. Laotian Times. Retrieved from <https://laotiantimes.com/2025/07/23/widespread-flooding-hits-laos-in-an-early-monsoon-season/>

⁵⁰ Siviero, B. (2025, August 25). *Northern Laos braces for heavy rains as Typhoon Kajiki prompts railway halt*. Laotian Times. Retrieved from <https://laotiantimes.com/2025/08/25/northern-laos-braces-for-heavy-rains-as-typhoon-kajiki-prompts-railway-halt/>

⁵¹ Asian Transport Outlook (ATO). (2024). *Transport and Climate Profile: Lao People's Democratic Republic*. Retrieved from <https://asiantransportoutlook.com/analytical-outputs/countryprofiles/>

5.4.2 Adaptive capacity factors

Adaptation efforts encompass both software and hardware components. The software includes policies, regulations, knowledge, and design as part of the legal and normative framework for urban development and transportation. This also involves enforcement, cultural practices, and community responsibility regarding cleanliness and environmental stewardship. The hardware refers to existing and planned infrastructure, such as roads, drainage systems, sewerage, waste treatment facilities, and all other urban and transport-related infrastructure.

Nature-Based Solutions: Pakse's "sponge city" project (bioswales, permeable pavements) reduced floods by 40%.

Policy Integration: The NDC (2021) mandates climate-proof drainage in provincial capitals by 2030.

Strengthening the resilience and adaptability of public works and transport infrastructure is a key adaptive measure. This involves developing and implementing regulations, standards, and plans for climate-resilient infrastructure and transportation. Enhancing research and transferring technologies suitable for the country's specific conditions is necessary. Standards and techniques for the construction and maintenance of infrastructure should be developed to ensure resilience to hazards like storms, landslides, floods, and earthquakes.

Improving inadequate drainage and flood defense systems by increasing paved roads and using durable materials enhances adaptive capacity. Developing smart city plans and improving urban drainage systems, alongside protecting wetlands, lakes, and riverbanks, contribute significantly to urban resilience. Strengthening policy and planning frameworks, integrating climate risk assessments into planning, and ensuring adequate funding for maintenance and disaster response are crucial for building resilience. Developing specialized training programs and enhancing technical expertise in climate risk management are critical. Furthermore, developing climate-resilient coordination mechanisms and emergency response manuals are essential for preparedness. Implementing urban cooling strategies, including expanded green spaces, reflective surfaces, and green roofs, can mitigate urban heat island effects and improve thermal comfort. Integrating nature-based solutions like vegetated bioswales, green infrastructure, and sponge-city designs into urban planning can effectively manage stormwater runoff and reduce flood risks. Strengthening waste segregation, community compost hubs, and local recycling ecosystems will ensure efficient urban cleanup and waste management, fostering resilient and sustainable urban environments. Developing robust disaster preparedness and response systems, including community-based early warning systems, further enhances resilience in the transport sector.

5.5 Water Resources

The water sector in Lao PDR is impacted by recurring floods, droughts, and seasonal water variability, underscoring the importance of robust planning and management. Although strategic frameworks have been established, challenges remain in implementing these plans, particularly regarding the development of reliable groundwater data systems, inter-agency coordination, and long-term institutional capacity.

5.5.1 Sensitivity factors (or vulnerabilities)

Environmental Vulnerabilities

- ▶ Climate Variability and Hydrological Cycle Disruption
 - Changes in rainfall patterns have intensified both drought and flood occurrences.
 - Shortened monsoon seasons reduce water recharge and lead to prolonged dry periods.

- Five-day cumulative rainfall exceeding 200mm overwhelms river systems, especially in provinces like Champasak and Khammouane.
- ▶ Flood Risks and Riverine Inundation
 - Frequent flooding in the Mekong River basin and its tributaries cause infrastructure damage, loss of lives, and economic disruptions.
 - Poorly maintained levees and riverbanks increase vulnerability to high precipitation events.
- ▶ Groundwater Depletion and Quality Degradation
 - Groundwater stress with extraction exceeding recharge.
 - Quality deterioration, including arsenic contamination, poses serious health and water security risks.
 - Erratic rainfall reduces reliable aquifer recharge.
- ▶ Heat Stress and Ecosystem Degradation
 - Maximum daily temperatures over 45°C reduce dissolved oxygen in water, leading to fish kills and ecosystem collapse.
 - Land degradation, deforestation, and erosion increase sedimentation in rivers and reservoirs, reducing water retention capacity and raising landslide risks.
- ▶ Hydropower Vulnerability
 - Droughts reduce hydropower output (Simulation models for the Mekong Basin estimate that ongoing droughts can reduce hydropower production by approximately 4,000 GWh/year, particularly during extended dry season⁵²)
 - Hydropower operations alter downstream ecosystems and fisheries, exacerbating water-related challenges.

Socio-Economic Vulnerabilities

- ▶ Aging and Inefficient Infrastructure
 - Outdated water infrastructure is poorly maintained and fails under extreme climate conditions.
 - Damaged irrigation systems and uncoordinated water allocations reduce agricultural productivity.
- ▶ Urbanization and Competing Demands
 - Rapid urban growth increases pressure on water supply systems and leads to over-extraction of groundwater.
 - Expanding cities compete with agriculture for water resources, reducing repair and maintenance budgets for irrigation.
- ▶ Water Quality and Sanitation Challenges
 - Pollution from agriculture, industry, and untreated wastewater degrades water quality.
 - Irregular access to clean water increases public health risks, especially during flood events.
 - Insufficient wastewater treatment
 - Lack of capital investment on treatment infrastructure
 - Low Tariff to non-revenue water treatment and production
- ▶ Institutional and Data Gaps
 - Groundwater data is fragmented, with decade-long gaps due to project-based collection.
 - Technical capacity is limited at local levels, reducing responsiveness.
 - Reliance on short-term, donor-funded projects jeopardizes the sustainability of water initiatives.
 - Hacked or inactive platforms hinder public access to real-time water data.
 - Coordination is often informal (e.g., via WhatsApp), lacking institutional rigor in disaster response.

⁵² Chowdhury, A. F. M. K., Dang, T. D., Nguyen, H. T. T., Koh, R., & Galelli, S. (2021). The Greater Mekong's climate-water-energy nexus: How ENSO-triggered regional droughts affect power supply and CO₂ emissions. *Earth's Future*, 9, e2020EF001814. <https://doi.org/10.1029/2020EF001814>

- ▶ **Hydropower Governance Gaps:** Electricity production is sometimes prioritized over water conservation, undermining downstream users and ecosystem needs.

5.5.2 Adaptive capacity factors

Environmental Capacities

- ▶ **Nature-Based and Infrastructure Solutions**
 - Check dams in Xekong increased dry-season water availability by 45%.
 - Creation of water conservation zones helps preserve ecosystems and regulate flow.
 - Reforestation and restoration of wetlands and riparian zones improve catchment health and water quality.
 - Development of basic flood- and drought-resilient infrastructure supports climate resilience in both rural and urban areas.
- ▶ **Improved Resource Management Tools**
 - Integrated Water Resources Management (IWRM) is promoted through initiatives like the GCF-funded FP117 project.
 - Mapping tools (e.g., ArcGIS) and remote sensing technologies enhance forecasting and monitoring of water risks.
 - Reservoir operation adjustments help regulate water availability under variable climate conditions.
 - Flood and drought risk assessments in river basins support informed dam safety and operation planning.
- ▶ **Water Quality Protection**
 - Investment in water treatment facilities and sewage networks safeguards water quality during extreme events.
 - Collaboration with industries on wastewater discharge regulations improves aquatic ecosystem protection.

Socio-Economic Capacities

- ▶ **Community Engagement and Capacity Building**
 - Participatory watershed management mechanisms empower local actors and ensure inclusive governance.
 - Community training in groundwater management fosters local stewardship and sustainability.
 - Awareness campaigns and accessible data systems (including gender considerations) improve decision-making.
- ▶ **Monitoring and Early Warning Systems**
 - Drought monitoring using soil moisture and rainfall projections (via MRC and satellite data) enables timely response.
 - Improved information systems support early warning dissemination across sectors like energy, agriculture, and health.
- ▶ **Water Use Efficiency and Agricultural Resilience**
 - Promotion of small-scale retention systems and efficient irrigation techniques helps maintain crop yields.
 - Switching to drought-resilient or less water-intensive crops supports food security under water stress.
 - Diversification strategies reduce socio-economic dependence on water-sensitive agricultural systems.
- ▶ **Policy and Institutional Strengthening**

- Legal reinforcement of forest and watershed protection ensures long-term ecosystem resilience.
- Formal coordination structures improve institutional readiness and response to water-related hazards.
- Aligning national climate finance with adaptation co-benefits in water and food systems supports a just transition.

The sectoral vulnerability assessment was conducted in two complementary steps to ensure both evidence-based analysis and stakeholder validation.

Step 1 – Based on the above presented elements, we can assess the level of vulnerability, using a scale from 1 (Low) to 3 (High), for each sector using the combination of:

- Number and severity of sensitive factors (environmental + socio-economic),
- Presence and adequacy of adaptive capacities.

Agriculture & Forestry Sector Vulnerability Level: 3 (High)

1. **Important Sensitive factors:** Numerous and severe sensitive factors including climate extremes, heat stress, drought, ecosystem fragility, and market dependence and several socio-economic challenges with limited infrastructure, low institutional capacity, land tenure insecurity, and demographic vulnerabilities.
2. **Weak Adaptive capacity:** While multiple strategies are listed (CSA, EbA, early warning systems), implementation in rural areas is often limited in practice, particularly in remote or upland regions.

Urban Development & Transport Sector Vulnerability Level: 2 (Moderate)

3. **Moderate to Important sensitive factors:** Several environmental stressors coupled with socio economic sensitive factors such as outdated planning systems, institutional and gender gaps, and exposure of critical infrastructure.
4. **Moderate to Strong Adaptive capacity:** Similar tools than for the agricultural sector (CSA, EbA), but urban areas may have more institutional capacity and investment potential for risk reduction (e.g., urban resilience programs, zoning, infrastructure upgrades).

Water Resources Sector Vulnerability Level: 3 (High)

5. **Important sensitive factors:** The sector is highly sensitive to climate variability, depletion of groundwater, riverine floods, and hydropower dependence. This sensitivity is coupled with the presence of several sensitive socio-economic factors such as aging infrastructure, institutional gaps, competing demands, and sanitation challenges.

Weak Adaptive capacity: Comprehensive but ambitious; water governance and implementation gaps remain, especially in rural or transboundary contexts.

Step 2 – Stakeholder validation and scoring: During the two (02) CRVA workshops, technical representatives from line ministries and sectoral agencies were invited to review the preliminary assessment. Using a participatory scoring exercise, stakeholders evaluated the relative importance of each sensitive and adaptive capacity factor within their sector, assigning a score from 1 (least important) to 3 (most important). They also provided qualitative inputs on sector-specific drivers of vulnerability and priority adaptation measures.

Results

The stakeholder scoring results presented in figure 35 confirmed but also balanced the high levels of vulnerability for the Agriculture & Forestry and Water Resources sectors, and a moderate vulnerability level for Urban Development & Transport as presented in Table 8.

This two-step approach ensured that the vulnerability assessment was both data-informed and context-specific, increasing its relevance and legitimacy for subsequent Sectoral Adaptation Plans and Guidelines.

Categories	Sensitive Factors (environmental)	Sensitive Factors (Socio-economic)	Adaptive Capacity	Level of vulnerability			Results
				1	2	3	
Note importance from 1 to 3 in the box (1 not relevant / important to the sector, 3 very relevant / important)							
Sector 1: Agriculture & Forestry							
Agriculture yields	(1/10) Rainfall variability (2/10) Climate extreme	(N/A) Land access and tenure insecurity (N/A) Economic dependence and low diversification (N/A) Limited infrastructure and resources	(1/10) Climate Smart Agriculture (CSA) (2/10) Forest and land management (3/10) Community participation and gender inclusion		2	3	3
Livestock	(3/10) Flooding and extreme rainfall (4/10) Drought stress	(N/A) Low technical and institutional capacity	(4/10) Infrastructure improvement		3	2	2
Fish stock	(5/10) Deforestation (6/10) Pest and diseases	(N/A) Demographic and social challenges (N/A) Market dependency and globalization risks	(5/10) Ecosystem-Based Adaptation (EbA) (6/10) Policy and strategic framework		2	3	3
Soil Quality	(7/10) Soil degradation and erosion (8/10) Heat stress	(N/A) Urban expansion and land pressure	(7/10) Simulation and early warning tools (8/10) Livelihood diversification		4	1	2
Forest Biodiversity	(9/10) Aquatic ecosystem degradation (10/10) Loss of biodiversity		(9/10) Biodiversity conservation (10/10) Education		1	3	3
Sector 2: Urban Development & Transport							
Infrastructure	(N/A) Increased flood risk (N/A) Urban Heat Stress	(1/8) Poor drainage systems (2/8) Outdated Transport infrastructure (3/8) Outdated Urban planning	(1/8) Nature Based- Solutions (NbS) (2/8) Urban cooling and stormwater management (3/8) Disaster Risk Reduction in Infrastructure planning		1	5	3
Urban Ecosystems		(4/8) Limited infrastructure and resources	(4/8) International collaboration and finance mobilization		1	4	3
Urban Clean Up		(5/8) Limited financial capacities (6/8) Limited institutional capacities	(5/8) Policy and strategic planning tools (6/8) Community based planning awareness		3	2	2
Hydraulic infrastructure		(7/8) Gender and urban inequality (8/8) Manual and/or fragmented data systems	(7/8) Capacity Building and Technical Training (8/8) Climate resilient Infrastructure		2	3	3
Sector 3: Water Resources							
River & reservoir flows	(N/A) Climate Variability and Hydrological cycle disruption (N/A) Flood risks and Riverine inundation	(1/5) Water Quality and Sanitation Challenges (2/5) Institutional and Data Gaps	(1/6) Improved Resource Management Tools (2/6) Water Quality Protection		1	2	3
Hydraulic infrastructure	(N/A) Groundwater depletion and quality degradation (N/A) Heat stress and ecosystem degradation	(3/5) Hydropower Governance Gaps (4/5) Urbanization and Competing Demands	(3/6) Monitoring and early warning systems (4/5) Nature Based and Infrastructure Solutions		2	1	2
Water quality	(N/A) Hydropower vulnerability	(5/5) Aging and inefficient infrastructure	(5/6) Community Engagement and Capacity Building (6/6) Policy and strategic framework			3	3
Groundwater management					1	2	3

Figure 34: Participatory Vulnerability Assessment Results

Source: Annex 5

Table 8: Consultant Sectoral level of vulnerability assessment

<i>Sensitive Factors (environmental)</i>	<i>Sensitive Factors (Socio-economic)</i>	<i>Adaptive Capacity</i>	<i>Level of vulnerability</i>
Sector 1: Agriculture & Forestry			
1. Rainfall variability and climate extremes 2. Climate extreme 3. Flooding and extreme rainfall 4. Heat stress 5. Soil degradation and erosion 6. Deforestation and forest ecosystem fragility 7. Pests and diseases 8. Aquatic ecosystem degradation	9. Land access and tenure insecurity 10. Economic dependence and low diversification 11. Limited infrastructure and resources 12. Low technical and institutional capacity 13. Demographic and social challenges 14. Market dependency and globalization risks 15. Urban expansion and land pressure	16. Climate-Smart Agriculture (CSA) 17. Forest and land management 18. Community participation and gender inclusion 19. Ecosystem-Based Adaptation (EbA) 20. Simulation and early warning tools 21. Biodiversity conservation	3 High
Sector 2: Urban Development & Transport			
22. Increased Flood Risk 23. Urban Heat Stress 24. Vulnerability of Transport Infrastructure to Extreme Events	25. Poor Drainage Systems 26. Outdated Urban Planning 27. Weak Management Systems 28. Manual and Fragmented Data Systems 29. Limited Financial and Institutional Capacity 30. Urban-Rural and Gender Inequalities 31. Exposure of Critical Infrastructure	32. Nature Based- Solutions (NbS) 33. Urban cooling and stormwater management 34. Disaster Risk Reduction in Infrastructure planning 35. International collaboration and finance mobilization 36. Policy and strategic planning tools 37. Community based planning awareness 38. Capacity Building and Technical Training	2 Moderate
Sector 3: Water Resources			
39. Climate Variability and Hydrological Cycle Disruption 40. Flood Risks and Riverine Inundation 41. Groundwater Depletion and Quality Degradation 42. Heat Stress and Ecosystem Degradation	44. Water Quality and Sanitation Challenges 45. Institutional and Data Gaps 46. Hydropower Governance Gaps 47. Aging and Inefficient Infrastructure 48. Urbanization and Competing Demands	49. Improved Resource Management Tools 50. Water Quality Protection 51. Monitoring and Early Warning Systems 52. Community Engagement and Capacity Building 53. Nature-Based and Infrastructure Solutions 54. Water Use Efficiency and Agricultural Resilience	3 High

43. Hydropower Vulnerability		55. Policy and Institutional Strengthening	
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6 IMPACT & RISK ASSESSMENT

6.1 General approach

The objective of this section is to evaluate the potential impacts of climate hazards on the targeted sectors (Agriculture & Forestry, Water Resources, Urban Development & Transport) and assess associated climate risks and impacts under both current and future conditions. This process builds on the results of the hazard, exposure, and vulnerability assessments previously conducted for each sector and study area.

The impact and risk assessment is based on the IPCC risk framework, which defines climate risk as the interaction between hazards, exposure, and vulnerability. The methodology aims to translate climate data and sectoral insights into an integrated view of how climate change affects systems, assets, and communities.

