CLIMATE CHANGE VULNERABILITY ASSESSMENT

Attapeu Province

Final Report 2019

ADAPTATION FUND

UN HABITAT
FOR A BETTER URBAN FUTURE

Climate Change Vulnerability Assessment – Attapeu Province
Final Report 2019

First edition 2019

United Nations Human Settlements Programme
P.O. Box 30030, Nairobi 00100, Kenya
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www.unhabitat.org

HS Number:
ISBN Number(Series):
ISBN Number:(Volume):

DISCLAIMER

ACKNOWLEDGEMENTS

Funding for the Attapeu Province Climate Change Vulnerability Assessment was provided by the Adaptation Fund under the framework of the Enhancing the climate and disaster resilience of the most vulnerable rural and emerging urban human settlements in Lao PDR project.

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Design and layout: Yanling Cheung, María Celeste Espinazo
Cover Photo © UN-Habitat Lao PDR

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LIST OF ACRONYMS

ARCC	Adaptation and Resilience to Climate Change
BAU	Business as usual
CBDRR	Community-based Disaster Risk Reduction
CLEAR	Consolidated livelihood exercise for analyzing resilience
DPCC	Disaster Prevention and Control Committee
DRM	Disaster Risk Management
DTA	Development triangle area
GCM	Global circulation model
GDP	Gross demostic product
GIS	Geographic information system
GIZ	Gesellschaft für Internationale Zusammenarbeit
GPAR	Governance and Public Administration Reform
IPCC	Intergovernmental Panel on Climate Change
INFORM	Index for Risk Management
IRV	Intermediate Rural Villages
L-CRVA	Lao Climate Risk and Vulnerability Assessment
LRV	Local Rural Villages
MoF	Matrix of Functions
MRC	Mekong River Commission
MRV	Main Rural Villages
NGO	Non-governmental organization
PHC	Population and Housing Census
SDGs	Sustainable Development Goals
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNREDD	United Nations Programme on Reduced Emissions through Deforestation and Forest Degradation
USAID	United States Agency for International Development
UXO	Unexploded ordinance
VDPCC	Village Disaster Prevention Control Committee
VDPU	Village Disaster Prevention Units

FOREWORD

Responding Climate Change with vulnerability assessments

Climate change is one of the most pressing international issues in the world today. The Government of Lao PDR has recognised the threat that climate change presents to national development. In recent years, severe floods, storms and droughts have affected much of Lao PDR, including the three southernmost provinces of Attapeu, Sekong and Saravan. Temperatures have increased dramatically and are predicted to continue to do so. Rainfall has become more erratic and in many areas and the dry season is becoming more prolonged.

For national development to proceed in a way that meets the government's target of becoming a middle income country by 2020, adaptation to climate change is essential. Lao PDR has ratified the Paris Agreement and has launched an ambitious and fair Nationally Determined Contribution to the Paris Agreement that prioritises mitigation actions, to reduce the causes of climate change, and adaptation responses, to cope with its consequences.

However, a great deal of work will be required to meet the targets laid out in Lao PDR's NDC, and to continue to develop in line with the 8th Five-Year National Socio-Economic Development Plan. A lack of data can hamper efforts at the local and national levels to respond effectively to challenges posed by climate change, especially considering that capacity at local level is limited. This is particularly challenging, as climate change impacts are often complicated and often manifest themselves over many years.

On behalf of the Ministry of Public Works and Transport, I recognise that we all must play our part in the response to climate change. Water supplies, for example, as the vulnerability assessment shows, will be threatened by prolonged periods of drought, with the poor being most seriously affected, unless we take action to adapt our systems to climate change. The consultations held with targeted communities also highlight access to water supply as a key factor to increase resiliency of vulnerable communities. Providing access to water supply is in line with the national goal to achieve 80% coverage by 2020. The Ministry is thus enthusiastically collaborating and partnering with UN-Habitat to execute the 'Enhancing the Climate and Disaster Resilience of the Most Vulnerable Rural and Emerging Urban Human Settlements in Lao PDR' project, funded by the Adaptation Fund, between 2017 and 2021.

The provincial climate change vulnerability assessments in Attapeu, Sekong and Saravan Provinces for the first time give local and national government staff the evidence basis to plan for an effective, targeted and cost-efficient adaptation response to climate change that meets the needs of everyone, especially the poor and indigenous people. Based on this, the project will construct small-scale water infrastructure that adapts to the challenges presented by climate change and enhances community resilience. This work is also a vital contribution to giving provincial and district staff under the Ministry of Public Works and other government departments the capacity and knowledge they need to analyse and deliver services to the people of Lao PDR in the face of the challenges posed by climate change.

Finally, on behalf of the Ministry of Public Works and Transport, I would like to take this opportunity to express my sincere gratitude to all stakeholders for their support to, and cooperation with, the government of Lao PDR in developing these assessments. Specifically, I would like to thank the Adaptation Fund, for providing funding support, and UN-Habitat for its technical support to the overall implementation of the project. The Government of Lao PDR looks forward to continued support in the future, and is determined to meet its obligations in the continued response to climate change.

Dr. Bounchanh Sinthavong
Minister
Ministry of Public Works and Transport, Lao PDR

FOREWORD

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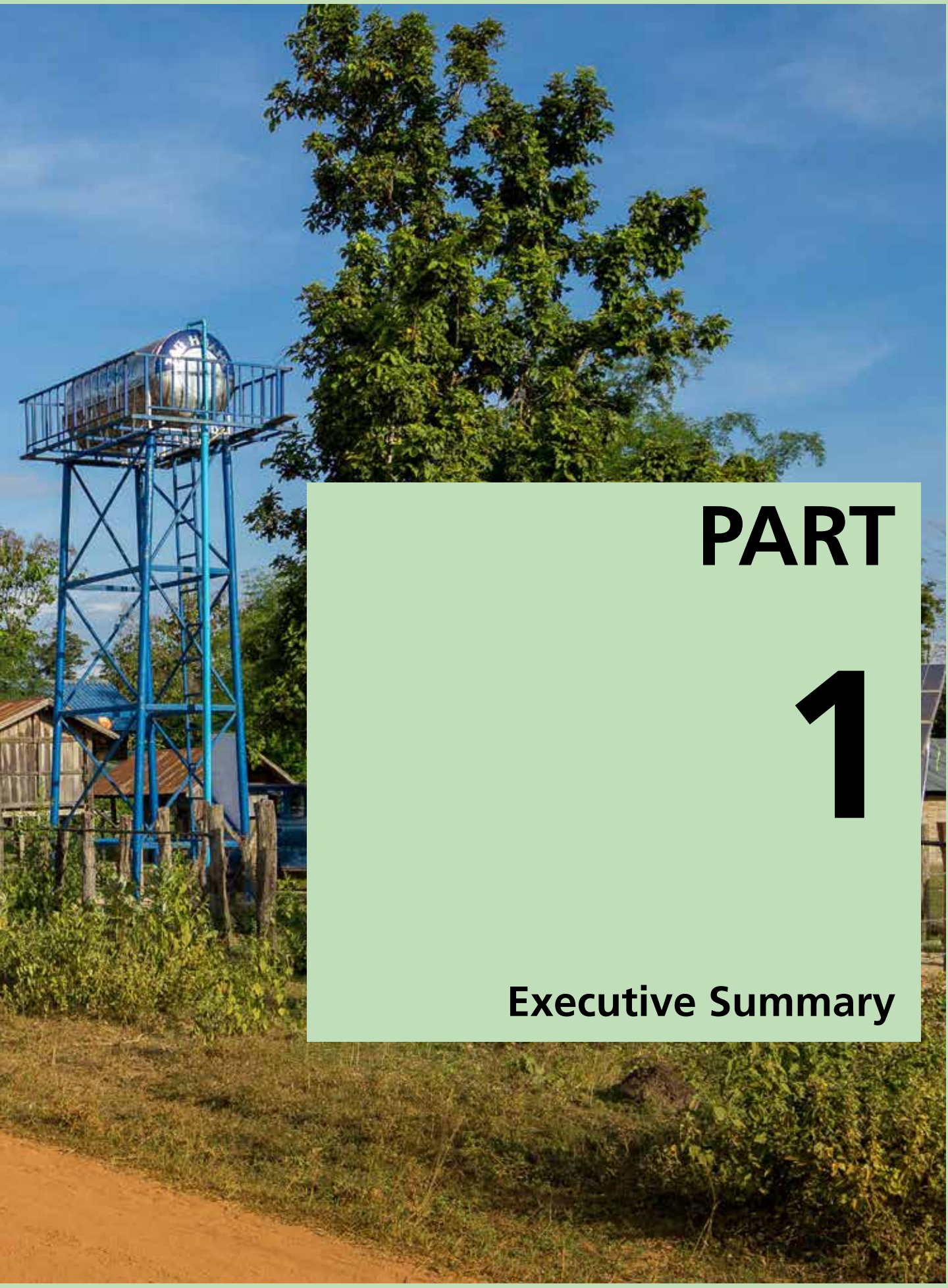