In this assessment, the IPCC risk framework is operationalized through a stepwise analytical approach. First, climate hazards are identified and characterized in terms of their intensity, frequency, and spatial distribution based on historical data and future projections. Second, sectoral exposure is assessed by identifying the systems, assets, and populations potentially affected by these hazards. Third, vulnerability is analyzed through the evaluation of sensitivity and adaptive capacity, drawing on both quantitative data and qualitative insights from stakeholder consultations. These components are then integrated to identify sector-specific risk hotspots and to support the prioritization of adaptation measures. This structured approach ensures a consistent interpretation of climate risk across sectors and provides a robust basis for decision-making.

Climate risk centers on the interaction between hazard, vulnerability and exposure. The risk is typically estimated as the product of the probability of a hazard occurring and the impact it would have on the system if it did occur.

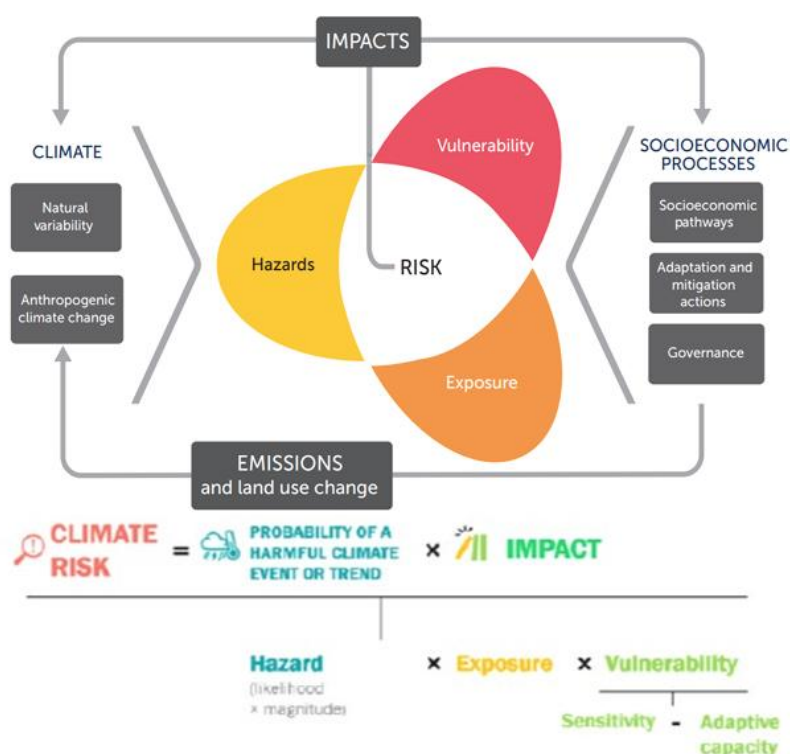


Figure 35: Interrelations between components of climate risk

Source: Fourth Assessment Report (AR4), IPCC

Note: Climate risks are not static, they evolve over time as climate conditions, exposure, and vulnerability change. Therefore, it's important to monitor climate risks and review the assessment regularly.

The severity of potential impacts was estimated based on sector-specific sensitivity factors, such as crop yield loss, infrastructure disruption, water insecurity, biodiversity degradation, or public health consequences. The evaluation integrates both biophysical indicators (e.g., precipitation, temperature), key findings from the "Lao PDR Provincial Storyline-based Climate Risk, Vulnerability, and Adaptation Assessment" and qualitative data from FGDs and stakeholder interviews.

Using a **risk matrix approach**, each hazard is scored according to its **exposure assessment** and **severity of impact** for each sector. This allows classification of risks into five categories: *negligible, low, moderate, high, or extreme*.

		Exposure level				
Severity of impact		Very low	Low	Moderate	High	Very high
	Extreme	High risk	High risk	Extreme risk	Extreme risk	Extreme risk
	Major	Moderate risk	High risk	High risk	Extreme risk	Extreme risk
	Moderate	Low risk	Moderate risk	High risk	High risk	Extreme risk
	Low	Low risk	Low risk	Moderate risk	High risk	High risk
	Very Low	Negligible	Low risk	Low risk	Moderate risk	High risk

Figure 36: Format of the risk matrix based on exposure level and severity of impact

Source: Internal production

6.2 Cross-Cutting Analysis

Over the past few years, the targeted sectors have experienced several climate-related disasters like floods or droughts that have impacted activities with dire consequences. In view of outputs of analysis of climate context and projections, it appears that following hazards are likely to affect the targeted sectors in present situation as well as to eventually worsen in the future due to climate change:

► Droughts and extreme heat events:

- Current Situation: Low to moderate exposure across most regions for drought (recurrence every 3–8 years) and moderate to high risk for heat waves.
- Future Projection: Longer dry spells and reduced annual precipitation expected. By 2100, the entire country will experience very high risk (20+ days/year with HI >36°C) under both SSP2-4.5 and SSP5-8.5 scenarios.
- Impact on sectors: Agricultural yields decline, livestock heat stress increases, reduction and degradation of water resources and decreasing of urban livability.

► Floods:

- Current Situation: Pluvial and river floods occur every 1-2 years, especially in central Lao PDR.
- Future Projection: By 2050 under SSP5-8.5, pluvial floods are expected to occur more than once per year across all study provinces; river floods show a similar increasing frequency.

- Impact on sectors: Disruption of water supply infrastructure, urban drainage overwhelmed, damage to transport and housing. Highlights the need for both structural and non-structural mitigation (e.g., improved drainage, waste management).

► **Landslides:**

- Current situation: Concentrated in the mountainous northeast, triggered by intense rainfall and degraded vegetation.
- Future Projection: Increased likelihood due to more frequent and intense rainfall. Areas where PET exceeds rainfall >20% of days are at high risk of soil degradation and slope failure.
- Impact on sectors: Direct risk to infrastructure (roads, housing), reduced agricultural land productivity, and damage to forest ecosystems.

GEDSI cross-cutting overview

All the hazards presented directly impact the targeted sectors but also lives and livelihoods and are experienced differently by women and men and by vulnerable groups such as ethnic minorities, Persons with Disabilities (PWDs), low level income households or rural households. Yet, these differences are often misunderstood due to the lack of both quantitative and qualitative disaggregated data. Evidence of differentiated impact is not widely and systematically collected in the Lao PDR, as in many countries in the Asian region.

In addition to the direct impacts of climate change and disasters, many indirect effects linked to the socioeconomic dimensions and climate change and disaster risk management can be observed in Lao PDR. Regarding gender as an example, both direct and indirect impacts of climate change and hazards for women and men are determined by preexisting gender inequalities.

Hence the importance to include GEDSI reflection for each sectoral analysis.

6.3 Impact Analysis per sector

6.3.1 Agriculture & Forestry

Over 70% of the population in Laos rely on agriculture which has a half contribution to Gross domestic product in the country⁵³ but climate change impacts pose critical risks to agricultural production, forestry, and the livelihoods dependent on these sectors.

► **Flooding**

Intense rainfall events and tropical storm which are common in Lao PDR and increasingly intense with climate disruption can have severe impact on the agriculture sector. It can lead to seed washouts, nutrient leaching leading ultimately to crop loss and can also severely damage farmland crops. In Lao PDR, floods usually occur during the rainy season beginning from May to October, particularly between August and September, when tropical storms and typhoons collide. Central and southern provinces are mostly affected by floods.

⁵³ Climate Impacts Tracker. (n.d.). Laos – Heat wave. Retrieved July 7, 2025, from <https://www.climateimpactstracker.com/laos-heat-wave/>

Table 9: Flooding event in Lao PDR between 2017 and 2021

Events	Impacted provinces	Damages & Losses	Casualties
Tropical Storm Koguma - June 2021	Vientiane, Xiengkhouang. Xayaboury, Luang Prabang. Bokeo, Saravan, and Xekong.	Damages affected 10 districts, 136 villages, 3,098 families, 15,012 people (7,532 women), 2,305 houses. Losses of housing, arable land, livestock, schools, irrigation systems, telecommunication systems, roads, bridges, and public utilities estimated total losses costing 172.23 million kip.	04 people injured
Tropical Storm Noul No. 11 and Tropical Storm Linfa No. 15, - October 2020	Savannakhet, Xekong, and Saravan	The floods affected 19 districts, 253 villages, 17,062 families, 92,773 people (39,806 women). The disasters caused substantial economic, social, environmental, and infrastructure losses totaling an estimated 784.56 billion kip.	06 deaths. 03 persons missing.
Typhoons Podul and Kajiki - 2019	Khammouane, Savannakhet, Saravan, Champasak, Attapeu, and Luang Prabang.	affected 45 districts, 1,534 villages, 154,359 families, 767,771 persons (53,415 women) Estimated loss amounted to 1,460 billion kip	19 deaths. 01 person missing.
Tropical Storm Son-Tinh - July 2018, Tropical Storm Bebinca - August 2018	Vientiane Capital, Huaphan, Khammouane, and Attapeu.	The Xepian-Xenamnoy dam burst damages alone reached as high as 35 million US dollars, almost 10% of the total damage cost'.	No data
Tropical Storm Sonca July 2017	Saravan, Champasak, Xekong, Xayaboury, Bolikhamxay, Savannakhet, and Attapeu	Over 1.700 families in these provinces were affected. Floods in that year caused economic losses amounting to 3,166.99 billion kip or approximately 371.5 million US	03 deaths 01 injured.

Source: UNDP, Lao PDR Post Flood and Post Drought Recovery Guideline, 2021.

Between July and September 2018, Laos experienced cascading climate shocks mainly the Tropical Storm Son-Tinh, flash floods from a dam collapse, and Cyclone Bebinca, impacting 55 districts across 13 provinces. The Lao PDR Post-Disaster Needs Assessment report (2018)⁵⁴ found that the floods affected approximately 2,382 villages and 616,000 people, destroying nearly 1,700 homes. Total damage and losses were estimated at US \$371.5 million (2.1 % of 2018 GDP), with agriculture accounting for 57 % of economic losses.

Summary of the Damage and Losses (billion Lao Kip)			
SECTOR	DAMAGE	LOSSES	TOTAL
Productive sectors			
Agriculture: crops, livestock, fisheries, forestry, irrigation	139.80	1,087.60	1,227.30

Figure 37: July - September 2018 Damage and Losses estimation from PDNA

Source: Government of Lao PDR, Post-Disaster Needs Assessment: Floods 2018.

⁵⁴ Government of Lao PDR, Post-Disaster Needs Assessment: Floods 2018, Vientiane: Ministry of Planning and Investment, February 2019. Available at: https://laopdr.un.org/sites/default/files/2019-08/2018%20PDNA_English.pdf

► Heat Waves and Droughts

Heatwaves and droughts can severely impact the agriculture and forestry sectors in Lao PDR. During drought periods, especially when they occur in the cultivation season, farmers are often forced to replant seedlings, delaying rice production and increasing vulnerability to food insecurity. According to UNDP (2021)⁵⁵, approximately 188,000 families have been affected by prolonged droughts in the past two decades, facing not only crop losses but also challenges related to drinking water access and deteriorating soil moisture.

Historically, severe droughts have occurred in 1961, 2003, 2007, 2015, 2018, and 2019. According to UNDP (2021) in 2003, droughts in the northern and central regions caused over USD 16.5 million in damage, while in 2007 the estimated losses reached around USD 1 million. In 2015, an El Niño-driven drought significantly affected agriculture in provinces such as Xayaboury, with over 1,000 hectares of crops (including rice, sweet corn, and fruit) damaged, particularly in the districts of Ngeun, Xienghone, Phiang, and Kenthao. The 2019 drought was especially severe, reducing rice yields across the country to only 40% of the expected levels due to the delayed onset of rainfall. Lately 2024 has been recorded as the hottest year, Laos faced extreme temperatures, peaking at 43.2°C in April, with an increase of 1.5°C compared to 1.48°C in the previous year, according to the World Meteorological Organization (WMO)⁵⁶. During this year farmers grappled with lower yields of crops like coffee and vegetables in April-May 2024 due to a severe heatwave. The heatwave 2024 intensified by high humidity, posed severe risks to farmers that work outdoors, increasing dehydration with the risk of heatstroke and other relevant illnesses. Those who are more exposed to heat and maximum temperature due to their occupation, such as farmers, are at the highest risk of such health impacts⁵⁷.

Heat stress on crops is also a growing concern. As detailed in Section 4 several provinces are classified under "Very High" or "High" heat exposure, experiencing between 10 and 20 days or even more than 20 days per year exceeding 36°C. Projections indicate that rice yields in Lao PDR could decline by 5–20% by the 2040s due to rising temperatures and rainfall variability, with regional estimates suggesting a potential reduction of 15.2–17.2% across Asia⁵⁸.

For livestock, heat stress (that has been assessed with an indicator of a Temperature–Humidity Index) mirrors these patterns and contributes to increased animal health risks and can lead to livestock loss.

Additionally, biodiversity and soil health are increasingly threatened. Forest biodiversity is particularly vulnerable to prolonged heat events (daily temperatures exceeding 35°C for three or more consecutive days. Shifts in temperature and precipitation patterns are expected to result in the decline of endemic species and key ecosystem services. On the soil front, cumulative precipitation and consecutive dry-day indicators point to rising risks such as degradation of agricultural and forest soils.

► Landslides and erosion

Landslides and erosion pose significant threats to both agriculture and forestry in Lao PDR, particularly in mountainous and hilly areas with unstable soils and high rainfall intensity. In the agriculture sector, these hazards result in the direct loss of arable land, especially on sloped terrain where soil is easily washed away, leading to declining productivity and food insecurity. Erosion strips away nutrient-rich topsoil, which is essential for crop cultivation, and may take decades to naturally replenish. For instance, during the 2018 floods in Laos, thousands

⁵⁵ National Disaster Management Secretariat and UNDP. *Post-Flood and Post-Drought Recovery Guideline*. Vientiane: Lao PDR, September 2021.

⁵⁶ World Meteorological Organization. (2024, July 5). *WMO confirms 2024 as warmest year on record at about 1.5°C above pre-industrial level*. <https://wmo.int/news/media-centre/wmo-confirms-2024-warmest-year-record-about-155degc-above-pre-industrial-level>

⁵⁷ Climate Impacts Tracker. (n.d.). *Laos – Heat wave*. Retrieved July 7, 2025, from <https://www.climateimpactstracker.com/laos-heat-wave/>

⁵⁸ National Disaster Management Secretariat and UNDP. *Post-Flood and Post-Drought Recovery Guideline*. Vientiane: Lao PDR, September 2021.

of hectares of agricultural land were reported damaged or lost due to landslides and erosion, particularly in provinces like Attapeu and Xekong⁵⁹.

In the forestry sector, landslides can uproot trees, destroy forest stands, and degrade ecosystems, particularly in areas where forests have already been weakened by illegal logging or shifting cultivation. This degradation contributes to habitat loss, reduced biodiversity, and weakened carbon sequestration capacity. Soil erosion also increases sedimentation in rivers and reservoirs, affecting downstream water quality and irrigation systems. The long-term impact includes reduced resilience of forest ecosystems to climate stressors, diminished timber value, and growing restoration costs for degraded landscapes.

The multiple stressors impacting agriculture, including heat stress, drought, floods, pests, and soil degradation, are not isolated issues but interact to create complex and compounding vulnerability. For instance, heat stress directly reduces crop yields while simultaneously increasing evapotranspiration, which exacerbates soil moisture deficits and raises irrigation demands. This interconnectedness necessitates holistic and integrated adaptation strategies. For example, developing drought-resilient crops must be combined with improved water management and soil conservation practices to be truly effective. Furthermore, while advanced technologies and climate-resilient varieties are crucial, the significant reliance on rain-fed agriculture (72% of rice area) and subsistence farming means that adaptation efforts must also integrate and enhance traditional practices, such as adjusting cropping calendars. A successful adaptation approach therefore requires a strategic blend of advanced research and technology transfer alongside community-based, context-specific solutions that build upon existing local knowledge.

The forestry sector presents a unique opportunity for multi-benefit climate solutions. While it is directly impacted by climate change through biodiversity loss, increased forest fires, and pest infestations, it also offers significant adaptive capacity through reforestation, sustainable management, and the application of Ecosystem-based Adaptation (EbA) principles. Moreover, increasing forest cover is a key national mitigation target (aiming for 70% by 2030) and attracts international funding through initiatives like REDD+. This means that investments in the forestry sector yield synergistic benefits for both climate adaptation (enhancing ecosystem resilience, improving water retention, mitigating landslides) and climate change mitigation (carbon sequestration), while simultaneously supporting livelihoods and conserving biodiversity. This makes the forestry sector a high-return investment for climate finance in Lao PDR.

⁵⁹ Ibid.

GEDSI in the Agriculture and Forestry Sector

Climate hazards such as tropical storms, heavy rainfall and flooding, heatwaves, droughts, and erosion have disproportionate impacts on marginalized groups in the agriculture and forestry sectors in Lao PDR. Women, people with disabilities, ethnic minorities, and low-income rural households often depend heavily on subsistence agriculture and natural resources for their livelihoods, yet have limited access to climate information, land rights, agricultural inputs, credit, or decision-making spaces that could increase their adaptive capacity.

Floods and tropical storms disproportionately affect women-headed households and those with limited mobility, particularly in remote areas, as they are less likely to have the means to evacuate or recover from crop and asset loss. Disruption in forest activities, such as non-timber forest product collection, also directly affects ethnic minority groups and rural women engaged in informal forest-based economies.

Heatwaves and droughts increase the burden on women and girls, who are typically responsible for collecting water and ensuring household food availability. During drought periods, access to safe water for irrigation and domestic use becomes limited, increasing workload and reducing time for education or income-generating activities. Additionally, people with disabilities may be more isolated and excluded from early warning systems or emergency support during extreme heat or water shortages.

Soil erosion and land degradation particularly impact communities practicing shifting cultivation or living in highland areas, where loss of arable land threatens food security. As these communities can often include ethnic minorities with limited access to alternative livelihoods, they are especially vulnerable to cascading economic and social effects.

A GEDSI-sensitive approach to climate adaptation in agriculture and forestry should prioritize inclusive access to early warning systems, resilient livelihood diversification, land tenure security (especially for women), and participation in community-based resource management. Strengthening disaggregated data collection is also key to better identifying and addressing the specific needs of vulnerable groups.

Table 10: Summary of Key Climate Risks and Impacts on Agriculture and Forestry by Province

Hazard Type	Provinces (Risk Rating)	Brief Impact Description
Heat Stress (Crops)	Champasak (Very High),	Reduced crop photosynthesis, flowering abortion, yield failure
	Khammouane (High),	
	XXekong (High),	
	Oudomxay (Moderate),	
	Xiangkhoang (Moderate),	
Heat Stress (Livestock)	Phongsaly (Low)	Decline in feed intake, animal stress
	Champasak (Very High),	
	Khammouane (High),	
	XXekong (High),	
	Oudomxay (Moderate)	
Soil Quality (Cumulative 5-Day Precipitation)	Xiangkhoang (Moderate),	Soil erosion, land degradation
	Phongsaly (Low)	
	Champasak (Very High),	
	Khammouane (Very High),	
	XXekong (High),	
Soil Quality (Consecutive Dry Days)	Oudomxay (Moderate)	Soil moisture deficits, land degradation
	Xiangkhoang (Moderate),	
	Phongsaly (Low)	
	Champasak (Very High),	
	Khammouane (High),	
Heat Stress (Forests)	XXekong (High)	Hydraulic failure in trees, tree death, biodiversity loss
	Oudomxay (Moderate),	
	Xiangkhoang (Moderate),	
	Phongsaly (Low)	
	Champasak (Very High),	
Drought Stress (Crops)	Khammouane (High),	Depleted soil moisture, stomatal closure, reduced productivity
	XXekong (High)	
	Oudomxay (Moderate),	
	Xiangkhoang (Moderate),	
	Phongsaly (Low)	
Heat Stress (Fish Stocks)	Champasak (Severe),	Oxygen depletion, elevated fish kill risks
	Khammouane (Severe),	

Table 11: Risk assessment matrix for the Agriculture and Forestry Sector

Agriculture and Forestry					
Risks	Hazards	Exposure assessment	Severity of impact	Risk per hazard	Computed risks
Crop failure	Drought	Moderate / High	Major	High	Extreme
	Heat waves	Very high	Major	Extreme	
	Flooding	Moderate / High	Major	Extreme	
	Erosion	Moderate / High	Major	Extreme	
Livestock / Fish farming loss	Drought	Moderate	Moderate	High	High
	Heat waves	Moderate	Major	Extreme	
	Flooding	Low / Moderate	Moderate	Moderate	
	Erosion	Low / Moderate	Low/Moderate	Moderate	
Soil degradation and loss of arable land	Drought	Moderate	Major	High	Extreme
	Heatwaves	Very high	Major	Extreme	
	Flooding	Moderate / High	Major	Extreme	
	Erosion	Moderate / High	Major	Extreme	
Biodiversity loss	Drought	Moderate / High	Major	High	High
	Heatwaves	Very high	Major	Extreme	
	Flooding	Moderate	Moderate	Moderate	
	Erosion	Moderate / High	Major	High	

6.3.2 Urban Development and Transport

As presented, the urban development & Transport sector is critically exposed to floods, drought, heatwaves and landslides. This exposure combined with the level of vulnerability assessed (2 – moderate) can lead to prolonged urban service disruption and cascading.

► Urban Flooding

Intense rainfall can overwhelm urban drainage systems, resulting in flash floods that inundate streets, homes, and public facilities. This is particularly critical in areas with undersized, poorly maintained, or informal drainage infrastructure, which are common in rapidly expanding urban zones in Lao PDR. Flash floods not only damage property but also disrupt essential urban services such as electricity, solid waste collection, and water supply. Moreover, overburdened sanitation systems can lead to sewage overflow, increasing the risk of waterborne disease outbreaks such as cholera, typhoid, and diarrhea, especially in low-income areas.

Transport infrastructure is also highly vulnerable. Roads, bridges, and drainage culverts can be washed out or structurally compromised, leading to road closures, traffic paralysis, and increased repair costs. For example, the June 2021 flash floods in Vientiane caused widespread road damage and delayed emergency response services. Landslides triggered by saturated soils on steep terrain can further damage roads and cut off access to remote areas.

Therefore, transport systems in Lao PDR are highly sensitive to climate extremes, particularly floods and inadequate urban drainage. Poorly designed or under-capacity drainage along road corridors frequently leads to waterlogging, pavement deterioration, and erosion of road bases, which compromise both transport safety and serviceability. In urban centers such as Vientiane and Pakse, even moderate rainfall often results in localized flooding of arterial and secondary roads, reducing traffic flow, increasing accident risk, and delaying emergency response. The 2018 national floods demonstrated the scale of this vulnerability: more than 66% of total flood damage costs were borne by transport infrastructure, including washed-out culverts, collapsed bridges, and road closures that disrupted connectivity across provinces⁶⁰

Settlements located in high-risk zones like unstable slopes or floodplains, face the greatest exposure. These areas frequently house low-income populations who can lack access to housing adequately protected from flooding or insurance. The combination of social vulnerability and physical exposure makes these communities highly susceptible to loss of life, property, and prolonged recovery times. In some cases, flash floods can isolate entire communities, preventing access to emergency aid and basic services for days.

The 2018 floods are a good example of the important damage and losses that can be caused by flooding for the urban development and transport sector. As mentioned above, the Lao PDR Post-Disaster Needs Assessment report (2018)⁶¹ valued the total overall effects of the 2018 floods on the economy at an estimated 3,166.99 billion Lao kip, or approximately US\$371.5 million. The floods also caused 64 fatalities and exacerbated health issues like malnutrition and dengue due to damaged facilities.

Summary of the Damage and Losses (billion Lao Kip)			
SECTOR	DAMAGE	LOSSES	TOTAL
Social sectors			
Housing and settlements	21.2	0.57	21.69
Education	18.73	1.68	20.41
Health and nutrition	8.58	3.32	11.89
Culture	10.11	0.25	10.36
Productive sectors			
Industry and commerce	0.80	2.99	3.78
Tourism	21.87	9.59	31.46
Infrastructure sectors			
Transport	822.02	784.80	1,607.82
Electricity	42.20	3.20	45.40
Water supply and sanitation	50.96	19.02	69.98
Waterways	116.90		116.90
TOTAL	1,113.37	825.42	1,939.69

Figure 38: July - September 2018 Damage and Losses estimation from PDNA

Source: Government of Lao PDR, Post-Disaster Needs Assessment: Floods 2018.

⁶⁰ ⁶⁰ Government of Lao PDR, Post-Disaster Needs Assessment: Floods 2018, Vientiane: Ministry of Planning and Investment, February 2019. Available at: https://laopdr.un.org/sites/default/files/2019-08/2018%20PDNA_English.pdf

⁶¹ Ibid.

► Drought

Prolonged drought periods can significantly affect urban systems by reducing the availability of surface and groundwater resources, leading to water shortages for domestic consumption, sanitation services, firefighting, and urban cooling. These shortages can result in hygiene issues, increased risk of disease transmission due to poor sanitation, and service delivery failures, particularly in densely populated or informal settlements. Vulnerable groups such as low-income households and residents of peri-urban areas with limited infrastructure are often the most impacted, as they have fewer alternatives and coping mechanisms. Inadequate water availability may also hinder fire suppression efforts, increasing the risk of urban fires during dry seasons. For example, during the 2019 drought in Lao PDR, urban areas experienced critically low Mekong River water levels, affecting municipal water intake systems⁶² and making river navigation and/or transportation difficult.

► Heatwaves

Periods of extreme heat can lead to severe heat stress, particularly in densely built urban areas where the Urban Heat Island (UHI) effect is intensified by low vegetation cover, high building density, and heat-retaining surfaces like concrete and asphalt. These conditions pose serious public health risks, especially for vulnerable groups such as the elderly, children, and individuals with pre-existing health conditions. Heatwaves can lead to increased hospitalizations, heat-related illnesses, and even mortality, as observed during regional heatwaves in Southeast Asia in 2019 and 2023⁶³. Households without access to air conditioning or proper ventilation, often poorer households, are at a higher risk of heat-related health impacts, exacerbating existing inequalities. According to the World Bank in 2020, 22% of the urban population in Lao PDR lived in informal settlement⁶⁴ where heat-related health risks are exacerbated. According to the WHO⁶⁵ heat-related medical conditions will inevitably increase due to heatwaves in Lao PDR: under a high emissions scenario in Lao PDR, heat-related deaths among elderly people are expected to increase to approximately 72 per 100 000 by 2080, compared with 3 per 100 000 worldwide from 1961 to 1990.

Infrastructural systems also suffer under prolonged heat stress. For instance, transport infrastructure may experience fatigue, including rail buckling and asphalt deformation, while energy systems face rising peak demand due to the widespread use of cooling appliances.

Moreover, the demand for urban green spaces significantly increases during these periods as residents seek shade and cooler environments. However, in built cities, access to well-maintained public parks can be limited and lack of such access further increases exposure for low-income groups living in high-density, poorly ventilated housing. This underlines the need for climate-adaptive urban planning measures such as increased tree canopy cover, cool roofing materials, and equitable access to green infrastructure.

Heatwaves are often referred to as a ‘silent killer’ because, unlike high-impact events such as floods, they typically receive less attention and are not systematically followed by post-event needs assessments. As a result, data on losses and damage related to heatwaves remain scarce and fragmented.

⁶² Mekong River Commission, *Mekong Low Flow and Drought Conditions in 2019–2021: Hydrological Conditions in the Lower Mekong River Basin*, Technical Report, January 2022. Available at: <https://www.mrcmekong.org/wp-content/uploads/2024/08/LowFlowReport20192021.pdf>

⁶³ International Bank for Reconstruction and Development & World Bank. (2023). *Unlivable: What the Urban Heat Island Effect Means for East Asia's Cities*. Washington, DC: World Bank. <https://doi.org/10.1596/978-1-4648-2015-1>

⁶⁴ World Bank. (n.d.). *Population living in slums (% of urban population) - Lao PDR*. World Bank Open Data. <https://data.worldbank.org/indicator/EN.POP.SLUM.UR.ZS?locations=LA> Retrieved from: <https://data.worldbank.org/indicator/EN.POP.SLUM.UR.ZS?locations=LA>

⁶⁵ World Health Organization (WHO), *Impact of Climate Change in the Lao People's Democratic Republic, and Recommendations for a Climate-Resilient Health System: Summary Brief of the Lao PDR Health National Adaptation Plan (H-NAP)*, August 2023, https://cdn.who.int/media/docs/default-source/wpro---documents/countries/lao-people's-democratic-republic/hen_summary_hnap_eng_22aug23.pdf?sfvrsn=7e112b71_6.

► Erosion

Landslides can cause severe damage to transportation infrastructure by destroying or blocking roads, bridges, and railway lines. This results in major mobility disruptions, delays in the movement of goods and people, and significantly increased logistics and maintenance costs. In mountainous or remote areas, such disruptions can isolate entire communities, particularly vulnerable populations that rely on limited access routes for essential services, trade, and healthcare. For instance, in Lao PDR, landslides during the wet season can disrupted routes such affecting trade connectivity and access to emergency services. Such events could increase the financial burden on local and national authorities due to costly emergency repairs and reconstruction.

Rapid urbanization, projected to reach 47.7% by 2025, acts as a significant climate risk multiplier. UN Habitat, 2024. This demographic shift concentrates population and infrastructure in already vulnerable areas, such as those along the Mekong River, simultaneously increasing exposure to climate hazards and straining existing urban services like drainage and waste management. This creates a feedback loop where climate impacts, such as those driving rural-to-urban migration, intensify pressures on cities, which then become more vulnerable due to uncontrolled growth and strained resources. Consequently, urban planning in Lao PDR must explicitly integrate climate risk assessments and adaptation measures, moving beyond traditional infrastructure development to embrace "smart city" concepts, green infrastructure, and "sponge city" designs to manage runoff and heat stress. Without such proactive, climate-resilient planning, uncontrolled urbanization will significantly increase future disaster losses and exacerbate urban vulnerabilities.

The CRVA also highlights that the fundamental issue of "non-standard design, low quality in construction, and inadequate maintenance" is a primary reason for infrastructure vulnerability, rather than solely climate exposure. This observation implies that addressing climate resilience in infrastructure requires not only new, climate-proof designs but also a fundamental improvement in construction quality standards, maintenance regimes, and regulatory oversight. This points to a deeper need for institutional strengthening and capacity building within the public works and transport sector, extending beyond mere financial investment in new projects.

GEDSI in the Urban Development and Transport Sector

Climate hazards such as urban flooding, heatwaves, droughts, and erosion disproportionately affect vulnerable groups, including women, persons with disabilities, the elderly, low-income households, and informal settlers. In the urban development and transport sector, these impacts can exacerbate existing inequalities by limiting access to essential services, mobility, safety, and economic opportunities.

Urban flooding and heavy rainfall frequently disrupt transportation systems, hinder access to schools, healthcare, and workplaces, and may confine people with reduced mobility or caregiving responsibilities, most often women and persons with disabilities, to their homes. Informal settlements, often located in flood-prone or poorly drained areas, tend to be more exposed to flooding and receive less investment in resilient infrastructure, amplifying risks for low-income and socially excluded communities. Women are also disproportionately affected by floods due to the risk of experiencing GBV in temporary shelters and camps⁶⁶.

⁶⁶ Asian Development Bank. (2022). *Women's resilience in the Lao People's Democratic Republic: How laws and policies promote gender equality in climate change and disaster risk management*. <https://www.adb.org/sites/default/files/publication/801386/women-resilience-lao-pdr.pdf>

Heatwaves exacerbate health risks, especially for pregnant women, the elderly, children, and outdoor workers, many of whom are engaged in the informal sector and may not have access to cooling or green spaces. Households without air conditioning or access to urban green areas experience greater physical and psychological stress. This highlights the intersection between urban planning and social inequality, as lower-income households tend to live in denser, less vegetated neighborhoods.

Elderly residents, as well as those with disabilities and chronic medical conditions, are most at risk of the health impacts of heat. Vulnerability to heat-related conditions is significantly affected by respiratory and cardiovascular conditions, which make it harder for the body's cooling responses to function. Infants and people over 75 are particularly vulnerable to heat waves. The vulnerability of elderly people is particularly salient in Lao PDR, because the population of the region above the age of 65 is projected to triple between 2020 and 2050⁶⁷.

Erosion and landslides, especially in hillside urban settlements or along transport corridors, can isolate communities with limited mobility and reduce access to essential services. If evacuation or emergency response routes are damaged, the risk to vulnerable groups increases significantly.

Integrating GEDSI into urban and transport planning means ensuring inclusive infrastructure design (e.g., accessible transport stops, early warning systems that reach everyone, shaded walkways), targeted investments in underserved neighborhoods, and active participation of women, persons with disabilities, and marginalized groups in decision-making. A GEDSI-responsive adaptation strategy should identify and address these differentiated risks to promote equity, resilience, and inclusive development.

Table 12: Risk assessment matrix for the Urban Development and Transport Sector

Urban Development and Transport					
Risks	Hazards	Exposure assessment	Severity of impact	Risk per hazard	Computed risks
Public health issues for urban population	Drought	Moderate / High	Moderate	High	High
	Heat waves	Very high	Major	Extreme	
	Flooding	High /Very high	Major	Extreme	
	Erosion	Low/Moderate	Low/Moderate	Low	
Safety issues for urban population	Drought	Moderate	Low	Low	Moderate
	Heat waves	Moderate / High	Moderate	High	
	Flooding	High /Very high	Major	Extreme	
	Erosion	Low/Moderate	Low/Moderate	Low	
Infrastructure strains and / or damages	Drought	Moderate	Moderate	Moderate	High
	Heatwaves	High /Very high	Moderate	High	
	Flooding	High /Very high	Extreme	Extreme	
	Erosion	Low/Moderate	Extreme	High	
	Drought	Moderate / High	Low/Moderate	High	High

⁶⁷ United Nations, Department of Economic and Social Affairs, Population Division. (2024). *World Population Prospects 2024: Summary of Results*. <https://desapublications.un.org/file/20847/download>

Services interruption and Economic disruption	Heatwaves	High /Very high	Low/Moderate	High	
	Flooding	Very high	Extreme	Extreme	
	Erosion	Low/Moderate	Moderate/High	Moderate	
Increased energy demand	Drought	Very high	Major	Extreme	Moderate
	Heatwaves	Very high	Major	Extreme	
	Flooding	Moderate	Low/Moderate	Low	
	Erosion	Low	Low/Moderate	Low	

6.3.3 Water Resources

Laos boasts abundant water resources with its tropical climate alternating wet (May to October) and dry (November to April) seasons. With significant annual rainfall (1800 mm), abundant internal freshwater resources (240 km³/y) and a relatively small population, Lao PDR has a very high volume of available water per capita (28,000 m³)⁶⁸. The Mekong River courses through its heartland with the basin area of the river covering 202,000 square kilometers in the country. For generations, the Mekong has sustained communities, providing essential resources for drinking, irrigation, fishing, and transportation. However, the effects of climate change are increasingly evident, with rising temperatures, erratic precipitation patterns, and the proliferation of hydropower dams threatening the delicate balance of ecosystems and livelihoods.