PART 1

Executive Summary

1 Executive Summary

The main objective of this assessment is to enable sub-national authorities in Lao People's Democratic Republic (PDR) to make informed planning decisions about taking actions to adapt to climate change. More specifically, the assessment is the evidence basis to develop climate change action plans that will guide the implementation component of the '*Enhancing the climate and disaster resilience of the most vulnerable rural and emerging urban human settlements in Lao PDR*' project. The vulnerability assessment shows how climate change will exacerbate already significant development challenges; while poverty has reduced throughout Attapeu Province, people in or nearly in poverty often rely on climate-sensitive livelihoods, particularly agriculture.

The vulnerability assessment in Attapeu Province was conducted in 66 villages, distributed across four of the province's five districts. There were 33 villages in Sanxai District, 15 in Xaisetha District, 10 in Samakkhixai District and 8 in Phouvong District. These villages have a population of 60,156, about 43 per cent of the province's total.

Lao PDR is one of the world's most vulnerable countries to climate change. The Germanwatch Global Climate Risk Index ranked it the 8th most vulnerable country in the world in 2013[1], due to its high dependence on climate sensitive natural resources and low adaptive capacity. This presents a significant obstacle to achieve the Sustainable Development Goals and national economic and social development goals. The impacts of climate change are already being felt in Lao PDR.

Between 1992 and 2009, the total area affected by flooding grew exponentially from around 1,000 square kilometres to about 25,000 square kilometres. On average, floods and storms have killed around 40 people and affected around 200,000 people annually in the same period. 14 of Lao PDRs' 17 provinces, including Attapeu, have experienced flooding at least once since 1995[2].

Annual average rainfall is about 2,203 millimetres per year in Attapeu Town, over 90 per cent of which falls in the rainy season from May to October. The last 30 years have seen a significant decrease in rainfall in Attapeu; down from almost 2,400 millimetres in 1984, a decline of more than 10 per cent. There has also been a decline in the number of rainy days, and continuing variability, with more than a 2,000 millimetre difference between the driest year in the dataset and the wettest.

The average annual temperature has shown an increase of about 1.2°C. The average temperature for April – the hottest month, has shown an increase of over 1.5°C in the same period. Four of the five hottest years in the dataset were recorded since 2010 (in 2016, 2015, 2013 and 2010)[3]. Attapeu had never experienced a temperature over 40°C until 2013, when a temperature of 40.1°C was recorded. This record was broken in 2016 when a temperature of 41.2°C was recorded. Almost all communities surveyed during the assessment said the temperature had increased, with 74 per cent of villages throughout the province observing a significant temperature increase.

Attapeu faces multiple hazards, as shown in the table below :

Hazard	No. of villages affected in Samakkhixai (out of 10)	No. of villages affected in Xaisetha (out of 15)	No. of villages affected in Sanxai (out of 33)	No. of villages affected in Phouvong (out of 8)	Details
Floods	10	14	6	8	Affects houses, infrastructure and income
Storms	10	14	28	8	Affects houses, infrastructure and income
Landslides	0	3	1	0	Minor issue in Attapeu Province
Drought	10	14	16	8	Mainly affects incomes

1 The Climate Risk Index for 2013: the 10 most affected countries. The Global Climate Risk Index 2015 online: https://germanwatch.org/de/download/10333.pdf.
2 Laos Intended Nationally Determined Contribution to the UNFCCC (2015), p.5.
3 The annual average of the maximum temperature recorded in each month.

Climate change projections show that temperatures are forecasted to increase by up to 2.5°C by 2050. Rainfall change models indicate that there will be a slight increase in rainfall over a shorter rainy season. It is not possible to infer changes in severe storms, but the changing rainy season means that more extreme rainfall events are more likely.

Forest land makes up around 70 per cent of land cover in all four districts, followed by agricultural land. There has been deforestation of varying degrees, primarily along roads, flood plains and near mining concessions. Sanxai District has lost the greatest amount of forest, 348km². Forests are also threatened by small-scale illegal cutting as more than 90 per cent of households in each district rely on forest sources for firewood or cooking fuel.

In Attapeu Province, only 10 per cent of roads were paved in 20124, all of which were national roads. 20 per cent of the villages surveyed have access to paved roads. The selected villages in Samakkhixai District are far more accessible by road than those in Sanxai or Phouvong Districts, while Xaisettha District is around the provincial average. Household electricity access is about 80 per cent in Attapeu Province, in line with the national average. However, only 70 per cent of households in Sanxai District have access to electricity. Water access is variable across the districts, in Samakkhixai District, 84 per cent of households accessed water from protected sources, while in Sanxai District, 71 per cent relied on unprotected sources. Across the province, however, at least 50 per cent of villages reported fluctuating water availability due to temperature and dry season changes.

Poverty continues to be a pressing challenge for Attapeu Province. Attapeu's poverty rate of 18.9 per cent[4] is low compared to the national poverty rate of 24.8 per cent[5]. Xaisetha and Samakkhixai Districts have fairly low poverty rates, 12.9 and 13.4 per cent respectively, whereas the poverty rate in Sanxai and Phouvong Districts are closer to the national average, at 22.5 and 22 per cent, respectively[6]. Literacy rates are also low, especially in Phouvong and Sanxai Districts, at about 64 per cent in each. This correlates with primary school enrolment, which is around 59 per cent in both districts, and less than 80 per cent and 70 per cent in Samakkhixai and Xaisetha Districts, respectively. People tend to depend on agriculture and livestock, with little evidence of employment in industry and service sectors, which are less climate dependent.

40 per cent of the villages in Sanxai District are classified by the assessment as local rural villages, which indicate the lowest level of socio-economic and infrastructure development. Among the four Districts, Samakkhixai District has the highest overall level of socio-economic development. In each district, development is characterized by a small cluster of settlements that provide all the services available in the district. Overall, better transport and infrastructure means that lowland villages have greater levels of connectivity and development[7].

The vulnerability index prepared by this vulnerability assessment shows that vulnerable villages are dispersed throughout Attapeu Province. While villages in Sanxai are, in many cases, less exposed, their lower levels of development contribute to high vulnerability. Meanwhile, more developed villages in Samakkhixai and Xaisetha are also vulnerable because of their exposure, especially to flooding.

The assessment defines three adaptation scenarios; business as usual, resilient infrastructure built to maintain current living standards, and resilience built to enhance socio-economic development. The second of these is the bare minimum requirement to cope with the anticipated effects of climate change, without allowing these effects to compromise people's living standards.

Finally, the assessment highlights some possible climate change impacts under the business-as usual scenario if no actions are taken. These show that the capacity of people to access water will significantly decline, access to transportation services will become far more difficult and that, because of human factors, forest coverage will continue to decrease.

4 Coulombe et al (2016) Where are the Poor? Lao PDR Census-based Poverty Map: Province and District level Results, Lao Statistics Bureau, the World Bank, p.98
5 Ibid, p.21
6 Ibid, p.99
7 See map ATA01

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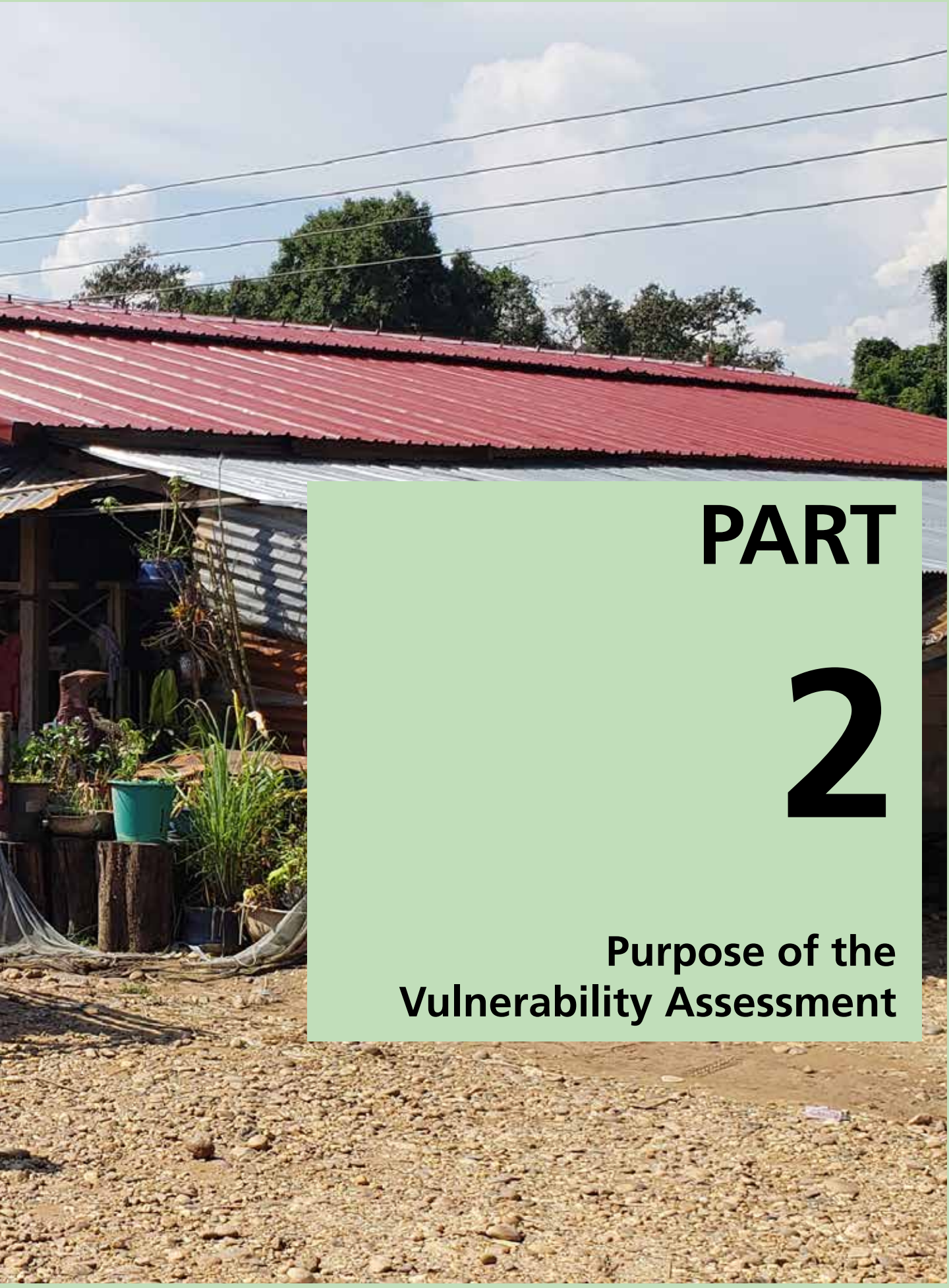

PART 2

Purpose of the Vulnerability Assessment

2 Purpose of the Vulnerability Assessment

2.1 Background

Lao People's Democratic Republic (PDR) is one of the world's most vulnerable countries to climate change. The Germanwatch Global Climate Risk Index ranked it the 8th most vulnerable country in the world in 2013[8], due to its high dependence on climate sensitive natural resources and low adaptive capacity. Besides, the country faces a very high lack of coping capacity, indicating significant challenges in reducing negative consequences in the aftermath of a hazard[9]. Storms, floods, and droughts have increasingly affected Lao PDR in recent years by causing, *inter alia*, landslides, fires, disease outbreaks, loss of life, and damage to infrastructure and livelihoods. Climate change will cause the dry season to be longer and hotter, the rainy season to be shorter and wetter, and hazards to become more intense.

This presents a significant obstacle to achieving the Sustainable Development Goals and national economic and social development goals. The overall objective of Lao PDR's 8th Five Year Socio-economic Plan is to significantly reduce poverty in all areas and 'graduate' from Least Developed Country status by 2020. As the Plan notes, this requires 'effective management and efficient utilization of natural resources'. This will be achieved through three outcomes: 1) Sustained, inclusive economic growth with economic vulnerability (EVI) reduced to levels required for growth support (discussed further in the economic context section, below), 2) Human resources are developed and the capacities of the public and private sectors are upgraded; poverty in all ethnic groups is reduced, all ethnic groups and both genders have access to quality education and health services; the unique culture of the nation is protected and consolidated; political stability, social peace and order, justice and transparency are maintained, and finally 3) Natural resources and the environment are effectively protected and utilized according to green-growth and sustainable principles; there is a readiness to cope with natural disasters, the effects of climate change and for reconstruction following natural disasters[10].

Lao PDR's economy is one of the fastest growing in the world, with GDP growth averaging just under 8 per cent per year over the last decade[11]. Supported by this growth, poverty rates nationwide fell from 27.6 per cent in 2008 to 23.2 per cent in 2013[12] [13]. While the contribution of agriculture to overall GDP has declined slightly in recent years, it still comprises 24.8 per cent of the economy. The remaining share is divided between industry (27.5 per cent) and services (47.7 per cent)[14]. However, in 2015, agriculture still employed 65 per cent of the labour force, which, though a decrease from 71.3 per cent in 2010[15], still represents a high figure, and indicates low incomes in the agriculture sector.

The impacts of climate change are already being felt in Lao PDR. The land area and number of people exposed to flooding has increased 25 times, while storms and floods typically affect about 200,000 people per year throughout the country. Total economic losses resulting from Typhoon Ketsana in 2009 totalled 1.1 per cent of GDP[16]. 14 of Lao PDR's 17 provinces, including Attapeu, have experienced flooding at least once since 1995[17]. Similarly, drought has affected six provinces over the same time period[18], and projections show that Attapeu, along with the other provinces targeted under this project, Sekong and Saravan, will be the most seriously affected areas in Lao PDR[19].

8 The Climate Risk Index for 2013: the 10 most affected countries.
The Global Climate Risk Index 2015 online: https://germanwatch.org/de/download/10333.pdf.
9 World Risk Report 2016, p.65.
10 Ministry of Planning and Investment, (2016) 8th Five-year National Socio-economic Development Plan, p.87-89.
11 According to World Bank data - http://www.worldbank.org/en/country/lao - accessed 17/8/2017.
12 Ministry of Planning and Investment, (2016), 8th Five-year National Socio-economic Development Plan, p.3.
13 The World Bank quotes a slightly higher national poverty headcount figure of 24.8 per cent for 2015.
14 Ibid, p.5.
15 Ibid, p.11.
16 Laos Second National Communication to the UNFCCC (2013) p.56.
17 Laos Intended Nationally Determined Contribution to the UNFCCC (2015), p.5.
18 ibid
19 UNDP-ICEM (2017) L-CRVA Summary Report, p.31.

2.2 Enhancing the Climate and Disaster Resilience of the Most Vulnerable Rural and Emerging Urban Human Settlements in Lao PDR

To support Lao PDR in addressing these issues, the Adaptation Fund financed the 'Enhancing the Climate and Disaster Resilience of the Most Vulnerable Rural and Emerging Urban Human Settlements in Lao PDR' project beginning in 2017 for four years. The project is being implemented by UN-Habitat and executed by the Ministry of Public Works and Transport.

The project's main objective is to enhance the climate and disaster resilience of the most vulnerable rural and emerging urban human settlements in Southern Lao PDR by increasing access to sustainable basic infrastructure systems and services, emphasizing resilience to storms, floods, droughts, landslides and disease outbreaks.

To achieve this, the project has ***four*** components:

1. Institutional strengthening to reduce vulnerability in human settlements.

2. Building capacity at the community and human settlement level for climate resilience

3. Enhance climate and disaster resilient infrastructure systems in human settlements

4. Knowledge management, advocacy and monitoring

The total budget for the project is US$4.5 million. The project works in 189 villages in eight districts: Samuoi and Ta Oi in Saravan Province, Kaleum and Dakcheung in Sekong Province, and Phouvong, Sanxai, Xaisettha and Samakkhixai in Attapeu Province.