Prolonged drought periods can significantly affect water resources as it can lead to reduced river flow, declining reservoir levels, and shortages in irrigation water. Similarly, heatwave can lead to increased evaporation, reduced surface water availability, water quality issues. Flooding events can lead to contamination of water sources, infrastructure damage (dams, canals), service disruption. And finally, landslides can lead to blockage of water courses, sedimentation of reservoirs and irrigation systems. All these climate hazards can have multiple impacts as water resources are central to multiple sectors, including agriculture, energy, and urban development. They events cause widespread damage to agriculture, industry, infrastructure, human lives, and property. Limited water access due to groundwater depletion and surface water scarcity poses significant challenges to food security and livelihoods. There are also adverse effects on hydrological systems, biodiversity, and public health.

First, water resources are fundamentally linked to public health in Lao PDR. Access to safe water remains a significant challenge for much of the country's 7.4 million population. According to the UN and UNICEF⁶⁹, while 84% of the population has access to basic water services at home, only 18% have access to safely managed water that meets daily needs for drinking, sanitation, and hygiene. In total, 82% of households lack access to a safely managed water supply, and 39% lack access to safe sanitation. This situation is exacerbated by multiple climate-related hazards:

1. **Droughts** reduce surface water volumes, which concentrates pollutants and degrades water quality, especially in communities dependent on rivers and streams. This increases public health risks and leads to higher water treatment costs, increased competition for water resources, and heightened vulnerability among poor and marginalized groups.
2. **Flooding** can contaminate water sources with sewage, waste runoff, and debris or directly damage water supply infrastructure. According to the 2018 Post-Disaster Needs Assessment (PDNA)⁷⁰, in Lao

⁶⁸ World Bank. (2017). Lao PDR systematic country diagnostic. Retrieved 22 August 2019

from <http://documents.worldbank.org/curated/en/983001490107755004/pdf/Lao-PDR-SCD-03-09-2017-03162017.pdf>

⁶⁹ Planet Water Foundation. (n.d.). Where we operate: Laos. Retrieved July 8, 2025, from <https://planet-water.org/where-we-operate/laos>

⁷⁰ Government of Lao PDR, *Post-Disaster Needs Assessment: Floods 2018*, Vientiane: Ministry of Planning and Investment, February 2019. Available at: https://laopdr.un.org/sites/default/files/2019-08/2018%20PDNA_English.pdf

PDR, floods caused over 50 billion LAK in damage to water and sanitation systems, disrupting access to clean water for more than 120,000 households.

Additionally, water resources are also fundamental to the agriculture sector, directly supporting crop irrigation, livestock hydration, and agro-processing activities. In predominantly rain-fed agricultural systems such as those in Lao PDR, the timing and reliability of water availability strongly influence planting and harvesting cycles. Farmers in Laos face dual challenges: water excess, which can flood fields and delay or damage crops, and water scarcity. Insufficient or erratic rainfall, as well as declining river flows and groundwater levels, can severely disrupt agricultural productivity, reduce yields, and heighten the risk of food insecurity.

3. **Repeated drought** events, such as those in 2015 and 2019, caused substantial water shortages in key agricultural provinces like Champasak, delaying crop cycles and reducing yields. In addition to declining reservoir levels, the limited availability of robust irrigation reservoirs, often noted by the Lao Farmer Association⁷¹, further constrains agricultural resilience. Irrigation infrastructure, often limited in coverage and aging, is especially critical during prolonged dry periods. Effective water resource management is thus essential to ensure stable food production and to strengthen the resilience of rural livelihoods in the face of climate variability.
4. **Flooding** can affect can pose a significant threat to agricultural water resources in Lao PDR, particularly due to its effects on irrigation systems, water quality, and field accessibility. When floodwater inundates farmland, they can damage canals, pumps, and small-scale irrigation infrastructure, disrupting water distribution critical for crop production. For example, during the floods of July–September 2018, triggered by heavy monsoon rains and the collapse of the Xe Pian–Xe Namnoy dam, over 100,000 hectares of farmland were flooded across 17 provinces. The Post-Disaster Needs Assessment (PDNA)⁷² estimated more than USD 11 million in damages to irrigation infrastructure alone, impacting farmers' ability to resume planting for the next season. Furthermore, floodwater can contaminate surface water sources used for irrigation with debris, chemicals, and waste, degrading water quality and increasing risks of crop disease. This contamination could further reduce the usability of agricultural water sources, especially in low-lying provinces such as Savannakhet, Champasak, and Attapeu, where rice farming is highly dependent on controlled irrigation. As climate change intensifies rainfall patterns, improving the resilience of agricultural water systems to flood hazards is crucial for safeguarding food production and rural livelihoods in Laos.
5. **Landslides** contribute to sedimentation of reservoirs and disruption of irrigation systems. A study in the Nam Ou Basin of the Lower Mekong River Basin found that under a high-emissions scenario by 2070, sedimentation could reduce reservoir storage capacity by 26% compared to 17% without climate change⁷³. This sediment build-up decreases available irrigation water and clogs canals and intakes, increasing system maintenance needs and disrupting service delivery.
6. **Simultaneously water resources** also play a critical role in the energy sector, particularly in Lao PDR, where hydropower accounts for over 90% of electricity generation⁷⁴. The availability and flow of rivers directly influence the reliability and capacity of hydroelectric power plants, making the sector highly sensitive to climate-related water fluctuations. Multiple hazards can compromise this system.

During **droughts** or extended dry seasons, reduced river discharge leads to lower reservoir levels, directly impacting hydropower output. In 2024, a significant rainfall shortage left Laos' dam reservoirs at only 30% of their capacity, resulting in a 10% drop in electricity production compared to 2023⁷⁵. Such shortfalls threaten not only domestic energy supply but also industrial productivity and electricity exports.

⁷¹ Laotian Times. (2024, April 30). *Rural Laos struggles with dwindling water resources amidst climate change*. Retrieved from <https://laotiantimes.com/2024/04/30/rural-laos-struggles-with-dwindling-water-resources-amidst-climate-change/>

⁷² Government of Lao PDR, *Post-Disaster Needs Assessment: Floods 2018*, Vientiane: Ministry of Planning and Investment, February 2019. Available at: https://laopdr.un.org/sites/default/files/2019-08/2018%20PDNA_English.pdf

⁷³ Shrestha, B. & Maskey, Shreedhar & Babel, Mukand & van Griensven, Ann & Uhlenbrook, Stefan. (2018). Sediment related impacts of climate change and reservoir development in the Lower Mekong River Basin: a case study of the Nam Ou Basin, Lao PDR. *Climatic Change*. 149. 10.1007/s10584-016-1874-z.

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⁷⁵ Radio Free Asia. (2024, June 5). *Despite heavy rainfall, Laos still plagued by drought, experts say*. <https://www.rfa.org/english/news/laos/rainfall-drought-world-environment-day-06052024095324.html>

Flooding presents another critical risk. It can damage dams, canals, and hydropower infrastructure, leading to service disruption. A stark example is the July 2018 collapse of the Xepian–Xe Nam Noy hydropower dam in Attapeu Province, which followed heavy rainfall brought by Tropical Storm Son-Tinh. The failure released over 5 billion m³ of water, caused at least 27 fatalities, and displaced hundreds⁷⁶. This tragedy underscored the vulnerability of hydropower infrastructure to extreme weather events and the cascading impacts on downstream communities and national power supply.

Landslides and sedimentation, exacerbated by shifting rainfall patterns, can block waterways, reduce reservoir lifespans, and increase infrastructure maintenance costs. As climate variability intensifies, ensuring the sustainable and resilient management of water resources is essential to safeguarding Lao PDR's energy security and broader economic stability.

In conclusion, climate impacts on water resources directly affect energy security and food security. This complex relation has been considered water-energy-food nexus. Policy and planning in these interconnected sectors must therefore be deeply integrated. Decisions concerning dam operations, for example, have direct consequences for both energy production and downstream agricultural water availability, underscoring the need for comprehensive trade-off analyses and multi-stakeholder governance to ensure sustainable resource management across the nexus. A fragmented approach to water management will inevitably fail; thus, Integrated Water Resources Management (IWRM) is not merely a policy recommendation but an absolute necessity. This requires robust cross-sectoral coordination, for example, with meteorological, energy, and agriculture sectors, and a holistic consideration of both surface and groundwater dynamics. Decisions regarding dam operations, for instance, have direct consequences for both energy production and downstream agricultural water availability, necessitating careful trade-off analyses and multi-stakeholder governance.

While surface water issues are often prominent, critical and less obvious threats to groundwater also exist. These include depletion due to increased demand and surface water scarcity, and even quality deterioration, such as arsenic pollution observed in Champasak province. Moreover, unmonitored groundwater use is a significant concern. This situation necessitates elevating groundwater management as a priority within IWRM, requiring robust monitoring systems, specific regulations, and community awareness to prevent over-extraction and pollution, especially in vulnerable regions. It is important to note that while some regional studies indicate general groundwater depletion, other localized assessments, such as for the Vientiane basin, project an increase in groundwater recharge under future climate conditions. This highlights the need for localized assessments and management plans, as groundwater dynamics can vary significantly by basin.

GEDSI in the Water Resources Sector

Climate-induced hazards such as floods, droughts, heatwaves, and erosion have differentiated impacts on water resources that disproportionately affect vulnerable and marginalized populations in Lao PDR. These groups include women, persons with disabilities, ethnic minorities, the elderly, and low-income rural households, many of whom already face barriers to equitable access to safe and reliable water services.

In rural area, **women and girls**, who are primarily responsible for water collection and household water management in many Lao communities, bear a disproportionate burden when water sources are disrupted. According to the World Bank Data⁷⁷, in Laos rural area 49 % of households water fetchers are adult females, and 12% are children under 15 years old mainly girls. During droughts, for instance, the distance and time

⁷⁶ Global Resilience Institute. (n.d.). *Laos dam collapse reveals dangers of hydropower infrastructure in a changing climate*. Northeastern University. Retrieved July 8, 2025, from <https://globalresilience.northeastern.edu/laos-dam-collapse-reveals-dangers-of-hydropower-infrastructure-in-a-changing-climate/>

⁷⁷ CARE International in Lao PDR. (2023). *Impact of climate change on gender in Phongsaly Province*. Scaling-Up Nutrition Civil Society Alliance (SUN CSA). Retrieved from https://suncsalaos.org/wp-content/uploads/2024/08/CARE-Impact-of-CC-on-Gender-on-PSL_SK-2.pdf

required to collect water often increase, exposing women and girls to physical hardship, time poverty, and protection risks. A study from World Vision⁷⁸ on Phongsaly and Salavane Province revealed that 74% of respondents viewed fetching water as the main responsibility of girls. The unequal distribution of water fetching responsibilities, often fall upon daughters and daughters in law. School girls aged 7-11 years often start their day by fetching water before heading to school at 6 am. They repeat this task in the evening around 4-5 pm. The same study revealed that in Salavan Province, 52% of the residents consume over 70 liters per day from community boreholes for drinking and domestic uses, necessitating more than 4 water fetching trips daily and in Phongsaly province, women and young girls living within 50-100 meters of the water point have to fetch water three times daily (morning, afternoon, and evening) spending approximately 20-30 minutes per trip. When water sources are disrupted, it induces an increase in the time spent collecting water by women and girls, and therefore a reduction in the time they would spend on other activities, whether social, educational, or income-generating. During dry season, water is collected from open dug wells near the river from which water quality is uncertain. When water quality deteriorates, whether due to sedimentation from erosion or contamination during floods, the health risks (e.g., diarrheal diseases) disproportionately affect children, elderly people, and individuals with limited mobility or access to healthcare.

People with disabilities (PWDs) and the elderly may be unable to safely access emergency water supplies or relocated water points after a flood, particularly when infrastructure such as roads or bridges is damaged. Similarly, during extreme heat or water scarcity, PWDs may face heightened vulnerability due to pre-existing health conditions and limited access to cooling and sanitation facilities.

Ethnic minorities in remote or upland areas often rely on informal or unprotected water sources⁷⁹, making them more exposed to the impacts of seasonal droughts and floods. Due to remote geographic access and lack of political representation, and in spite of attempts from GoL to ensure equality amongst Lao citizens, many ethnic groups lack access to Government infrastructure, social services, and experience generational poverty. Therefore, these groups may be excluded from formal water governance processes or lack information due to language and communication barriers, reducing their ability to prepare for or respond to water-related climate hazards.

Their livelihoods and cultural practices have resulted in smaller villages, dotted throughout the varied geography of the country that have conducted for certain communities to a relative isolation and has created difficulties for official access to Government provided social services.

Ensuring GEDSI-responsive water resource management includes:

- Prioritizing inclusive consultation processes that involve women, ethnic minorities, and PWDs in planning and disaster response,
- Improving access to safe water and sanitation facilities that are physically and socially accessible,
- Supporting community-based early warning systems and climate information dissemination in local languages,
- And addressing gendered labor burdens in water collection, especially during periods of scarcity.

Without intentional GEDSI integration, climate hazards risk deepening existing inequalities in water access and health outcomes. Strengthening the resilience of water infrastructure and governance systems must therefore be accompanied by strategies that ensure equitable access, representation, and protection for all.

⁷⁸ Ibid.

⁷⁹ GIZ. (2022, May). *Ethnic Groups Development Plan (EGDP) for the Scaling up the implementation of the Lao PDR Emission Reductions Programme through improved governance and sustainable forest landscape management (Project 2)*. Submitted to the Green Climate Fund. Retrieved from <https://www.giz.de/de/downloads/giz2022-en-annex-6d-ethnic-groups.pdf>

Table 13: Summary of Key Climate Risks and Impacts on Water Resources

Hazard Type	Key Indicator / Condition	Affected Provinces/Areas	Brief Impact Description
Flood Stress	5-day cumulative rainfall >200mm	Champasak, Khammouan	Heightened floodplain inundation risks, overwhelmed river systems and levees
Heat Stress (Water Quality)	Max daily temp >45°C	Across water bodies	Oxygen depletion, fish kills, severe impact on aquatic ecosystems
Groundwater Recharge Variability	Annual precipitation <1000mm	Champasak	Jeopardized reliable aquifer recharge and sustainability during dry seasons
Groundwater Depletion & Quality Deterioration	Increased demand, surface water depletion, intensive exploitation	Central and southern areas (Khammouane, Savannakhet, Champasak)	Limited communities' access to water, arsenic pollution observed in Champasak
Localized Droughts	Shortened monsoon season, low Mekong water levels	Domestic crop production areas	Threat to food security, adverse effects on hydrological system, biodiversity, public health

Table 14: Risk assessment matrix for the Water Resources Sector

Water Resources					
Risks	Hazards	Exposure assessment	Severity of impact	Risk per hazard	Computed risks
Reduced river flow and surface water level	Drought	Very high	Major	Extreme	Extreme
	Heat waves	Very high	Moderate	Extreme	
	Flooding	Very low	Very low	Negligible	
	Erosion	Very high	Moderate	Extreme	
Reduced groundwater availability	Drought	Very high	Major	Extreme	High
	Heat waves	Low	Moderate	Moderate	
	Flooding	Very low	Very low	Negligible	
	Erosion	Very high	Major	Extreme	
Water Quality degradations	Drought	High	Major	Extreme	Extreme
	Heatwaves	High	Major	Extreme	
	Flooding	Very high	Major	Extreme	
	Erosion	Moderate	Major	High	
Infrastructure damage and service disruption	Drought	Very high	Moderate	Extreme	Extreme
	Heatwaves	Moderate	Low	Moderate	
	Flooding	Very high	Major	Extreme	
	Erosion	Very high	Major	Extreme	

7 SYSTEMATIC APPROACH OF IDENTIFYING RELATIONSHIPS BETWEEN CLIMATE AND ANTHROPOGENIC PRESSURES

7.1 General Approach

This section contains an analysis on the interaction between climate impacts and how anthropogenic factors amplify these effects. This approach involves a systematic view of climate change impacts and anthropogenic influences. What follows is a schematic systematic analysis followed by a detailed written assessment of the relationships between climate and anthropogenic pressures. It presents key findings and insights derived from the schematic of the IPCC's *Summary for Policymakers - Climate Change 2022: Impacts, Adaptation, and Vulnerability* report. IPCC's *Summary for Policymakers*.