Component 1 involves conducting province and district-level climate change vulnerability assessments. These will inform action plans, which in turn will decide the nature of investments under Component 3. Under Component 3, US$2.8 million will be invested in small-scale infrastructure that is adaptive to climate change. Component 2 will build the requisite capacity at the village level necessary to construct and maintain the infrastructure. Component 4 will facilitate replication and upscaling of the project.

2.3 Climate Change Vulnerability Assessment

The vulnerability assessment shows how climate change will exacerbate already significant development challenges in Attapeu Province. While the target districts, and Attapeu Province more generally, have made progress in reducing poverty, these reductions need to be sustained and continued in the face of climate change[20]. Moreover, people in or near poverty often rely on climate-sensitive livelihoods, particularly agriculture.

Moreover, the area faces unique and complex environmental challenges as a result of its rapid development. Hydropower is a major plank of Lao PDR's economic development strategy, with over 70 hydropower projects currently under development nationwide[21], including an estimated ten in southern Lao PDR.

Extensive hydropower development has seen the country's electrification rate increase from 15 per cent in 1990 to over 90 per cent in 2015[22], and once all hydropower projects that are currently planned or under construction come on-grid its power generation capacity will more than double. Much of this additional electricity capacity will be exported, primarily to Thailand and Vietnam.

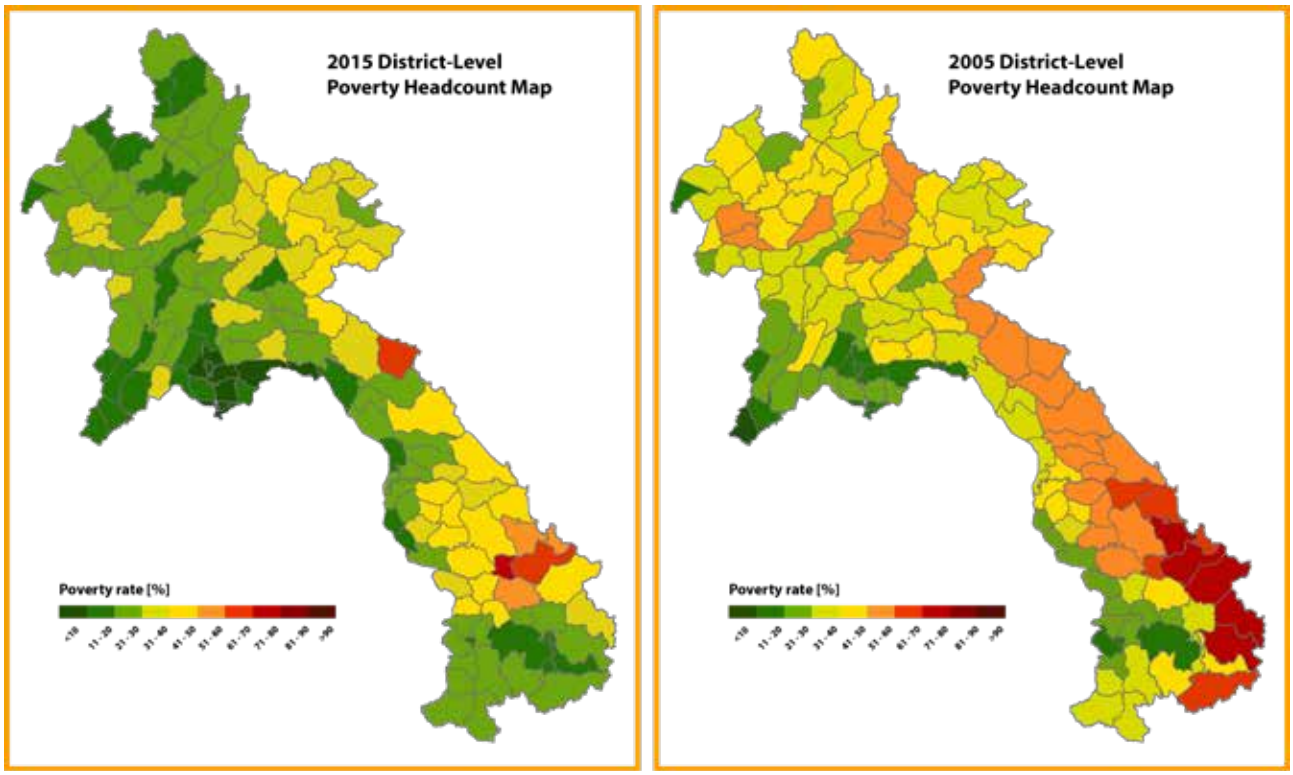

Figure 1 - Change in the district-level poverty headcount between 2005 (right) and 2015 (left)[23]

20 LSB/World Bank (2016), Where are the Poor? Lao PDR 2015 Census-Based Poverty Map: Province and District Level Results, p.15.

21 http://www.poweringprogress.org/new/2-uncategorised/3-hydropower-in-lao-pdr, accessed 22-8-17.

22 Phomsoupha (2016) – Concession Agreements of Independent Power Producers from the Lao Government's Perspective. PowerPoint Presentation, NCC, Vientiane 1st-3rd March, 2016.

23 LSB/World Bank (2016), Where are the Poor? Lao PDR 2015 Census-Based Poverty Map: Province and District Level Results, p.15.

a. Main Objectives

The main objective of this assessment is to enable sub-national authorities in Lao PDR to make informed planning decisions and take actions to adapt to climate change. More specifically, the assessment will be the evidence basis to develop climate change action plans that will guide the implementation component of the 'Enhancing the Climate and Disaster Resilience of the Most Vulnerable Rural and Emerging Urban Human Settlements in Lao PDR' project.

The assessment also aims to achieve the following co-benefits and sub-objectives:

- Increase the awareness of national and subnational decision makers, as well as practitioners in the development and NGO community, particularly through the following:

  - Understanding which of the 189 villages is particularly vulnerable to climate changes;

  - Knowledge of how infrastructure, ecosystems and socio-economic systems interact with, and contribute to, vulnerability;

  - Enhanced awareness of the spatial interaction of settlements in the target area, how this contributes to vulnerability, and how interventions can be sited effectively to benefit multiple villages;

  - Scenarios defined that help to identify a more resilient development pathway;

  - Based on the above, increased capacity to plan and implement adaptive pathways for the province and district that are spatially relevant, and guide the correct replication of the assessment's methodology.

- Significantly contribute to strategic action plans at the province and district levels to support climate change adaptation through more targeted investments at the village level.

b. Methodology

The methodology is designed to support provincial and district governments to identify current and future drivers of vulnerability in Attapeu by considering the current conditions and the projected changes in climate. The findings are presented with the intention of informing policy makers on priority investments and actions to adapt to climate change in a way that supports more balanced territorial development, economic growth and more equal prosperity

The methodology of the assessment:

1) Analyses critical systems, including infrastructure, socio- economic systems, and eco-systems in Attapeu's target districts,. It then ties this analysis together with a spatial analysis and a vulnerability index to identify the most vulnerable villages and their locations in the province.

2) Overlays pre-existing climate change projections in Lao PDR onto the current conditions in the three critical systems to project the probable future conditions if no adaptation actions are taken.

3) Defines future scenarios for action, based on business as usual (taking no action to adapt to climate change), a minimum adaptation scenario that maintains current development, and a more resilient and sustainable development scenario.

Data Collection Methods and Spatial Analysis Tools

The assessment used a mix of data gathering methods and spatial analysis tools to ensure the findings are as relevant as possible to the local context, which will increase the usefulness of the assessment for local and national decision-makers (see Figure 2).

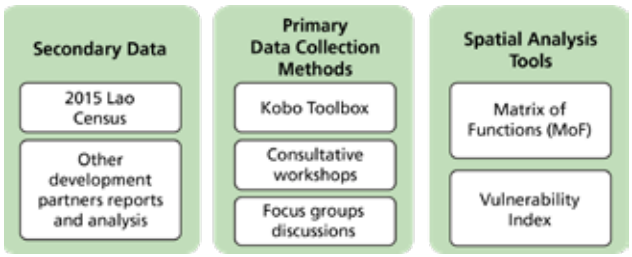

Figure 2 - Data collection methods and spatial analysis tools

The Vulnerability Assessment Report is anchored in the Lao National Census 2015 and used freely available data when possible to ease replication. The report anchored itself in the Lao National Census 2015, and, when possible, used data that is freely available, easing replication. The report also made use of the significant work already done by other international organisations, such as UNDP's Lao Climate Risk and Vulnerability Assessment (L-CRVA), which covered a similar area, and World Food Programme's Consolidated Livelihood Exercise for Analysing Resilience (CLEAR). The assessment team also undertook several missions to the field sites to gather information from the provincial and district-level stakeholders.

The most innovative aspect of the data collection was the tablet-based surveys in the target villages. Because the project covers 189 target villages, including 66 in Attapeu Province, that are spread across a large area with challenging terrain, a rapid means to gather data from each village was required. To address this, the project purchased ten low-cost tablet computers, created a survey through Kobo Toolbox, a free surveying/data gathering application, and trained enumerators in each district on how to use it. The tablets have 3G sim cards, and once the surveys were complete they were uploaded to a central database. Once in the database, a html-based infographic was then automatically populated. These infographics are freely available online

Spatial Analysis Using Matrix of Functions

The spatial and territorial analysis uses the matrix of functions (MoF) to provide national, district and local officials with the evidence to design actions that address specific areas of heightened vulnerability to climate change.

The matrix identifies which key eco-system, infrastructure and socio-economic services are available in each village, and describes the spatial development patterns in the province and district. Applied to climate change, it shows how the current spatial structure of the region enables or inhibits adaptation actions to changes in the climate. The matrix of functions is developed by using data collected from the tablet-based survey to determine where services are available. Key functions were listed, analysed and mapped in a GIS, and are presented in Sections 3.5 – 3.7 of the report.

Vulnerability Index

The Vulnerability Index provides an overview of the most vulnerable locations to current natural hazards and climatic conditions. Since there is no single way to establish comprehensive indices of vulnerability, this tool is used in connection with other approaches to ensure in-depth analysis. The assessment defines vulnerability as a function of exposure, sensitivity, and adaptive capacity.

Current Drivers of Climate Vulnerability

The assessment built a picture of underlying vulnerability in three categories; environmental conditions, socio-economic conditions and infrastructure conditions. Climate-related hazards, including historical, current, and potential future change, were then overlaid to give a comprehensive picture of current and future climate change vulnerability.

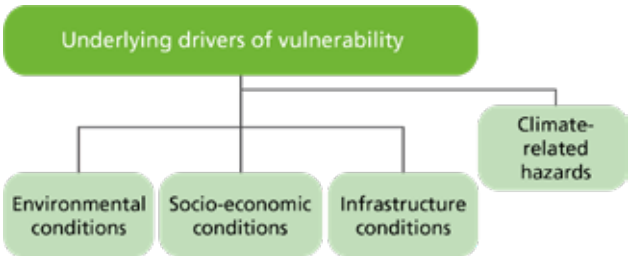

Figure 3 - Determination of current drivers of climate vulnerability

Environment and Ecosystem Conditions

This assessment analysed the ecosystem services in the two districts and people's dependence on the benefits such ecosystems provide. Through the vulnerability assessment survey and secondary analysis, the assessment determined which services were used most frequently by communities and how climate change and other man-made factors were affecting the quality and availability of these services.

Socio-Economic Conditions

The analysis revealed the main sources of livelihood and the social conditions which were enabling development, such as education level and productive sectors, which are essential for climate change adaptation. The analysis utilized quantitative data, including data from the census and economic information from provincial level government departments. The analysis also included primary data gathered from the tablet-based survey, which allowed the assessment team to understand that poverty, livelihoods and ethnic minority issues are critical in Attapeu Province.

Infrastructure Conditions

This analysis focused on the conditions and spatial distribution of the built environment to understand the connectivity to climate and other natural hazards. The analysis provides a description of transportation infrastructure, predominant construction techniques and materials, and the spatial distribution of public facilities. These factors are key to understanding the vulnerability of critical assets such as housing, schools, and health centres to the heightened intensity of natural hazards, including droughts, storms, and floods. Data was collected through a mix of the tablet-based surveys, census data, and analysis of other datasets in a GIS environment.

Future Vulnerability Scenarios

The projected changes in the climate were overlaid onto current conditions, assuming no adaptation actions are taken. This provides planners with a future scenario of forest coverage, freshwater availability and agriculture without any adaptation actions. This analysis helps planners to prioritise and choose the most appropriate actions to adapt to climate change in the future.

Spatially based coefficients[24] of projected climate change were assigned and then multiplied against a given service, such as water availability. The multiplied effect of the increased temperature was then mapped in a GIS environment. It is important to note that these are scenarios rather than forecasts, showing what the future could be like.

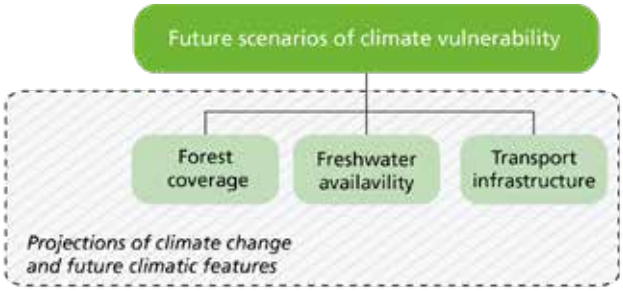

Figure 4 - Determination of future climate vulnerability

Building for Adaptation

Finally, strategic actions plans were created at the province and district level, based on both the governments' capacities and communities' main concerns. These action plans will inform adaptation and resilience planning at the village level.

c. Key Principles

Simplicity and Ease of Replication

The Vulnerability Assessment Report uses 'plain English' where possible. This aids translation into the Lao Language and makes the report's findings easier to communicate.

Secondly, the assessment used open source software and accessible data wherever possible. The assessment relied heavily on data from the 2015 census, which is available from the Lao Statistics Bureau upon request, and from the survey conducted using the Kobo Toolbox, an open source software. The tablets used were low-cost, at around US$130 each. Moreover, the assessment team did not pay for satellite imagery or use advanced high-cost GIS software to allow to ease replication.

Thirdly, to facilitate the replication of the assessment, the assessment's methodology was presented to stakeholders from all provinces at a workshop in Attapeu in August 2017. Training was provided for the 32 enumerators who conducted the survey in all 189 villages. The enumerators were mostly district-level government staff from the 8 target districts, including four in Attapeu.

This makes the assessment part of a broader effort to increase capacity at the subnational and national levels.

Participatory Approach

In developing the assessment, the enumerator teams visited all 189 villages and interviewed village chiefs as well as villagers. While there was only 1 survey per village, the questionnaires were answered by consensus. The vulnerability assessmentteam visited all eight districts targeted by the project, including the four in Attapeu Province.

National Ownership

The government of Lao PDR owns the findings from the assessment. This report is designed to influence and improve decision making in Attapeu Province regarding climate change. As climate change is a strategic and long- term challenge, it requires complex information to support decision making. This report is designed to be an aid to that decision making.

Avoiding Duplication and Using Existing Data

Extensive work has already been conducted in Lao PDR on climate change and other issues of relevance, such as environmental protection, disaster risk reduction and infrastructure development. This assessment seeks not to duplicate this extensive work, but to be informed by it and add value to it by taking it to a new audience (especially at the sub-national level). Climate change projections are an example of this is – extensive work has already been done to prepare climate change projections for Lao PDR. Rather than prepare new projections, the report built its future climate change scenarios on secondary data, using the excellent projections already in existence.