From climate risk to climate resilient development: climate, ecosystems (including biodiversity) and human society as coupled systems

(a) Main interactions and trends

(b) Options to reduce climate risks and establish resilience

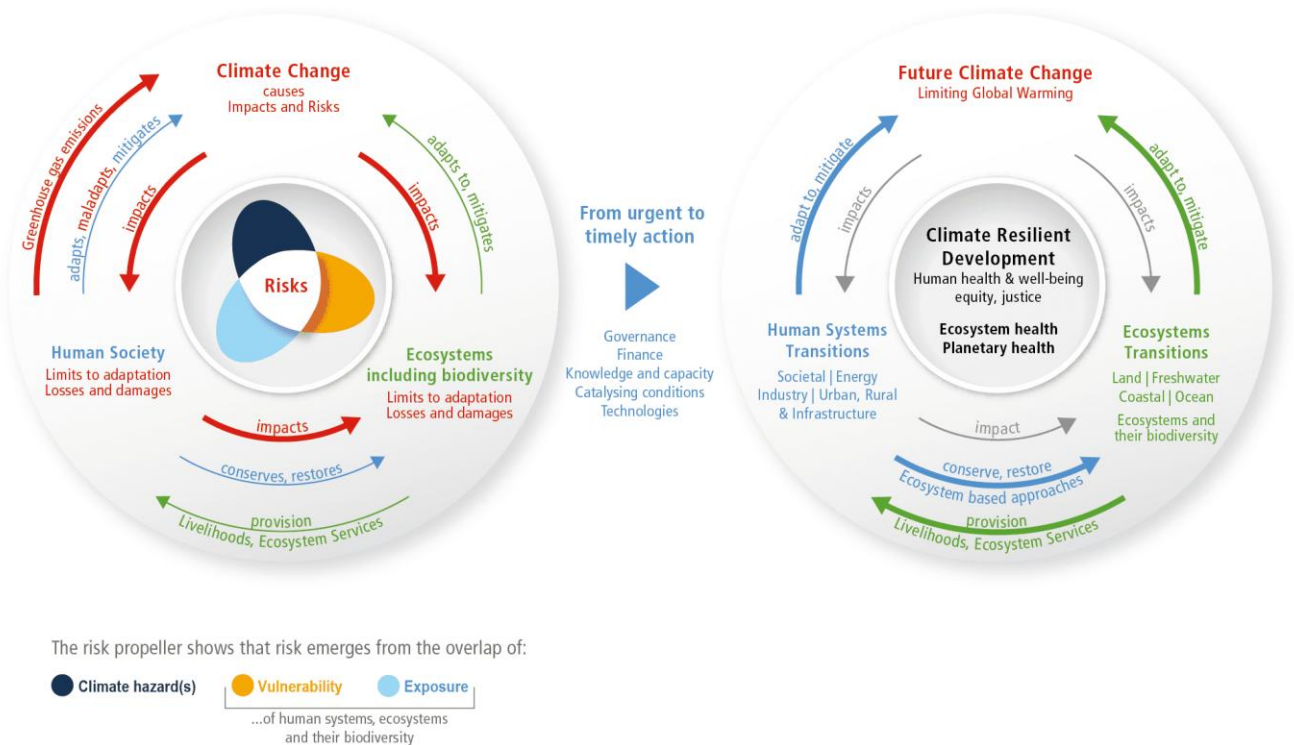


Figure 39: Climate risk to climate resilient development: climate, ecosystems (including biodiversity) and human society as coupled systems (IPCC, 2022).

Source: IPCC's *Summary for Policymakers*, 2022

7.2 Climate Change and Environmental Pressures mapping

In order to explore the interaction between climate impacts and how anthropogenic factors amplify these effects, a schematic has been developed in Annex 8. The schematic shows three columns. The left column shows the key factors that are causing Impacts – both from natural Climate Change and from Anthropogenic (caused/produced by humans) factors.

The central column shows the Impacts created, whilst the right-hand column links these Impacts to further Socio-economic Impacts.

The arrows show the relationships between natural and anthropogenic climate change, and how they both impact on our three selected sectors of water resources, agriculture and forestry, and urban infrastructure.

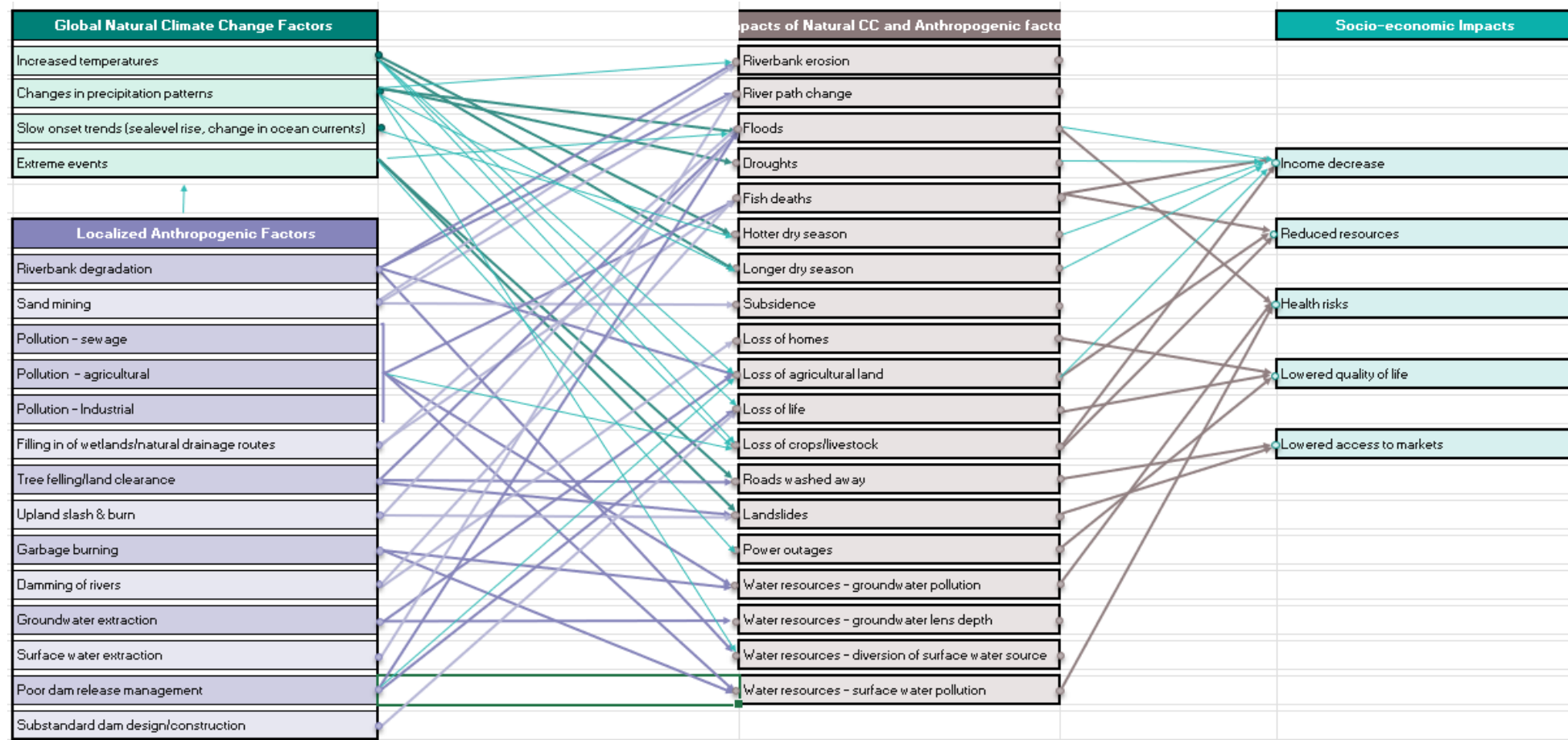


Figure 40: Climate change & Environmental Pressures Mapping
Source: Internal production (from Annex 8_CC & Environmental Pressures mapping)

7.3 Relationships between Natural Climate Impacts and Anthropogenic Pressures

Natural climate change is a cyclical process linked to the sun's energy, oceanic cooling and warming cycles, glacial variance and volcanic activity. These are natural cycles that have always taken place.

Climate change caused by anthropogenic (man-made) factors primarily relates to a significant increase in carbon dioxide over and above natural levels caused by human activity since the beginning of the Industrial Revolution, in the second half of the 18th century. This has both accelerated and changed the patterns of Natural climate change.

There is a strong consensus in the scientific community that globally observed climate change is mostly caused by anthropogenic factors, which have led to an increase in global atmospheric carbon dioxide. Natural climate change effects have been magnified and accelerated. These are primarily increased temperatures, changes in rainfall patterns, sea level rise, changes in oceanic currents and an increase in extreme weather events.

The graph below shows the natural climate change CO² cycles for 400,000 years before the Industrial Revolution and the rapid increase due to anthropogenic factors in recent years.



Figure 41: Graph of natural climate change CO² cycles

Source: University of Calgary

Looking at the figure 42 “Climate change and Environmental pressures mapping” it can be seen that localized impacts in Laos are caused by both natural climate change effects and anthropogenic factors. The main anthropogenic factor is of course CO₂ production, but more localized non-CO₂ related factors have also been examined.

Climate hazards appear to be mostly anthropogenic and have several human drivers but also human stressors:

► **Floods**

Floods are caused by changes in precipitation patterns and more frequent extreme rainfall events, which are amplified by global climate change. In Lao PDR, these are further intensified by human drivers such as land-use change and poorly planned urban development and compounded by local stressors that increase exposure and reduce resilience. For instance, the filling in of wetlands and natural drainage channels without planning or drainage compensation, deforestation, upland slash-and-burn agriculture, and widespread land clearance. All these human factors can reduce the land's capacity to retain and absorb stormwater, increasing runoff speed and volume, and contributing to erosion and flash flooding.

Hazards Human drivers:

1. Global GHG emission contributing to change in rainfall pattern
2. Deforestation and removal of vegetative cover
3. Conversion of wetlands and floodplains to agriculture or urban plan
4. Expansion of impervious surfaces (concrete, asphalt)

Human stressors:

5. Unplanned urban development in flood-prone area
6. Inadequate and clogged drainage infrastructure
7. Poor enforcement of zoning and building regulations
8. Limited early warning systems and response capacity

► **Droughts & Heatwaves**

As seen, hotter and longer dry seasons are increasingly common in Lao PDR, impacting agriculture, energy production, and public health. Droughts and heatwaves stem from shifting rainfall patterns and rising temperatures, both climate hazards driven by anthropogenic global emissions. In addition, their impacts are worsened by local human drivers that affect water availability and land use, and stressors that limit resilience.

Hazards Human drivers:

9. Global GHG emissions increasing average temperatures
10. Poor watershed management and deforestation, reducing groundwater recharge
11. Expansion of water-intensive crops (e.g., bananas, rubber)
12. Dam construction altering natural flow regimes

Human stressors:

13. Low water storage capacity in rural and urban areas
14. Limited irrigation coverage
15. Poor coordination in water resource management
16. Lack of heat-adapted urban infrastructure

► **Landslides & Erosion**

These hazards are especially prominent in the hilly and mountainous terrain of northern and central Lao PDR. While intense rainfall can trigger slope failure, the risk is exacerbated by human activity that destabilizes the landscape.

Hazards Human drivers:

17. Deforestation from logging and shifting agriculture and plantation expansion
18. Road construction and hydropower development without adequate slope stabilization
19. Quarrying, mining, and sand extraction
20. Poor terracing practices on cultivated slopes

Human stressors:

21. Settlement or farming in erosion-prone areas
22. Absence of soil retention infrastructure (e.g., check dams, reforestation)
23. Limited enforcement of land-use planning and environmental safeguards
24. Lack of community awareness and preparedness for landslide risks

These are human drivers and stressors are examined by Sector in the following subsections.

7.3.1 Agriculture and Forestry

Climate change factors affecting Agriculture and Forestry are a mix of natural climate change and anthropogenic. The four main risks and impact that have been identified for the agriculture and forestry sectors: (1) Crop failure (2) Livestock/ fish farming losses, (3) Soil degradation and loss of arable land, and (4) biodiversity loss. Each of these impacts in addition to be induced by the stated climates hazard appears to have anthropogenic stressors or drivers.

► Crop failure

Crop failure in Lao PDR results from a complex interplay of climate hazards and human-induced stressors. While climate change impacts such as rising temperatures, shifting precipitation patterns, and the increased frequency of extreme weather events (including floods, droughts, and storms) can directly threaten agricultural productivity, these risks are significantly amplified by unsustainable agricultural practices. One major issue is the growing reliance on monoculture systems, particularly crops like maize and cassava, which are not only vulnerable to pests and diseases but also reduce soil fertility over time and are often water intensive⁸⁰.

Additionally, land pressure and shortened fallow periods, especially in upland areas where shifting cultivation is still widely practiced can contribute to the further depletion of soil nutrients and yields reduction. In addition, the increasing use of chemical fertilizers and pesticides contributes to soil degradation and pollution of nearby water sources, which can negatively affect plant health and long-term agricultural viability, particularly via leaching and erosion in rain-prone regions⁸¹.

Limited irrigation infrastructure is another major constraint. As of recent estimates, only about 12% of Lao agricultural land is irrigated, leaving most farmers reliant on rainfed systems that are highly sensitive to variability in seasonal rainfall⁸². This dependence increases the risk of crop failure during delayed monsoons or prolonged dry spells. The lack of access to climate-resilient seed varieties, weather forecasting tools, and agricultural extension services further limits farmers' ability to adapt to changing conditions.

⁸⁰ World Bank & Climate Investment Funds. (2023, June 30). *Resilient and low-carbon agriculture in Lao PDR: Priorities for a green transition* (P1775940).

⁸¹ Institute for Global Environmental Strategies (IGES). (2023). *State of Water Environmental Issues: Lao PDR*. Water Environment Partnership in Asia (WEPA). Retrieved from https://wepa-db.net/wp-content/uploads/2023/02/1_State-of-water-environment_Lao-PDR.pdf

⁸² United States Department of Agriculture, Foreign Agricultural Service. (2020, June 12). *Laos rice report annual* (Global Agricultural Information Network Report No. LA2020-0001). Retrieved from https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Laos%20Rice%20Report%20Annual_Bangkok_Laos_06-08-2020

All together, these human drivers (monoculture expansion, degraded soils, weak irrigation systems, and limited adaptive capacity) make agricultural production in Lao PDR highly vulnerable to both chronic and acute climate risks.

► **Livestock / Fish farming losses**

The losses in livestock and fish farming in Lao PDR is the result of multiple interlinked factors, where climate hazards and human stressors converge. As presented in the report, climate-related threats such as rising temperatures, irregular rainfall, prolonged dry spells, and extreme weather events contribute directly to heat stress, dehydration, reduced pasture quality, and the spread of animal diseases. However, these risks are intensified by anthropogenic stressors tied to traditional and under-resourced livestock systems.

Poor sheltering and inadequate access to water are key vulnerabilities. Traditional livestock husbandry practices can leave animals exposed to harsh climatic conditions, with limited protection from extreme heat or heavy rainfall. During dry seasons, water scarcity becomes critical, reducing both drinking water availability and pasture productivity. Feed shortages during these periods further compromise animal health, making herds more susceptible to malnutrition and mortality during droughts or floods. Inadequate veterinary services and limited access to animal health surveillance also increase the risk and spread of climate-sensitive diseases, such as foot-and-mouth disease and avian influenza, which have periodically affected livestock across the country⁸³.

In the fisheries and aquaculture sectors, both climate and human pressures are at play. As presented, high temperatures, especially during heatwaves when air temperatures exceed 35°C, can cause thermal stress and oxygen depletion in fishponds, especially in shallow or poorly managed systems. Droughts and low-flow periods reduce water quality and increase concentration of pollutants. However, many fish stock losses in Lao PDR are primarily linked to human-induced pollution. In recent years, fish die-offs have been reported following chemical runoff from agricultural plantations and construction activities. For instance, in 2023, mass fish deaths occurred in Vientiane following the suspected discharge of pesticides from nearby banana farms, and a similar incident occurred in Houayxay in 2017. Industrial pollution has also played a role: in 2020, local authorities reported fish mortality near Kasy, allegedly linked to construction runoff from the China–Lao railway project, while mining discharges in the Nam Ngum basin have long been a source of water quality concerns.

Finally, river modification and wetland losses can also be important stressors. The filling of wetlands, particularly in peri-urban areas, and the damming of rivers without adequate fish ladders or bypass systems hinder migration patterns and reduce breeding grounds for native species⁸⁴.

As a result, these cumulative pressures, both climatic and anthropogenic, are reshaping aquatic ecosystems and reducing the resilience of communities dependent on livestock and fisheries for their livelihoods and food security.

► **Soil degradation and loss of arable land**

Soil degradation and the loss of arable land in Lao PDR result from a combination of natural climate hazards and human-induced stressors. While heavy rainfall, flooding, drought, and erosion are key climate-driven factors, their impact is significantly amplified by unsustainable land use and agricultural practices. One of the most critical drivers is deforestation and land clearing for agriculture. The expansion of commercial plantations, such as rubber, banana, and cassava under intensive agricultural practices cultivation, often involves the complete removal of natural vegetation, leaving soils bare and highly vulnerable to erosion. Between 2002 and 2024, Lao

⁸³ Spiller, Dario & Franceschini, Gianluca & Henry, Matieu & Falcucci, Alessandra & Wisser, Dominik & Petri, Monica. (2023). An analysis of the effects of climate change on livestock – A case study in the Lao People's Democratic Republic. 10.4060/cc7320en.

⁸⁴ Baird, I. G., & Hogan, Z. S. (2023). Hydropower dam development and fish biodiversity in the Mekong River Basin: A review. *Water*, 15(7), 1352. <https://doi.org/10.3390/w15071352>

PDR lost approximately 5.16 million hectares of tree cover, equivalent to a 27% decline in national forest area⁸⁵, drastically reducing the land's capacity to retain moisture and resist erosion.

In upland areas, slope farming without erosion control measures can contribute to the acceleration of land degradation. The absence of terracing, contour planting, or cover crops can lead to increased surface runoff during intense rainfall events, stripping away nutrient-rich topsoil. This can be especially problematic in provinces like Luang Namtha, Oudomxay, and Xieng Khouang, where hilly terrains are cultivated⁸⁶.

In addition, unsustainable tillage practices and the excessive use of chemical fertilizers and pesticides can weaken soil structure, reduce organic matter, and disrupt the soil's microbiological balance. Degraded soils are not only less fertile they are also less able to absorb water, making them more prone to both drought-related hardening and flood-related erosion which could threaten to shorten the productive lifespan of farmland.

Together, these anthropogenic pressures amplify the vulnerability of Lao PDR's agricultural land to climate impacts and contribute to long-term declines in productivity, food security, and ecological resilience.

► Biodiversity loss

Biodiversity loss in Lao PDR is driven by a combination of climate-related hazards, such as rising temperatures, prolonged droughts, ecosystem shifts, and wildfires, and a wide range of human-induced stressors. One of the most critical human drivers is deforestation and habitat fragmentation, largely caused by the expansion of commercial plantations (e.g., rubber, banana, cassava), logging activities, and infrastructure development, including roads, hydropower dams, and mining operations.

Poor river regulation and dam management also contribute to biodiversity loss, especially aquatic biodiversity. Hydropower development, such as in the Nam Theun, Nam Ngiep, and Xayaburi river basins, has altered natural flow regimes, blocked fish migration routes, and disrupted seasonal flood patterns essential for breeding and feeding cycles⁸⁷. In these cases, the lack of fish passages or environmental flow releases threaten the presence of migratory fish species on which local communities rely for subsistence and income.

Another compounding factor is the weak enforcement of conservation laws. Although Lao PDR has established a network of National Protected Areas (NPAs) and National Biodiversity Conservation Areas (NBCAs), however, in spite of formal protections, illegal logging, land encroachment for agriculture persists inside these areas. Conservation areas, important biodiversity hotspots are sometime encroached for agricultural use, further reducing ecosystem diversity. Land-use change is therefore a dominant driver, with poorly planned development, unsustainable agricultural practices, and weak governance leading to rapid ecological degradation.

7.3.2 Urban Development & Transport

Climate change factors affecting Urban Development & Transport sector are a mix of natural climate change and anthropogenic. The five main risks and impact that have been identified for the sector: (1) Public health issues for the urban population (2) Safety issues for the urban population, (3) Infrastructure strains and/or damages (4) Services interruption and economic disruption and (5) Increased energy demand. Each of these impacts in addition to be induced by the stated climates hazard appears to have anthropogenic stressors or drivers.

⁸⁵ Global Forest Watch. (n.d.). *Lao People's Democratic Republic dashboard*. Retrieved July 9, 2025, from <https://www.globalforestwatch.org/dashboards/country/LAO/>

⁸⁶ Pierret, A. (n.d.) "Management of soil erosion and water resources in the uplands of Lao PDR."

⁸⁷ Baird, I. G., & Hogan, Z. S. (2023). Hydropower dam development and fish biodiversity in the Mekong River Basin: A review. *Water*, 15(7), 1352. <https://doi.org/10.3390/w15071352>

► Public health issues

Public health of urban population can be endangered by climate hazards such as heatwaves also named the 'silent killers', floods that can directly induce casualties or indirect ones with diseases after heavy rains or make health services inaccessible. However, these impacts are stressed by human factors such as inadequate or aging water and sanitation infrastructure. Indeed, poor drainage and aging septic systems can lead to water contamination during floods, increasing the risk of diarrhea and vector-borne diseases. In case of heat waves, UHI effects are amplified by dense construction materials such as concrete asphalt, the lack of vegetation and poorly ventilated buildings that trap heat; Moreover, as mentioned in the vulnerability assessment, slow response to outbreaks and limited adaptive health services reduce community resilience.

Public health in urban areas of Lao PDR is increasingly threatened by climate hazards such as heatwaves, often referred to as "silent killers," as well as floods and extreme rainfall events. These hazards can cause direct casualties but more frequently result in indirect health impacts, such as outbreaks of waterborne and vector-borne diseases, or disruption of access to health services due to inundated roads and damaged facilities.

These health risks are significantly amplified by human drivers and stressors. One major driver is the inadequacy and aging of urban water supply and sanitation infrastructure. In many Lao cities and towns, especially in peri-urban areas, drainage systems are undersized or clogged, and septic systems are poorly maintained⁸⁸. During floods, this results in the overflow of sewage into streets and water sources, increasing the risk of diseases such as diarrhea, dengue fever, and leptospirosis. For instance, the 2018 and 2022 flood events in southern Lao PDR led to spikes in dengue and diarrheal cases in the affected provinces. According to an official health ministry report, the number of dengue fever cases had surpassed 18,000 people and caused 17 deaths in August 2022⁸⁹.

In the context of heatwaves, the urban heat island (UHI) effect further elevates risk. This is driven by dense built environments, the widespread use of heat-retaining materials like asphalt and concrete, and the lack of green spaces and tree cover⁹⁰. Informal and low-income settlements are particularly vulnerable, as housing structures are often made of tin or cement with poor ventilation and limited insulation, exacerbating indoor heat exposure. According to recent vulnerability assessments, temperatures in densely built urban zones can be 3–5°C higher than surrounding rural areas during peak heat periods⁹¹.

Together, these human stressors (poor and aging infrastructure, inadequate urban planning, and limited health system capacity) compound the effects of climate hazards and increase the vulnerability of urban populations to a wide range of public health impacts.

► Safety issues

The safety of urban populations in Lao PDR is increasingly threatened by climate hazards such as flash floods, landslides, and severe storms. These events can cause direct physical harm, including injuries, fatalities, and the collapse of infrastructure. However, the severity and frequency of these safety risks are significantly exacerbated by human-driven factors and stressors related to urban development patterns, infrastructure quality, and institutional capacity.

⁸⁸ United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). (2014). *Background policy study on wastewater management in three countries: Lao PDR, Cambodia and Viet Nam*. Retrieved from: https://www.unescap.org/sites/default/files/Background%20Policy%20Study%20on%20Wastewater%20Management%20in%203%20Countries_24%20March_2014.pdf

⁸⁹ International Federation of Red Cross and Red Crescent Societies (IFRC). (2022, August 23). *Laos: Floods Emergency Plan of Action (EPoA)* MDRLA008. Retrieved from <https://adore.ifrc.org/Download.aspx?FileId=566287>

⁹⁰ International Bank for Reconstruction and Development & World Bank. (2023). *Unlivable: What the urban heat island effect means for East Asia's cities*. Retrieved from <https://doi.org/10.1596/978-1-4648-2015-1>

⁹¹ *Ibid.*

One major drive is the rapid and often unplanned urban expansion taking place in important cities. According to UN Habitat⁹² Lao PDR is characterized by rapid and uncontrolled urbanization with the highest urbanization rate in Asia (4,9%) which poses a huge pressure on important cities such as Vientiane, Savannakhet, and Pakse. In face of this pressure, several new settlements are established in flood-prone zones, erosion-prone slopes, or near unstable riverbanks, often without proper zoning, land-use regulation, or hazard risk assessments⁹³. As a result, entire neighborhoods are exposed to heightened physical risk during heavy rain or sudden water level rises.

Undersized, poorly maintained, or obstructed drainage systems are another critical stressor, contributing to urban flash flooding during intense rainfall events. Drainage networks in older city cores and fast-growing peri-urban zones are frequently clogged with waste or sediment, leading to surface water accumulation that damages homes, roads, and small businesses. For example, during the 2022 floods in Vientiane, knee-to-waist-deep water levels within hours were reported due to insufficient stormwater drainage and blocked drains⁹⁴. In flood-affected zones, roads may be washed out or become impassable, and essential services such as electricity, health care, and emergency response may be temporarily inaccessible.

► Infrastructure strains and/or damages

Urban infrastructure in Lao PDR is increasingly vulnerable to climate-induced damage, particularly from floods, landslides, heatwaves, and prolonged droughts. The most common impacts include washed-out roads and bridges, damaged drainage systems, and frequent power outages, all of which disrupt essential services and mobility. While these hazards stem from climatic factors, their impacts are significantly exacerbated by human drivers and stressors linked to planning, design, and maintenance shortcomings.

One of the key stressors is the aging and undersized nature of infrastructure. Many roads, culverts, and bridges were built decades ago with limited consideration for increasing rainfall intensity, higher peak flows, or heat stress. According to World Bank data⁹⁵, only 15 % of Lao PDR total road network is paved and 40% of paved roads are classified as in poor or bad condition. 40 percent of unpaved roads are inaccessible during the rainy season. Road and bridge infrastructure are particularly vulnerable as surfaces degrade rapidly under the pressure of heavy vehicle traffic, especially when foundations are weak or roads are waterlogged and if coupled with underfunded and irregular maintenance it may worsen conditions. For example, in cities like Vientiane and Luang Prabang, clogged storm drains, eroded road shoulders, and poorly maintained culverts have frequently contributed to localized flooding and transport disruptions during the monsoon season^{96 97}.

Landslides affecting transport routes in mountainous areas, are often triggered by rainfall but are worsened by deforestation, slope destabilization from road construction, and poor drainage around infrastructure. For example, in 1996 landslides occurred in Oudomxay and Bolikhamxay provinces. It was originated by heavy rainfall and inadequate soil structure and lead to the breaking of a 1MW hydro-power dam and 1.5 MW Nam Phao Dam⁹⁸.

⁹² UN-Habitat. (n.d.). *Lao People's Democratic Republic*. UN-Habitat. Retrieved from <https://unhabitat.org/lao-peoples-democratic-republic>

⁹³ United Nations Human Settlements Programme (UN-Habitat). (2016, October). *Request for project/programme funding: Building climate and disaster resilience capacities of vulnerable small towns in Lao PDR*. Adaptation Fund. https://fifspubprd.azureedge.net/afdocuments/project/8899/8899_Laos%20Project%20Proposal%20clean.pdf

⁹⁴ Laotian Times. (2022, August 20). *Vientiane capital floods again following heavy rains*. Retrieved from <https://laotiantimes.com/2022/08/20/vientiane-capital-floods-again-following-heavy-rains/>

⁹⁵ World Bank. (2023, September). *Lao PDR: Climate-resilient road connectivity improvement project—Environmental and social impact assessment (ESIA)*. Retrieved from <https://documents1.worldbank.org/curated/en/099091124140039164/pdf/BOSIB-d5c9a78b-ff1e-42cc-b126-8d9a3b3e4794.pdf>

⁹⁶ Laotian Times. (2023, June 28). *Vientiane capital suffers flash floods due to poor drainage and infrastructure maintenance*. Retrieved from <https://laotiantimes.com/2023/06/28/vientiane-capital-suffers-flash-floods-due-to-poor-drainage-and-infrastructure-maintenance/>

⁹⁷ Laotian Times. (2024, July 12). *Vientiane capital to tackle persistent flooding issues*. Retrieved from <https://laotiantimes.com/2024/07/12/vientiane-capital-to-tackle-persistent-flooding-issues/>

⁹⁸ Asian Disaster Reduction Center. (1998). *Lao PDR country report on disasters 1998* (Landslides section). In *ADRC country report*. Retrieved from <https://www.adrc.asia/countryreport/LAO/LAOeng98/index.pdf>

Power outages are another growing issue, typically occurring during or after extreme weather events such as intense storms and floods, which bring down transmission lines and poles. The resilience of the power grid is challenged by a combination of limited redundancy, aging distribution infrastructure, and delayed upgrades. For example, storm-related blackouts are common during the wet season in central and southern provinces⁹⁹, and can affect health facilities, businesses, and water pumping systems, etc.

Additionally, urban expansion into hazard-prone areas, such as low-lying floodplains or unstable hillsides, increases the exposure of infrastructure to damage. Limited integration of climate resilience into infrastructure planning, and fragmented institutional coordination further weaken the system's ability to withstand and recover from climate shocks.

► **Service interruption and Economic disruption**

Urban economies in Lao PDR are increasingly vulnerable to service interruptions and economic disruptions caused by climate hazards such as floods, prolonged droughts, and extreme temperatures. These hazards can directly disrupt transportation, electricity, water supply, and communications infrastructure, which are critical to the functioning of urban services and economic activity. The impacts are particularly severe in urban areas where infrastructure systems can be fragile or overstretched.

Additionally, the urban informal economy is highly vulnerable, and it constitutes a large share of economic activity in Lao PDR. In 2022, according to the UN approximately 83% of employment was informal, and 79,9% of men and 85,9% of women were self-employed without formal protections or social safety nets¹⁰⁰. Informal vendors, daily wage workers, and small-scale enterprises (SMEs) often operate in poorly constructed or unregulated spaces such as street markets, roadside kiosks, or makeshift stalls, that can sometimes be located in flood-prone or exposed areas. These groups are particularly vulnerable to climate shocks due to their lack of access to financial safety nets, insurance, or formal social protection mechanisms.

► **Increased energy demand**

Increased temperatures, prolonged droughts, and more frequent heatwaves are leading to a sharp rise in urban energy demand, particularly for cooling. In Lao PDR, these climate hazards are compounded by a number of human drivers and stressors that intensify both the demand for energy and the vulnerability of energy systems to disruption.

One key driver is the prevalence of poorly designed buildings with low thermal performance¹⁰¹ such as buildings constructed with inadequate insulation, poor ventilation, and no passive cooling features like roof overhangs, ventilated facades, or reflective surfaces. As a result, indoor temperatures can quickly rise during heatwaves, increasing reliance on air conditioning and electric fans.

Urban design also plays a significant role in exacerbating heat exposure. The lack of green spaces, urban tree cover, and shaded public areas in rapidly growing urban centers contributes to the urban heat island (UHI) effect, where densely built areas become significantly hotter than surrounding rural zones. Surfaces dominated by asphalt, concrete, and metal roofing absorb and retain heat, further raising ambient temperatures and cooling needs.

⁹⁹ RFA Lao. (2024, July 2). *Rainy season exacerbates Laos' power outages*. Radio Free Asia. Retrieved from <https://www.rfa.org/english/news/laos/rainy-system-electricity-debt-dam-laos-power-outages-07022024132451.html>

¹⁰⁰ UN (2022). *Lao PDR Common Country Analysis 2022: Understanding informality and Expanding social security coverage in Lao PDR. A comprehensive analysis to inform the UN Sustainable Development Cooperation Framework 2022–2026*. Retrieved from <https://laopdr.un.org/lo/download/77289/143626>

¹⁰¹ International Bank for Reconstruction and Development & World Bank. (2023). *Unlivable: What the urban heat island effect means for East Asia's cities*. Retrieved from <https://doi.org/10.1596/978-1-4648-2015-1>

This growing energy demand poses challenges to an energy system already vulnerable to seasonal variability. Lao PDR relies heavily on hydropower which is increasingly as assessed affected by droughts and lower dry season flows, leading to reduced generation capacity when electricity demand is at its peak. This mismatch, increased demand during hot, dry periods when supply is constrained, puts stress on the national grid and contributes to blackouts and voltage instability, particularly in secondary cities with aging transmission infrastructure¹⁰².

Therefore, as urbanization accelerates and heat extremes intensify, energy demand is expected to grow significantly unless climate-resilient urban planning, energy-efficient building codes, and renewable energy diversification are implemented.

7.3.3 Water Resources

Four main risks and impact have been identified for the water resources sectors: (1) The reduced river flow and surface water level, (2) the reduced groundwater availability, (3) water quality degradation, and (4) infrastructure damage and service disruption. Each of these impacts in addition to being induced by the stated climate hazard appears to have anthropogenic stressors or drivers.

► Reduced river flow and surface water level

Human activities are significantly contributing to the reduction of river flow and surface water levels in Lao PDR. The construction and operation of large-scale dams, both within Lao territory and upstream in neighboring countries, have modified the natural flow regimes of major rivers, particularly the Mekong and its tributaries¹⁰³. These hydropower projects, such as those on the Nam Ou and Xayaburi dams, regulate water for electricity generation, often resulting in reduced downstream discharge during critical dry season periods¹⁰⁴.

In addition, increasing water withdrawals for agricultural irrigation, especially in lowland rice cultivation areas and for agro-processing industries, are placing mounting pressure on surface water resources. Currently, water withdrawals are primarily directed for irrigation purposes, which amount to just 1.8% of the annual water available¹⁰⁵. Although this overall volume may appear modest, the real strain lies in the seasonal distribution, during dry months, withdrawals spike, reducing freshwater availability for other essential uses. With the country increased agro-processing demands this trend could increase the vulnerability to drought and heighten risk to rural livelihoods in southern provinces like Champasak and Savannakhet.

Depth to the top of the groundwater lens is increasingly a global problem, as farmers and rural populations must dig or drill deeper to access groundwater and then consume more electricity to pump it to the surface. The depth of groundwater will vary cyclically with natural climate change, but over many thousands of years. The depletion of the water lens in recent decades is almost entirely due to over extraction from the water lens. However, this has not affected Laos significantly due to the abundance of surface water and relatively low rural population.

Surface water sources, widely used in Laos, can be diverted by either riverbank degradation or reduction in river flow. Riverbank degradation and reduction of river flow can be caused through natural climate change factors such as changes in precipitation or extreme weather events, but these changes would take place over a very long

¹⁰² Laotian Times. (2024, May 9). *Heatwave strains power supply across Laos; Electricity state company responds to public backlash*. Retrieved from <https://laotiantimes.com/2024/05/09/heatwave-strains-power-supply-across-laos-electricity-state-company-responds-to-public-backlash/>

¹⁰³ Cronin, R., & Weatherby, C. (2023). *Analysis of hydropower impacts in the Mekong's 3S Basin*. Stimson Center. Retrieved from <https://www.stimson.org/2023/analysis-of-hydropower-impacts-in-the-mekongs-3s-basin/>

¹⁰⁴ *Ibid.*

¹⁰⁵ World Bank. (2017). Lao PDR systematic country diagnostic. Retrieved 22 August 2019 from <http://documents.worldbank.org/curated/en/983001490107755004/pdf/Lao-PDR-SCD-03-09-2017-03162017.pdf>

time. Diverted surface water sources are more likely to be linked to riverbank degradation caused by anthropogenic factors such as tree falling and land clearance close to the riverbank.

Deforestation is another major contributor to altered hydrological patterns. Between 2002 and 2024, Lao PDR lost 5.16 million ha of tree cover, equivalent to a 27% of its tree cover area¹⁰⁶, which reducing the water retention capacity of upland catchments. This land cover change can contribute to the acceleration of surface runoff, reduce infiltration, and diminish base flow contributions to rivers and streams, especially during dry seasons.