24 Defined in this case as a multiplier

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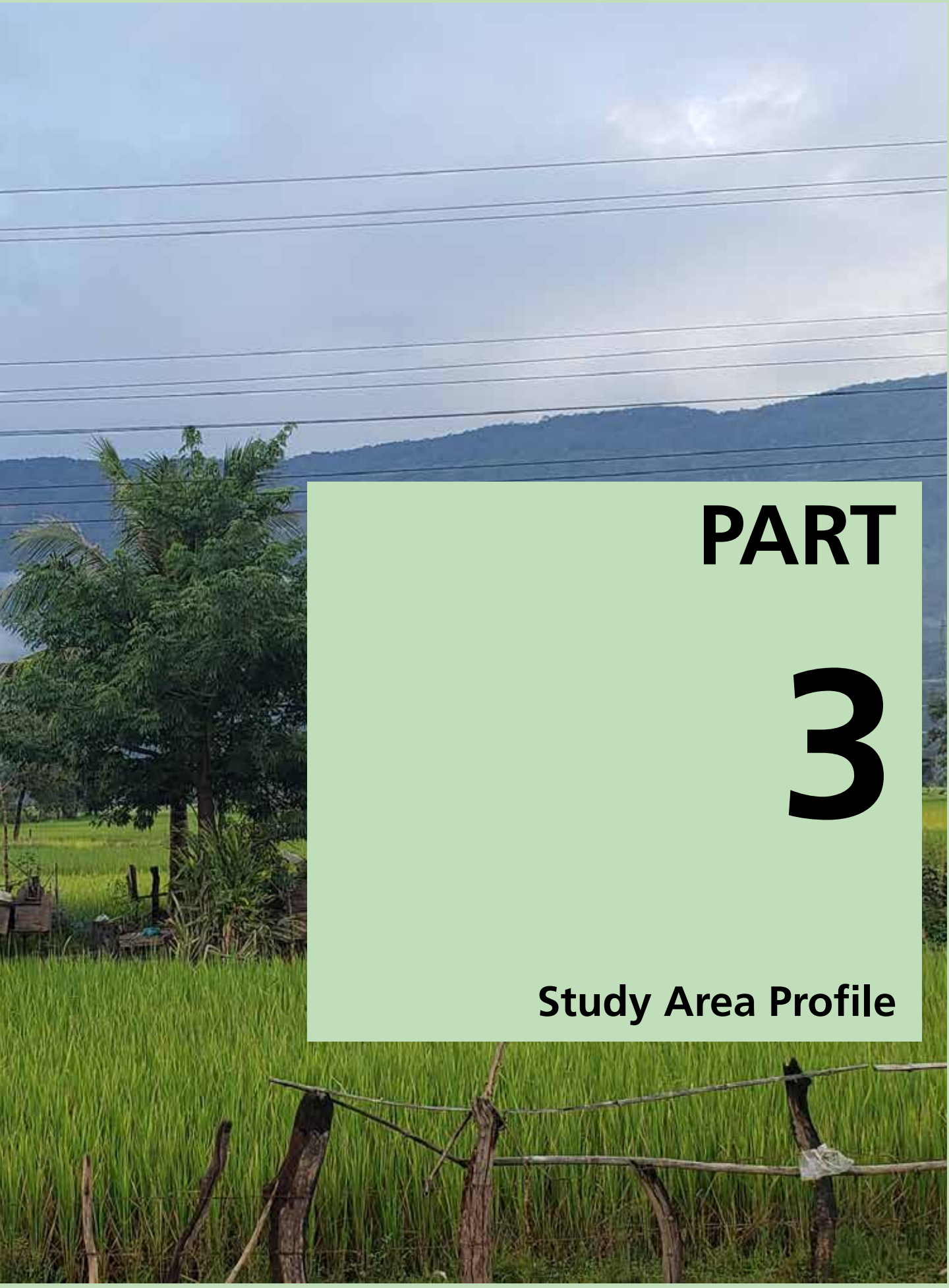


PART 3

Study Area Profile

3 Study Area Profile

3.1 Location and Physical Details

Attapeu Province is at the south-eastern tip of Lao PDR. It shares a 224-kilometre-long border with Cambodia to the south and 58-kilometre-long border with Vietnam to the east[25]. Attapeu is strategically located in the Development Triangle Area (DTA)[26], covering the border area between Southern Lao PDR, Northern Cambodia and the Central Highlands of Vietnam. The province covers 10,320 square kilometres, divided into five districts (Xaisetha, Samakkhixai, Sanamxai, Sanxai and Phouvong) and 147 villages[27]. The provincial capital Samakkhixai, also called Attapeu Town, is located at the western border of the province, close to the Bolaven Plateau.

While the central and western districts (Xaisetha, Samakkhixai and Sanamxai) of Attapeu Province are lowland areas, bordered by the slopes of the Bolaven Plateau in the west, the northern and southern districts (Sanxai and Phouvong) are primarily upland, characterized by a mountainous topography. The highest mountains can be found in the eastern part of the province, close to the border with Vietnam, with elevations up to 1,800 meters above sea-level.

The Xe Kong River traverses Attapeu from north to south in the western part of the province, close to the Bolaven Plateau, and intersects the provincial capital Samakkhixai. Originating in Vietnam and crossing three provinces in Lao PDR, the Xe Kong flows into the Mekong river in Cambodia, making it an important trans-boundary tributary and one of Lao PDR's major water bodies. In fact, it has the largest catchment area of all 12 main river basins in Lao PDR, covering 28,815 square kilometres[28]. Together with the Sesan and Sre Pok river basins, which border the southern edge of the Xe Kong Basin, shown in Figure 5, these basins are the largest and most important trans-boundary watershed of the Mekong River, contributing 20 per cent of the Mekong's annual discharge and 15 per cent of its sediment[29].

Figure 5 - Location of the Xe Kong and its neighbouring basins

25 Lao PDR Investment Promotion Department (2017): Attapeu. General Profile. Retrieved from: http://www.investlaos.gov.la/index.php/where-to-invest/provinces/audtapue (last accessed on 24/8/2017).

26 Lao PDR Department of Planning and Investment in Attapeu (2015): Infrastructure and Transportation. Retrieved from: http://www.dpia.gov.la/en/component/content/article/3/52.html (last accessed on 24/8/2017).

27 Lao PDR Ministry of Planning and Investment (2015): Lao Population and Housing Census 2015. Provisional Report, p. 18, 52.

28 Risk Assessment Report Vol I, p.25.

29 http://www.waterandnature.org /sites/default/files/sekong_basin_fact_sheet.pdf.

PHYSICAL DETAILS AND LOCATION OF SELECTED VILLAGES

Attapeu Province is located at the southeastern tip of Lao PDR, strategically located in the Development Triangle Area (DTA), an area covering the border area between Southern Laos, Northern Cambodia and Central Highlands of Vietnam. The province covers an area of 10,320 km2 which is divided into five districts (Xaisettha, Samakkhixai, Sanamxai, Sanxai and Phouvong), encompassing a total number of 147 villages. The central and western districts (Xaisettha, Samakkhixai and Sanamxay) are lowland areas, bordered by the slopes of the Bolaven Plateau in the west, the northern and southern districts (Sanxai and Phouvong) are characterized by a mountainous topography, making them primarily upland.

- Selected Villages

Transport Infrastructure

- Paved road
- Unpaved road

Rivers/Streams

- Perennial/Permanent
- Non-Perennial
- Districts boundaries
- Provinces boundaries

Data Sources: Lao Decide (www.decide.la), Population and Housing Census 2015 (Lao Statistics Bureau)
Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Concerning the legal status of any country,territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

3.2 Transportation Infrastructure

Attapeu Province is accessible by National Road 11, which connects Attapeu Town to the Vietnamese border to the east, and to Sekong, Saravan and ultimately National Road 13, which goes to Vientiane, in the north. National Road 18 connects Attapeu Town with Road 13 southbound between Pakse and the Cambodia border. However, this road isn't paved and hence generally only accessible in the dry season from November to April. Moreover, a new road was recently completed providing a direct link between Attapeu Town and Pakse.

These roads are almost entirely in the lowland areas, however. Many upland areas in Sanxai and Phouvong Districts can only be reached by unpaved roads or tracks, which makes access to the rural settlements they connect very difficult during the rainy season. There are 79 bridges in Attapeu province, which are critical to connectivity in rural settlements[30].

There is no railway network in Lao PDR, meaning roads are the primary means of passenger and freight transport. Up to 81 per cent of passenger traffic and 88 per cent of freight traffic are carried by road transport[31]. However, road traffic is still limited in Attapeu Province, which has one of the lowest road densities in Lao PDR[32].

Public transportation in Attapeu Province is limited to buses, with regular services to neighbouring provincial capitals, Vientiane and the Vietnamese border. An international standard airport was opened in Attapeu Province in 2015, and while Lao Airlines offered services to Pakse and Vientiane for a time, there are currently no passenger services[33]. Air transportation only plays a minor role in Lao PDR, contributing 10 per cent of the total passenger traffic and only one per cent of the total freight traffic[34].