These stressors collectively lead to reduced water availability for domestic, agricultural, and ecological needs, exacerbating vulnerability during periods of drought and prolonged dry spells.

► Reduced groundwater availability

In Lao PDR, increasing reliance on groundwater for both irrigation and rural water supply, particularly in areas lacking adequate surface water infrastructure, has contributed to declining aquifer levels. This trend is especially prominent in the lowland areas of central and southern provinces, such as Savannakhet and Champasak, where expanding agricultural activities and dry-season irrigation are placing significant pressure on local groundwater reserves¹⁰⁷.

A key driver of groundwater stress is the unregulated drilling of wells, especially during prolonged droughts, when surface water becomes scarce. In many rural districts, households and farmers resort to private well construction, often without permits or oversight, which exacerbates depletion. Additionally, the absence of a comprehensive groundwater monitoring network limits the government's ability to assess current extraction rates and manage recharge effectively.

Urbanization also contributes to groundwater vulnerability. The expansion of impermeable surfaces, such as roads, pavements, and buildings, in cities like Vientiane restricts the natural infiltration of rainwater, significantly reducing groundwater recharge. This is compounded by poor urban drainage and land use planning. Without proactive policies to manage urban runoff and promote recharge (e.g., through green infrastructure or permeable surfaces), urban aquifers remain at risk of long-term decline.

Climate change further intensifies this pressure by altering rainfall patterns and increasing evapotranspiration rates, which reduces both surface runoff and subsurface recharge, creating a feedback loop of increasing groundwater dependence and depletion.

► Water quality degradation

Water quality degradation in Lao PDR is driven by a combination of climate hazards and human-induced stressors. One of the primary contributors is agricultural runoff, as the increasing use of chemical fertilizers and pesticides can lead to nutrient loading and contamination of both surface and groundwater. Between 2000 and 2021, the volume of imported pesticides in Lao PDR increased more than tenfold, reflecting a growing

¹⁰⁶ Global Forest Watch. (n.d.). *Lao People's Democratic Republic dashboard*. Retrieved July 9, 2025, from <https://www.globalforestwatch.org/dashboards/country/LAO/>

¹⁰⁷ Australian Centre for International Agricultural Research (2012). *Improved groundwater access in Lao PDR: Community-based management and hydrogeological assessment*. ACIAR Final Report No. LWR/2010/081. Retrieved from https://www.aciar.gov.au/sites/default/files/project-page-docs/final_report_lwr.2010.081.pdf

dependency on agrochemicals¹⁰⁸ and that in case of flood event can impact surface water and groundwater sources.

In addition, inadequate sanitation infrastructure can exacerbate the issue. In peri-urban and rural areas, poorly maintained septic systems and pit latrines can be overwhelmed during floods, allowing raw sewage to enter nearby streams and aquifers. These challenges are compounded by improper solid waste management, with waste still being openly dumped or burned. The resulting leachate and toxic emissions contribute to both surface and groundwater pollution. Industrial activities, especially in the mining sector, further deteriorate water quality. For instance, in the Nam Ngum catchment, mining operations have led to elevated levels of heavy metals such as copper, lead, and zinc in river sediments, posing risks to aquatic life and communities dependent on these water sources¹⁰⁹.

These human drivers are deeply intertwined with climate risks: flooding events mobilize contaminants over large distances, while droughts reduce dilution capacity in rivers, concentrating pollutants and making water sources more hazardous for consumption and agriculture.

► Infrastructure damage and service disruption

Climate hazards in Lao PDR, particularly floods, but also landslides, droughts, and heatwaves, are increasingly causing damage to infrastructure and disruptions to basic services. While these impacts are driven by natural events, their severity is largely compounded by human factors.

One of the most significant stressors is the aging and under-maintained water-related infrastructure. Many existing irrigation canals, rural water supply systems, and hydropower installations were built decades ago, often without consideration for the intensity or frequency of current and projected climate extremes. Small-scale irrigation systems across the country can be vulnerable to sedimentation and flood-related damage, resulting in lower irrigation efficiency and reduced dry-season cropping. Similarly, older hydropower facilities are exposed to both spillway overflow during intense rainfall events and operational constraints during prolonged droughts, as experienced during the 2019 Mekong low-flow crisis, which nationally affected energy production¹¹⁰.

The lack of climate-resilient design standards can further increase this vulnerability. In many cases, infrastructure was not built to withstand the types of flash flooding now seen with greater regularity.

7.4 Socio-economic Impacts

The combined effects of climate hazards and anthropogenic drivers are producing increasingly severe socio-economic consequences for the population of Lao PDR. These impacts are felt across livelihoods, income, health, access to services, and overall quality of life, particularly among rural and urban low-income communities that are least equipped to cope.

Income and livelihood losses are among the most direct consequences of climate change. Floods, droughts, longer and hotter dry seasons, and extreme weather events can lead to crop failure, livestock and fish stock loss, undermining the primary sources of income for a large portion of the population engaged in subsistence

¹⁰⁸ Department of Agriculture (DOA), Lao PDR. (2022). *Agricultural Statistics 2021*. Vientiane: Ministry of Agriculture and Forestry. Retrieved from <https://www.laofab.org/document/download/5691>

¹⁰⁹ Marko Kallio (August, 2018). The impacts of Hydropower and mining on water quality: The case of the Nam Ngum catchment, Lao PDR. *Water Knowledge issue 2*. Retrieved from <https://archive.iwmi.org/wle/impacts-hydropower-and-mining-water-quality-example-nam-ngum-catchment-lao-pdr/>

¹¹⁰ Mekong River Commission. (2024). *Mekong low flow and drought conditions in 2019–2021: Hydrological analysis and recommendations*. Vientiane, Lao PDR: MRC Secretariat. Retrieved from <https://www.mrcmekong.org/wp-content/uploads/2024/08/LowFlowReport20192021.pdf>

agriculture, small-scale aquaculture, and informal trade. The loss of arable land due to erosion, land degradation, or flooding can further limit livelihood options.

Health risks are rising due to the growing incidence of waterborne and vector-borne diseases, such as diarrhea, dengue fever, and malaria. These risks are exacerbated by flooding and stagnant water, especially in peri-urban and low-lying areas with inadequate drainage and sanitation infrastructure. Pollution of surface and groundwater further compounds public health challenges, particularly during and after extreme weather events, when contamination peaks and access to healthcare is often disrupted.

Disruption of transport and basic service access is another socio-economic burden. Washed-out roads, landslides, and flooded bridges reduce physical access to markets, health services, schools, and administrative centers. This isolation has significant ripple effects: perishable goods cannot be sold, emergency services are delayed, and economic activities are disrupted. In mountainous provinces and flood-prone lowlands, these disruptions can persist for weeks, contributing to both income loss and social marginalization.

Ultimately, the accumulation of these impacts results in a decline in overall quality of life. Reduced income, worsening health, degraded housing, and unreliable access to basic services, compounded by poor adaptive capacity and limited safety nets, undermine the well-being of affected populations. These socio-economic stressors are not evenly distributed: women, children, elderly populations, ethnic minorities, and people living in informal settlements are often disproportionately affected. Without targeted interventions, these vulnerabilities are expected to deepen as climate risks intensify.

8 CONCLUSION AND FIRST RECOMMENDATIONS FOR SECTORAL ADAPTATION

The conclusions and initial recommendations are based on.

- An assessment of the hazards, vulnerability to those hazards, and risks to the three sectors under assessment from these vulnerabilities, contained in Sections 4-6 of this report
- The multi-criteria analysis for prioritizing adaptation measures from the Situations Analysis report (Annex 7)
- Input from stakeholders from each sector.

Recommendations for sectoral adaption are provided at a national scale, and also for each of the 6 Provinces studied under the NAP report "Lao PDR Provincial Storyline-based Climate Risk, Vulnerability, and Adaptation Assessment". The recommendations, shortlisted using the MCA process, came from the approved NAP (V6) report and so are consistent with national adaptation priorities.

The prioritization of adaptation measures was conducted using a Multi-Criteria Analysis (MCA), providing a structured and transparent basis for decision-making. The MCA approach was selected as it enables the comparison of adaptation options across multiple dimensions, including environmental relevance, socio-economic benefits, and implementation feasibility, in line with established practices in National Adaptation Plan processes.

First, an initial long list of adaptation measures was extracted from the National Adaptation Plan (NAP) and refined based on CRVA findings and stakeholder inputs. Each measure was then evaluated against ten criteria reflecting climate risk relevance, development priorities, and implementation conditions. These criteria were selected to ensure alignment with national policy objectives (e.g. NAP, NSEDP), as well as sector-specific vulnerabilities and stakeholder-identified needs.

1. Severity of climate change impacts
2. Contribution to poverty reduction
3. High value creation
4. Alignment with environmental and climate objectives
5. Contribution to lives and livelihood security
6. Feasibility of implementation and availability of resources
7. Sustainability and long-term benefits
8. Institutional capacity to implement
9. Financial operationalization
10. Urgency of action

To ensure consistent application, each criterion was clearly interpreted during scoring. For example, "severity of climate change impacts" reflects the extent to which a measure addresses high-risk hazards identified in the CRVA; "feasibility of implementation" considers technical, financial, and operational constraints; and "institutional capacity" reflects the ability of responsible agencies to implement and sustain the measure. This approach ensures that scoring is not only systematic but also grounded in sectoral realities.

Each criterion was assigned a weight (ranging from 0.4 to 1.0) to reflect its relative importance. Higher weights were attributed to feasibility, sustainability, institutional capacity, and financial operationalization, recognizing that implementation constraints represent a key barrier to effective adaptation in Lao PDR. Medium weights were assigned to criteria related to policy alignment and livelihood protection, while lower weights were attributed to urgency to avoid over-prioritizing short-term responses at the expense of long-term resilience.

The weighting approach was defined based on a combination of CRVA findings, national policy priorities, and established guidance on adaptation planning, and subsequently validated and refined through stakeholder consultations. Adaptation measures were scored on a scale of 1 to 10 for each criterion, and weighted scores were aggregated to produce a composite score, allowing for the ranking and prioritization of measures as presented in Figure 43 to 45.

This structured approach ensures that prioritization results are transparent, reproducible, and grounded in both quantitative analysis and stakeholder-informed judgment, thereby strengthening confidence in the identified priority adaptation measures.

The 10 recommendations with the highest total scores were selected as the preliminary priority adaptation measures for further analysis and stakeholder consultation.

Evaluation criteria:	Severity of CC Impacts			Poverty Reduction			High Value			Alignment with Environmental & Climate			Lives & Livelihood security			Feasibility of Implementation & availability of resources			Sustainability & long term benefits			Institutional capacity to implement			Financial operationalization			Urgency of Action			
Source of data	NAP-UNEP			NAP-UNEP			NAP-UNEP			NAP-UNEP			NAP-UNEP			NAP-UNEP			NAP-UNEP			NAP-UNEP			Consultant			NAP-UNEP			TOTAL
Proposed adaption measures from NAP-UNEP	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	WEIGHT
Improve irrigation and storage of excess rainfall to reduce impacts from drought	6	0.4	2.4	8	0.6	4.8	8	0.7	5.6	8	0.8	6.4	8	0.8	6.4	8	1	8	6	1	6	6	0.6	3.6	9	1	9	7	0.4	2.8	55
Improve drainage systems to mitigate the damage to plants from waterlogging	6	0.4	2.4	8	0.6	4.8	8	0.7	5.6	8	0.8	6.4	8	0.8	6.4	8	1	8	6	1	6	6	0.6	3.6	9	1	9	7	0.4	2.8	55
Regarding land use and planning, strengthen regulations on land leases and concessions to prevent deforestation and land degradation, and increase	10	0.4	4	6	0.6	3.6	9	0.7	6.3	10	0.8	8	7	0.8	5.6	4	1	4	9	1	9	3	0.6	1.8	6	1	6	8	0.4	3.2	51.5
Promote reforestation in areas exposed to high-risks of floods, storms, landslides	9	0.4	3.6	6	0.6	3.6	7	0.7	4.9	8	0.8	6.4	8	0.8	6.4	5	1	5	9	1	9	4	0.6	2.4	7	1	7	8	0.4	3.2	51.5
Policing and Provincial level control of seasonal burning	8	0.4	3.2	3	0.6	1.8	3	0.7	2.1	8	0.8	6.4	8	0.8	6.4	8	1	8	8	1	8	8	0.6	4.8	6	1	6	8	0.4	3.2	49.9
Apply sustainable forest and land management in the planning process to ensure local adaptation as well as national mitigation.	8	0.4	3.2	7	0.6	4.2	7	0.7	4.9	8	0.8	6.4	7	0.8	5.6	6	1	6	8	1	8	5	0.6	3	5	1	5	7	0.4	2.8	49.1
Identify and design location specific irrigation schemes and technologies to reduce risks such as using solar energy, self flowing water using surface water and underground water.	5	0.4	2	6	0.6	3.6	6	0.7	4.2	5	0.8	4	7	0.8	5.6	8	1	8	8	1	8	8	0.6	4.8	6	1	6	5	0.4	2	49.2
Utilize climate resilient designed infrastructure such as irrigation reservoirs and hydropower reservoirs by controlling and determining appropriate and safe water level in the reservoirs ahead of flooding season starts (rainy season), particularly Nam Ngum Dam 1, Nam Mang 3, Nam Theun 2, Theun Higboun, Xe Pongxay Namong, Xe Kaman and others.	5	0.4	2	2	0.6	1.2	2	0.7	1.4	5	0.8	4	8	0.8	6.4	9	1	9	9	1	9	9	0.6	5.4	8	1	8	4	0.4	1.6	48
Address landslide resilience in land management plans, ensuring that construction, mining, and agriculture do not destabilize slopes. To this end, EBA actions are crucial, such as maintaining a dense and biodiverse tree canopy, particularly in steep slopes, and conducting a detailed and standardized estimation of the value of loss and damage in agriculture.	9	0.4	3.6	6	0.6	3.6	7	0.7	4.9	7	0.8	5.6	8	0.8	6.4	5	1	5	8	1	8	4	0.6	2.4	5	1	5	8	0.4	3.2	47.7
Conduct a pilot study in selected districts to develop a standardized estimation of the value of loss and damage in agriculture.	2	0.4	0.8	5	0.6	3	3	0.7	2.1	8	0.8	6.4	8	0.8	6.4	8	1	8	6	1	6	8	0.6	4.8	8	1	8	5	0.4	2	47.5
Mainstream climate change adaptation in forestry and land-use planning strategy and action plan including through results-based management	8	0.4	3.2	6	0.6	3.6	7	0.7	4.9	9	0.8	7.2	7	0.8	5.6	5	1	5	8	1	8	4	0.6	2.4	5	1	5	6	0.4	2.4	47.3
Diversifying farming systems can enhance food security during climate shocks affecting specific crops.	5	0.4	2	5	0.6	3	5	0.7	3.5	5	0.8	4	8	0.8	6.4	8	1	8	8	1	8	8	0.6	4.8	4	1	4	8	0.4	3.2	46.9
Integrate management, prevention and control of climate change adaptation plan into the agriculture development plan at all levels within the agricultural sector. The integration includes revising agricultural laws, decrees and other policies related to agricultural sector and other relevant stakeholders.	3	0.4	1.2	3	0.6	1.8	3	0.7	2.1	9	0.8	7.2	7	0.8	5.6	8	1	8	8	1	8	8	0.6	4.8	5	1	5	8	0.4	3.2	46.9
Develop and update climate risk and vulnerability maps for the forestry and land-use planning sector to support the integration of climate change adaptation into the Participatory Land Use Planning and Forestry	8	0.4	3.2	5	0.6	3	7	0.7	4.9	8	0.8	6.4	7	0.8	5.6	6	1	6	7	1	7	4	0.6	2.4	6	1	6	6	0.4	2.4	46.9
Review and assess vulnerabilities, risks, impacts of previous floods, droughts, extreme climate events, and changing rainfall patterns on the agriculture sector as well as plan-options for climate change adaptation in agriculture and food security in general and in detail, focusing on production systems and other value-added chains that are at risk and affected.	6	0.4	2.4	3	0.6	1.8	3	0.7	2.1	7	0.8	5.6	6	0.8	4.8	8	1	8	8	1	8	8	0.6	4.8	6	1	6	8	0.4	3.2	46.7