3.3 Socio-Economic Issues

Agriculture is the main source of income in the province. In 2011, 84 per cent of all households in Attapeu Province sourced income from agriculture and were classified as farm households, according to the 2012 agricultural census[35]. Rice is by far the most important agricultural product in the region, with 99 per cent of agriculture-dependent households growing it[36]. There is 36,600 hectares of rice paddy land in Attapeu Province, in both lowland and highland regions. Rice paddies account for 50 per cent of the land use in the province, while forest covers only 6 per cent of the province's land area. Many households supplement their incomes with other activities, such as sourcing non-timber forest products like resins and bamboo[37].

Despite the large number of people who depend on agriculture for their livelihoods, the contribution of this sector to the province's GDP is comparatively low; only 27 per cent of Attapeu's income came from agriculture in 2013, while the industrial and service sectors, which employ far fewer people, contributed 45 per cent and 28 per cent respectively[38].

The share of agriculture in the economy has been gradually decreasing as the southern region of Lao PDR has industrialized. Cross-border trade has also been a driver of economic growth in Attapeu Province, due to its location in the development triangle area. Electricity generation and export is the main driver of cross-border trade, complemented by light industry, particularly timber and other forest products[39].

Output per capita in Attapeu Province was US$1,500 in 2013, above the national average of US$1,273 in the same year[40] [41]. This growth and relatively high GDP have contributed to a relatively low poverty rate in Attapeu; 18.9 per cent compared to the national average of 25.4 per cent [42]. There has been a significant shift since 2005, when the poverty rate for the province was above 40 per cent and was 60 per cent and 70 per cent in Phouvong

30 Risk Assessment Report Vol I, p.72.
31 Developing a National Risk Profile, p.35.
32 Ibid.
33 The Laotian Times (2016): Attapeu Airport Potential Examined during PM's Visit. Retrieved from: https://laotiantimes.com/2016/10/18/attapeu-airport-potential-examined-during-pms-visit/ (last accessed 24/8/2017).
34 Developing a National Risk Profile, p.34.
35 Lao PDR Agricultural Census Office (2012): Lao census of agriculture 2010/11, p.1.
36 FAO (2013): Lao PDR: Risk and Vulnerability Survey 2012/12. Analysis Report, p.88.
37 Lao PDR DDMCC & WFP (2012): Lao PDR. CLEAR: Consolidated Livelihood Exercise for Analyzing Resilience, p.1.
38 Lao PDR Investment Promotion Department (2017): Attapeu. General Profile. Retrieved from: http://www.investlaos.gov.la/index.php/where-to-invest/provinces/audtapue (last accessed on 24/8/2017).
39 Lao PDR Investment Promotion Department (2017): Attapeu. General Profile. Retrieved from: http://www.investlaos.gov.la/index.php/where-to-invest/provinces/audtapue (last accessed on 24/8/2017).
40 Lao PDR Investment Promotion Department (2017): Attapeu. General Profile. Retrieved from: http://www.investlaos.gov.la/index.php/where-to-invest/provinces/audtapue (last accessed on 24/8/2017).
41 Lao PDR Ministry of Planning & Investment (2015): Five-year national socio-economic development plan VIII (2016-2020), p.59.
42 World Bank, CDE & LSB (2016): Where are the poor? Lao PDR 2015 census-based poverty map: Province and District Level Results, p. 98.

and Sanxai Districts, respectively. This change highlights the significant development progress made in Attapeu Province in the last ten years. However, some villages remain very poor, suggesting unequal distribution of the benefits from socio-economic growth.

3.4 Demographic Trends

With a population of around 139,600 according to the 2015 census, Attapeu Province is the third-least populated province in Lao PDR, and the third-least densely populated, averaging only 14 people per square kilometre[43]. It has the third largest population growth rate in the country, however, with an average increase of 2.2 per cent per year between 2005 and 2015[44]. About 36 per cent of Attapeu's population lives in urban areas, slightly above the national average of 33 per cent[4546]. Lao PDR has one of the fastest urbanization rates in the world at 4.9 per cent, which is two and a half times the global average. While disaggregated data is not available, this national urbanization rate, coupled with Attapeu's rapid population growth, would suggest that the province is also rapidly becoming more urbanized[47].

78.9 per cent of Attapeu's population are above the age of 15. The literacy rate among this group is below the national average of 84.7 per cent[48]. Literacy rates also differ substantially between regions and among different demographic groups. In rural areas, the literacy rate drops to 75 per cent, and to only 67 per cent for women, compared to an overall female literacy rate of 71 per cent[49]. In urban areas, however, literacy rate is 91 per cent for men and 81 per cent for women. Literacy rates are closely linked to education levels; as much as 31.6 per cent of the population has not completed formal basic education[50]. Literacy rates are analyzed further in Section 4: Socio-Economic Analysis.

Lao PDR is a very diverse country that is home to more than 50 ethnic groups, according to the 2015 census[51]. The survey conducted by the assessment team showed that there are ten ethnic groups living in the 66 target villages in Attapeu Province; Alak, Brao, Cheng, Hrlak, Lao Lum, Oy, Sapoan, Tariang, and Ye Jeh.

Attapeu Province has the third largest prevalence of disabled people in Lao PDR, with a disability rate of 3.7 per cent among people aged 5 years or older[52]. Moreover, data at the national level shows that the prevalence is generally higher in rural areas, particularly those without road access, where the rate was observed to be as much as 30 per cent higher than the national average (about 4.8 per cent)[53].

3.5 Governance Structure

The governance structure in Lao PDR is mainly concentrated at the central level through the President of the Republic and the national government. The local administrative structure in Lao PDR is organised into three levels: i) provincial governments, as strategic development units; ii) district governments, as budgetary and planning units; and iii) village councils, as implementing units[54]. Lao PDR is divided into 17 provinces, 148 districts, and 8,507 villages[55] [56].

Since the early 1990s, Lao PDR has engaged in public administration reforms. In 1996, the Government of Lao PDR and UNDP developed the Governance and Public Administration Reform (GPAR) project, which "provided strategic funding for fiscal devolution and decentralized planning and expenditure management at district level"[57]. This project was one of the first steps in the country's process of de-concentration which took place throughout the 2000s. This decentralization process was initiated with the Prime Minister's instruction on 11 March 2000, which initiated the regulation and decentralisation of government functions[58]. It was followed by the Law on Local Administration, which passed in 2003 and states the principles concerning the organisation and functions of the three local levels.

The "Sam Sang" (three-build) policy, established in 2012, went further to strengthen local capacity. The

43 Lao PDR Ministry of Planning and Investment (2015): Lao Population and Housing Census 2015. Provisional Report, p. 16, 18.
44 ibid., p.16.
45 ibid. p.19.
46 Lao Statistics Bureau, (2016) Results of the Population and Housing Census, 2015, p.8.
47 CIA ().
48 Results of Population and Housing Census 2015, p.8, 155.
49 Ibid., p.155.
50 Ibid., p.67.
51 Ibid., p.122.
52 Results of Population and Housing Census 2015, p.71.
53 Ibid, p.71.
54 ADB (2012): Lao PDR Urban Development Sector Assessment, Strategy, and Road Map, p.4
55 Results of Population and Housing Census, Lao Statistics Bureau, 2015.
56 Correct at the time of writing, however there are frequent changes to the demarcations of villages, meaning that this number is constantly changing
57 Trends in the Governance Sector of the Lao PDR, Swiss Agency for Development and Cooperation, 2012.
58 ADB (2012): Lao PDR Urban Development Sector Assessment, Strategy, and Road Map, p.4

aim of this policy is to devolve responsibilities to lower levels of government. Provinces, defined as "strategic units", allocate resources and determine priorities. Districts, defined as "comprehensively strong units", ensure coordination between sector agencies in order to safeguard effective and efficient delivery in villages; and Villages, defined as "development units", deliver development outputs[59].

3.6 Target Villages

Population Distribution and Densities

The vulnerability assessment in Attapeu Province was conducted in 66 villages in four of the province's five districts; 15 villages in Xaisetha, 10 villages in Samakkhixai, 33 villages in Sanxai and 8 villages in Phouvong. These villages have a total population of 60,192 inhabitants; 43 per cent of the province's total population.

Sanxai District is mountainous and its villages are primarily upland. Phouvong District is partly upland, with the villages in Xaisetha and Samakkhixai mostly located in lowland and floodplain areas. Lowland/ floodplain villages tend to be closer together, more densely populated and generally have better access to infrastructure and services. Upland villages are less densely populated and often further from infrastructure and have fewer basic services.