Figure 42: Extract of the MCA Spreadsheet for the Agriculture & Forestry Sector

Evaluation criteria:	Severity of CC Impacts			Poverty Reduction			High Value			Alignment with Environmental & Climate			Lives & Livelihood security			Feasibility of Implementation & availability of resources			Sustainability & long term benefits			Institutional capacity to implement			Financial operationalization			Urgency of Action			
Proposed adaption measures from NAP-UNEP	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	TOTAL
																															WEIGHTED
1. Create building management regulations (Building Code) and improve waste management regulations.	8	0.4	3.2	6	0.6	3.6	6	0.7	4.2	8	0.8	6.4	9	0.8	7.2	9	1	9	9	1	9	8	0.6	5.4	6	1	6	8	0.4	3.2	57.2
2. Improve and build urban drainage systems and prevent floods in cities, along with the protection of protected areas, lakes, riverbanks, and wetlands to ensure that cities have good ecosystems and resilience to climate change.	8	0.4	3.2	3	0.6	1.8	3	0.7	2.1	6	0.8	4.8	8	0.8	6.4	8	1	8	8	1	8	8	0.6	4.8	10	1	10	8	0.4	3.2	52.3
3. Improve and build drainage systems and flood prevention in various cities, along with the protection of ponds, swamps, riverside areas and wetlands to ensure that cities have a healthy ecosystem and are resistant to climate change.	8	0.4	3.2	3	0.6	1.8	3	0.7	2.1	6	0.8	4.8	8	0.8	6.4	8	1	8	8	1	8	8	0.6	4.8	10	1	10	8	0.4	3.2	52.3
4. Invest in low-carbon public transport, such as electric buses and trains as well as in renewable energy sources and energy-efficient technologies as it helped reduce the dependency and enhance	8	0.4	3.2	2	0.6	1.2	2	0.7	1.4	9	0.8	7.2	9	0.8	7.2	8	1	8	8	1	8	8	0.6	4.8	8	1	8	8	0.4	3.2	52.2
5. Improve and build model landfills in small towns, second-ranked towns and big towns.	7	0.4	2.8	5	0.6	3	5	0.7	3.5	7	0.8	5.6	7	0.8	5.6	8	1	8	8	1	8	8	0.6	4.8	8	1	8	7	0.4	2.8	52.1
6. Promote and support public transport such as electric buses as it can lower traffic and pollution in cities, positively affecting the incidence of respiratory diseases.	5	0.4	2	5	0.6	3	6	0.7	4.2	8	0.8	6.4	6	0.8	4.8	8	1	8	8	1	8	8	0.6	4.8	8	1	8	6	0.4	2.4	51.6
7. Develop manuals on technical standards for managing the construction and repair of public works and transport infrastructure to cope with climate change.	7	0.4	2.8	4	0.6	2.4	4	0.7	2.8	8	0.8	6.4	6	0.8	4.8	9	1	9	8	1	8	8	0.6	4.8	6	1	6	9	0.4	3.6	50.6
8. Assess the impact of climate change on the sector of public infrastructure and transportation, as well as build organizational and	7	0.4	2.8	4	0.6	2.4	4	0.7	2.8	8	0.8	6.4	6	0.8	4.8	9	1	9	8	1	8	8	0.6	4.8	5	1	5	9	0.4	3.6	49.6
9. Study and collect data on drainage ditches within the city that are prone to floods during the rainy season in areas across the country.	8	0.4	3.2	5	0.6	3	5	0.7	3.5	8	0.8	6.4	8	0.8	6.4	8	1	8	8	1	8	3	0.6	1.8	6	1	6	8	0.4	3.2	49.5
10. Study and develop standards and techniques for the construction, and maintenance of infrastructure related to the integration of standards for ensuring and resilient to climate change.	7	0.4	2.8	4	0.6	2.4	4	0.7	2.8	8	0.8	6.4	6	0.8	4.8	9	1	9	8	1	8	8	0.6	4.8	2	1	2	9	0.4	3.6	46.6
11. Develop and implement regulations, standards and plans for adaptation and investment in the field of public infrastructure and	7	0.4	2.8	4	0.6	2.4	4	0.7	2.8	8	0.8	6.4	6	0.8	4.8	9	1	9	8	1	8	8	0.6	4.8	2	1	2	9	0.4	3.6	46.6
12. Study the possibility of conserving ponds, swamps, waterside areas and wetlands that is seen as necessary to maintain the ecological system of the city.	9	0.4	3.6	5	0.6	3	5	0.7	3.5	10	0.8	8	8	0.8	6.4	3	1	3	9	1	9	9	0.6	1.8	5	1	5	8	0.4	3.2	46.5
13. Integrate climate change adaptation into the strategy and action plan including through results-based management framework as well as the activities and functions of programs and projects for the construction and upgrading of infrastructure proactively and	5	0.4	2	5	0.6	3	5	0.7	3.5	10	0.8	8	8	0.8	6.4	7	1	7	7	1	7	7	0.6	4.2	1	1	1	8	0.4	3.2	45.3
14. Develop urban drainage planning and management standards for maintaining the environment in the construction and renovation	8	0.4	3.2	3	0.6	1.8	3	0.7	2.1	6	0.8	4.8	8	0.8	6.4	8	1	8	8	1	8	8	0.6	4.8	3	1	3	8	0.4	3.2	45.3
15. Encourage and promote the implementation of the Urban Environment Improvement Investment Projects in the	5	0.4	2	5	0.6	3	5	0.7	3.5	6	0.8	4.8	7	0.8	5.6	9	1	9	8	1	8	9	0.6	5.4	1	1	1	7	0.4	2.8	45.1

Figure 43: Extract of the MCA Spreadsheet for Urban Development & Transport

Evaluation criteria:				Severity of CC Impacts			Poverty Reduction			High Value			Alignment with Environmental & Climate			Lives & Livelihood security			Feasibility of Implementation & availability of resources			Sustainability & long term benefits			Institutional capacity to implement			Financial operationalization			Urgency of Action			TOTAL WEIGHT
Proposed adaption measures from NAP-UNEP				Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	Score	Weighting	Weighted score	
				9	0,4	3,6	9	0,6	5,4	9	0,7	6,3	9	0,8	7,2	9	0,8	7,2	8	1	8	8	1	8	8	0,6	4,8	9	1	9	7	0,4	2,8	62,3
1				8	0,4	3,2	7	0,6	4,2	7	0,7	4,9	8	0,8	6,4	8	0,8	6,4	8	1	8	8	1	8	8	0,6	4,8	9	1	9	7	0,4	2,8	57,7
2				3	0,4	1,2	6	0,6	3,6	6	0,7	4,2	6	0,8	4,8	8	0,8	6,4	9	1	9	9	1	9	9	0,6	5,4	10	1	10	8	0,4	3,2	56,8
3				8	0,4	3,2	8	0,6	4,8	8	0,7	5,6	10	0,8	8	8	0,8	6,4	7	1	7	6	1	6	7	0,6	4,2	2	1	2	5	0,4	2	49,2
4				3	0,4	1,2	5	0,6	3	4	0,7	2,8	6	0,8	4,8	8	0,8	6,4	9	1	9	9	1	9	9	0,6	5,4	4	1	4	8	0,4	3,2	48,8
5				8	0,4	3,2	4	0,6	2,4	3	0,7	2,1	8	0,8	6,4	5	0,8	4	7	1	7	7	1	7	7	0,6	4,2	9	1	9	7	0,4	2,8	48,1
6				3	0,4	1,2	6	0,6	3,6	6	0,7	4,2	6	0,8	4,8	8	0,8	6,4	9	1	9	9	1	9	9	0,6	5,4	1	1	1	8	0,4	3,2	47,8
7				8	0,4	3,2	6	0,6	3,6	4	0,7	2,8	8	0,8	6,4	6	0,8	4,8	7	1	7	7	1	7	7	0,6	4,2	6	1	6	5	0,4	2	47
8				5	0,4	2	6	0,6	3,6	5	0,7	3,5	6	0,8	4,8	8	0,8	6,4	6	1	6	9	1	9	5	0,6	3	5	1	5	8	0,4	3,2	46,5
9				8	0,4	3,2	4	0,6	2,4	5	0,7	3,5	10	0,8	8	8	0,8	6,4	6	1	6	5	1	5	5	0,6	3	6	1	6	6	0,4	2,4	45,9
10				3	0,4	1,2	5	0,6	3	4	0,7	2,8	6	0,8	4,8	8	0,8	6,4	9	1	9	9	1	9	9	0,6	5,4	1	1	1	8	0,4	3,2	45,8
11				3	0,4	1,2	5	0,6	3	4	0,7	2,8	6	0,8	4,8	8	0,8	6,4	9	1	9	9	1	9	9	0,6	5,4	1	1	1	8	0,4	3,2	45,8
12				8	0,4	3,2	8	0,6	4,8	5	0,7	3,5	9	0,8	7,2	8	0,8	6,4	4	1	4	8	1	8	4	0,6	2,4	2	1	2	7	0,4	2,8	44,3
13				5	0,4	2	3	0,6	1,8	3	0,7	2,1	6	0,8	4,8	5	0,8	4	8	1	8	8	1	8	8	0,6	4,8	6	1	6	6	0,4	2,4	43,9
14				5	0,4	2	6	0,6	3,6	5	0,7	3,5	6	0,8	4,8	8	0,8	6,4	6	1	6	9	1	9	5	0,6	3	2	1	2	8	0,4	3,2	43,5
15				7	0,4	2,8	3	0,6	1,8	3	0,7	2,1	8	0,8	6,4	8	0,8	6,4	7	1	7	8	1	8	5	0,6	3	3	1	3	6	0,4	2,4	42,9

Figure 44: Extract of the MCA Spreadsheet for the Water Resources Sector

8.1 Agriculture and Forestry – sectoral adaption recommendations

The top ten adaption recommendations scored under the Multi-criteria exercise from the Situation Analysis report are presented in Table 15:

Table 15: Priority Adaption Measure - Agriculture & Forestry

Priority	Adaption Measure - Agriculture & Forestry	Cost Group
1	Strengthen livestock and fisheries that can adapt to climate change.	1
2	Promote the use of technology in agricultural production	1
3	Improve irrigation and storage of excess rainfall to reduce impacts from droughts.	3
4	Regarding land use and planning, strengthen regulations on land leases and concessions to prevent deforestation and land degradation, and increase land and forest restoration efforts.	1
5	Promote reforestation in areas exposed to high risks of floods, storms, landslides, and others.	2
6	Policing and Provincial level control of seasonal burning	1
7	Apply sustainable forest and land management in the planning process to ensure local adaptation as well as national mitigation.	1
8	Utilize climate resilient designed infrastructure such as irrigation reservoirs and hydropower reservoirs by controlling and determining appropriate and safe water level in the reservoirs ahead of flooding season starts (rainy season), particularly Nam Ngum Dam 1, Nam Mang 3, Nam Theun 2, Theun Hinboun, Xe Pien-Xe Namnoi, Xe Kaman and others.	2
9	Address landslide resilience in land management plans, ensuring that construction, mining, and agriculture do not destabilize slopes. To this end, EbA actions are crucial, such as maintaining a dense and biodiverse tree cover because it protects against soil erosion.	1
10	Conduct a pilot study in selected districts to develop a standardized estimation of the value of loss and damage in agriculture.	2

The Hazard risks show that heat stress and drought stress are the main risks for crops, heat stress for fisheries, and heat stress for forest biodiversity. Increasing heat and drought cannot be easily halted but measures are recommended to address these stresses by selecting appropriate crops variants, preserving the condition of soils, preserving existing forestry and creating new forestry areas. The prioritized adaptation measures from the MCA exercise align with addressing the identified risks presented. The ten prioritized adaptation measures for agriculture and forestry will be discussed and final selection confirmed by stakeholders during CRVA meetings in June 2025.

Research and use of drought resilient rice varieties is vital for future food security. Much work has been done in this field and is ongoing.

Poorly regulated and/or enforcement of regulations has led to many concessions that have led to deforestation, land degradation through the use of chemicals, and watercourse pollution from insecticides and fertilizer. A tightening of these regulations and better enforcement is required to protect agricultural land and forest.

Improvement in ecological practices in agriculture and forestry will assist in improving soil quality and protect the loss of nutrients and topsoil during flood events. There are many practices that can be promoted across communities by outreach workers, including upland contour planting and pasture phasing.

The promotion of reforestation, particularly in areas prone to flooding and landslides, can mitigate the effects of climate change risks.

8.2 Urban Development & Transport – sectoral adaption recommendations

The top ten adaptation recommendations scored under the Multi-criteria exercise from the Situation Analysis report are presented in Table 16:

Table 16: Adaption Measure - Urban development & Transport

Priority	Adaption Measure - Urban development & Transport	Cost Group
1	Create building management regulations (Building Code) and improve waste management regulations.	1
2	Improve and build urban drainage systems and prevent floods in cities, along with the protection of protected areas, lakes, riverbanks, and wetlands to ensure that cities have good ecosystems and resilience to climate change.	3
3	Invest in low-carbon public transport, such as electric buses and trains as well as in renewable energy sources and energy-efficient technologies as it helped reduce the dependency and enhance transport resilience.	3
4	Improve and build model landfills in small towns, second-ranked towns and big towns.	3
5	Promoting and support public transport such as electric buses can lower traffic and pollution in cities, positively affecting the incidence of respiratory diseases.	3
6	Develop manuals on technical standards for managing the construction and repair of public works and transport infrastructure to cope with climate change.	2
7	Assess the impact of climate change on the sector of public infrastructure and transportation, as well as build organizational and personnel capacity to develop and manage infrastructure to be resilient and able to adapt to climate change.	1
8	Study and collect data on drainage ditches within the city that are prone to floods during the rainy season in areas across the country.	2
9	Study and develop standards and techniques for the construction, and maintenance of infrastructure related to the integration of standards for ensuring and resilient to climate change.	2
10	Develop and implement regulations, standards and plans for adaptation and investment in the field of public infrastructure and transportation.	2

The Hazard risks show that flash flooding, heat stress on humans and ecosystems, and rain stress on drainage and sanitation systems are the key risks. Increasing heat and rainfall intensity cannot be easily halted but measures are recommended to address these stresses by acting on existing infrastructure policies, regulations,

and introducing new regulations where required. The prioritized adaptation measures from the MCA exercise align with addressing the identified risks presented.

A key measure across Laos, for which some actions have been taken for Vientiane but no other towns, is a comprehensive drainage masterplan. The formulation and enforcement of such town-specific Masterplans is vital to be able to plan, control and address urban flooding issues. At present, drainage provisions for urban development and construction of new buildings are ad-hoc, with no provision for adequate drainage of individual buildings or village level primary drainage. Existing drains are filled in for driveways, newly constructed road drains are left unfinished and used for disposing of swept dust, and new buildings are constructed at a level higher than neighbors to protect themselves from flooding, without provision for a wider village-level solution for flood protection.

Public burning of garbage in urban centers has a twofold negative consequence – often garbage is dumped into open drains to burn, with residue blocking the drain and adding to flood risk, and the smoke from burning garbage affects health and adds to the atmospheric CO₂. Garbage burning is common in all Lao urban centers, including areas served by an affordable garbage collection service (typically 15,000kip/week in Vientiane).

Improved housing and building standards could include the provision of (i) adequate drainage from the house to nearest communal drain, and (ii) adequate permeable surfaces on the property. It is common in urban Laos for a property owner to cover most of the available unbuilt land with concrete, for carparking or for a general “neat” appearance. Enforced building standards including drainage and a minimum percentage of permeable land will reduce localized and citywide flooding.

Littering is a large problem in urban Laos and often litter is disposed of, or ends up in, the limited drain network. When the rain starts after a dry season all this garbage is washed into drains which contribute to their blockage. Public education and enforcement are required to minimize this social problem.

The ten prioritized adaptation measures for urban infrastructure will be discussed and final selection confirmed by stakeholders during CRVA meetings in June 2025.

8.3 Water Resources – sectoral adaption recommendations

The top ten adaptation recommendations scored under the Multi-criteria exercise from the Situation Analysis report are presented in Table 17:

Table 17: Adaption Measure - Water Resources

Priority	Adaption Measure - Water Resources	Cost Group
1	Build basic infrastructure and develop community water supply to cope with floods and droughts	3
2	Improve the irrigation systems to be more efficient and resilient to climate change and disasters.	3
3	Build small, medium and large-scale community water supply systems in drought-prone and water-scarce areas in both urban and rural areas to be able to provide water during the dry season	3
4	Create and improve legislation and plans on groundwater management and protection, including the implementation of such legislation and plans	2
5	Survey, collect data and assess water shortages and suitable areas for building water supply infrastructure.	2
6	Expand meteorological and hydrological stations across the country	3
7	Implement the adaptation measures against natural disasters to ensure the quality of water resources in the face of floods and droughts, such as investing in water treatment facilities and sewage networks.	3
8	Identify areas at climate risk for groundwater quantity.	2
9	Identify water and water resources protection zones.	1
10	Create and implement an integrated water resources management plan to adapt and be resilient to climate change by managing and protecting water catchments, water sources, water gathering areas, ponds, water reservoirs, water area soils, aquatic biodiversity, ecosystem services, water quantity, ensuring supply and access to water sources for all sectors and communities, and women group.	2

The Hazard risks show that flood stress on river levees, heat stress on reduction of dissolved oxygen, and rain stress on recharge of groundwater are the key risks. Increasing heat and reduced seasonal rainfall cannot be easily halted but measures are recommended to address these stresses by acting on existing Water Resources policies, regulations, and introducing new regulations where required. The prioritized adaptation measures from the MCA exercise align with addressing the identified risks presented.

The continued development of climate resilient urban and rural water supply systems is necessary to provide communities with a safe and sustainable water supply into the future. Good progress has been made over the last 2 decades in this, but care must be taken in source protection and selection in order for each water supply system to retain its 50+ years design life.

Water resources are being affected by the proliferation of hydroelectric dams across the country. The promotion and use of energy efficient products and building methods to decrease domestic energy consumption can help with the reduction in demand for more hydro dams. Groundwater extraction in the Mekong basin is not regulated in practice. Whilst the Mekong basin in Laos does not currently have a significant amount of groundwater extraction, as surface water is mostly utilized, planning for groundwater extraction and a licensing system will assist with aquifer management in the future as demand increases.

Measures to improve water quality, particularly during flood periods, can be improved. Urban centers in Laos do not yet have wastewater treatment plants, except for one small plant in Vientiane. Individual septic tanks are used for single households, with some larger hotels having basic package wastewater treatment systems. Septic tanks are often undersized, poorly maintained, and lack an effluent dispersion field or soak away, with partially treated effluent typically being disposed of to a road drain. During periods of flooding, this polluted water is widely distributed and contributes to a polluted groundwater lens. Improvement of domestic, government and industrial wastewater treatment will improve the quality of groundwater and surface water resources.

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