This vulnerability assessment focuses on rural, semi-urban and emerging urban settlements. As shown in the graph below, the target villages located in lowland areas (Samakkixay and Xaisettha) are more densely populated than the provincial average and than the upland villages in Sanxai and Phouvong Districts[60].

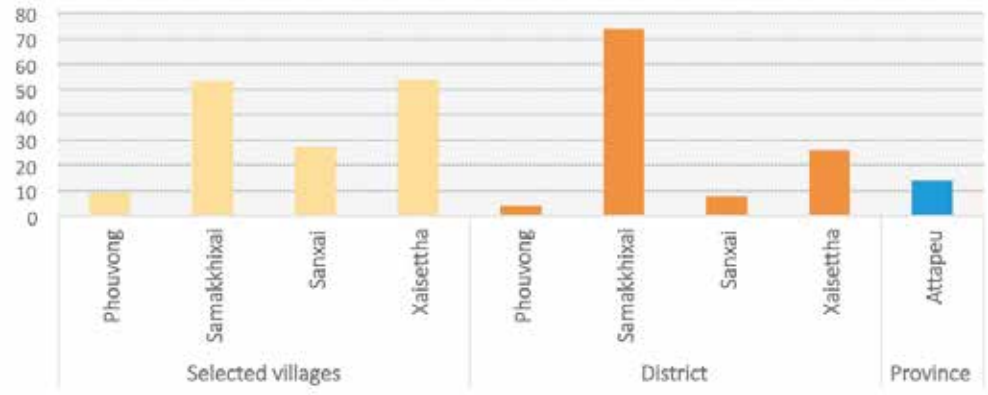
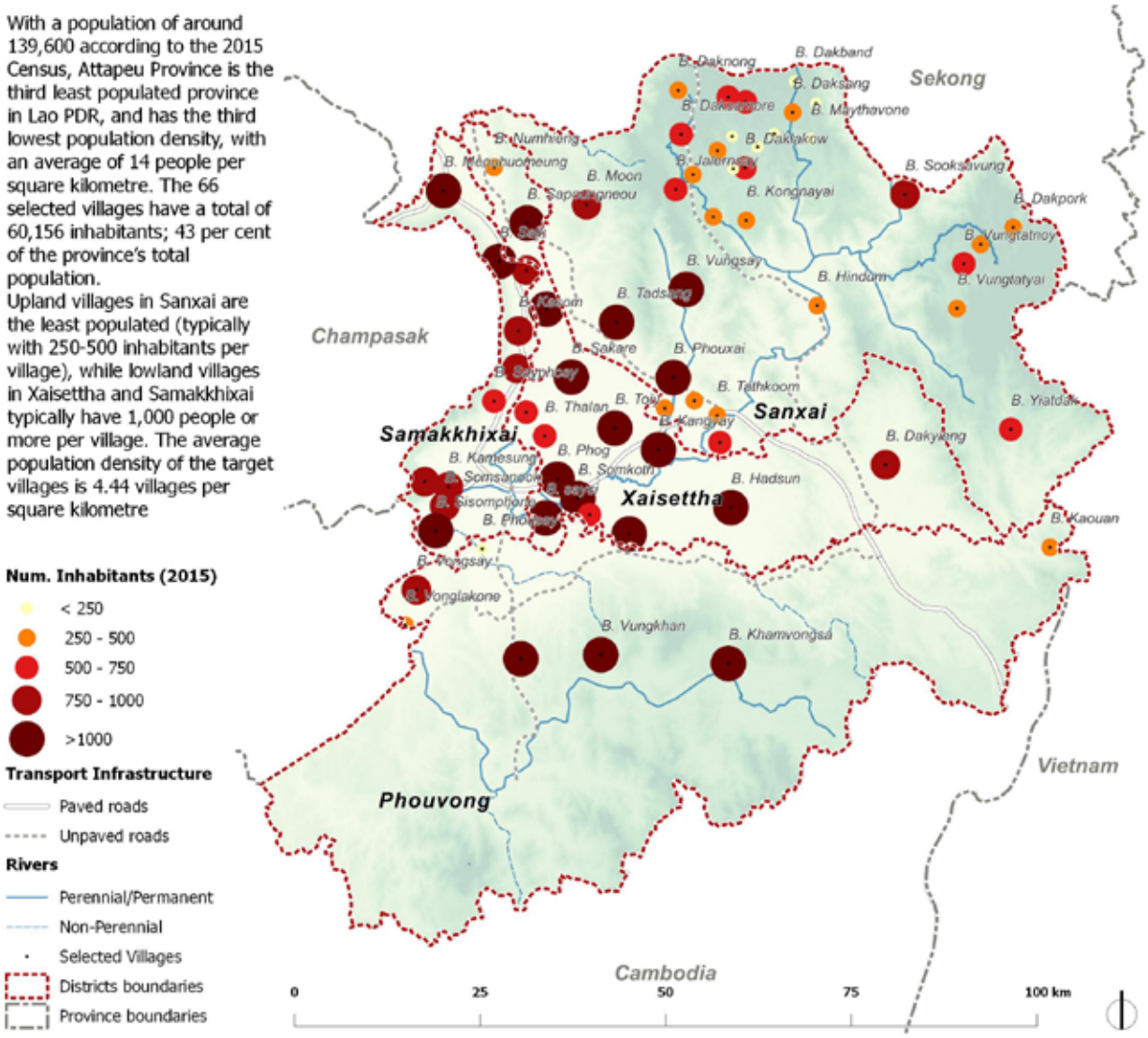


Figure 6 - Overview of population densities (inhabitants per square kilometre) in target villages

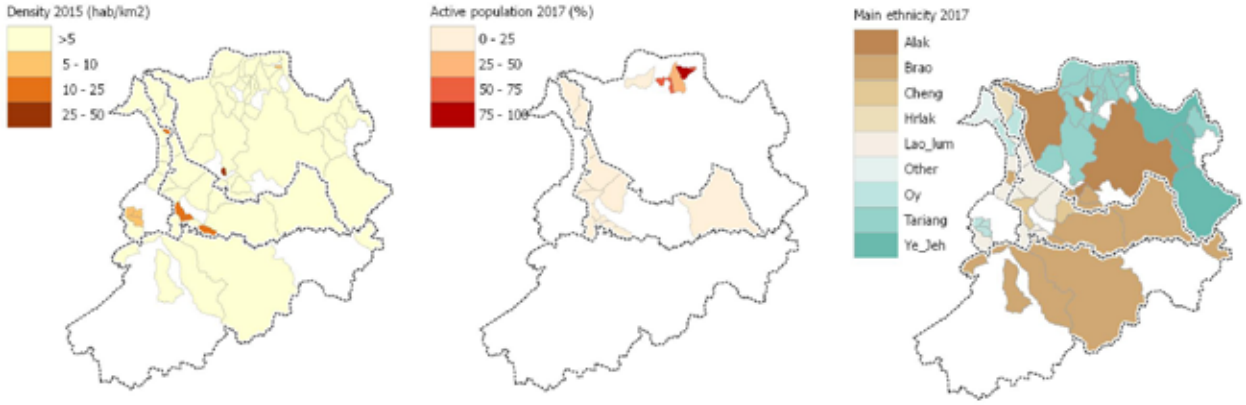
59 Sam Sang in practice: early lessons from pilot implementation, Australian Aid, 2015.
60 Source: Housing and population Census 2015

POPULATION SIZES IN SELECTED VILLAGES

With a population of around 139,600 according to the 2015 Census, Attapeu Province is the third least populated province in Lao PDR, and has the third lowest population density, with an average of 14 people per square kilometre. The 66 selected villages have a total of 60,156 inhabitants; 43 per cent of the province's total population.
Upland villages in Sanxai are the least populated (typically with 250-500 inhabitants per village), while lowland villages in Xaisettha and Samakkhixai typically have 1,000 people or more per village. The average population density of the target villages is 4.44 villages per square kilometre



POPULATION DENSITY, ACTIVE POPULATION AND ETHNICITY IN SELECTED VILLAGES



Data Sources: Lao Decide (www.decide.la), Population and Housing Census 2015, Lao Census of Agriculture 2010/2012, UN Habitat
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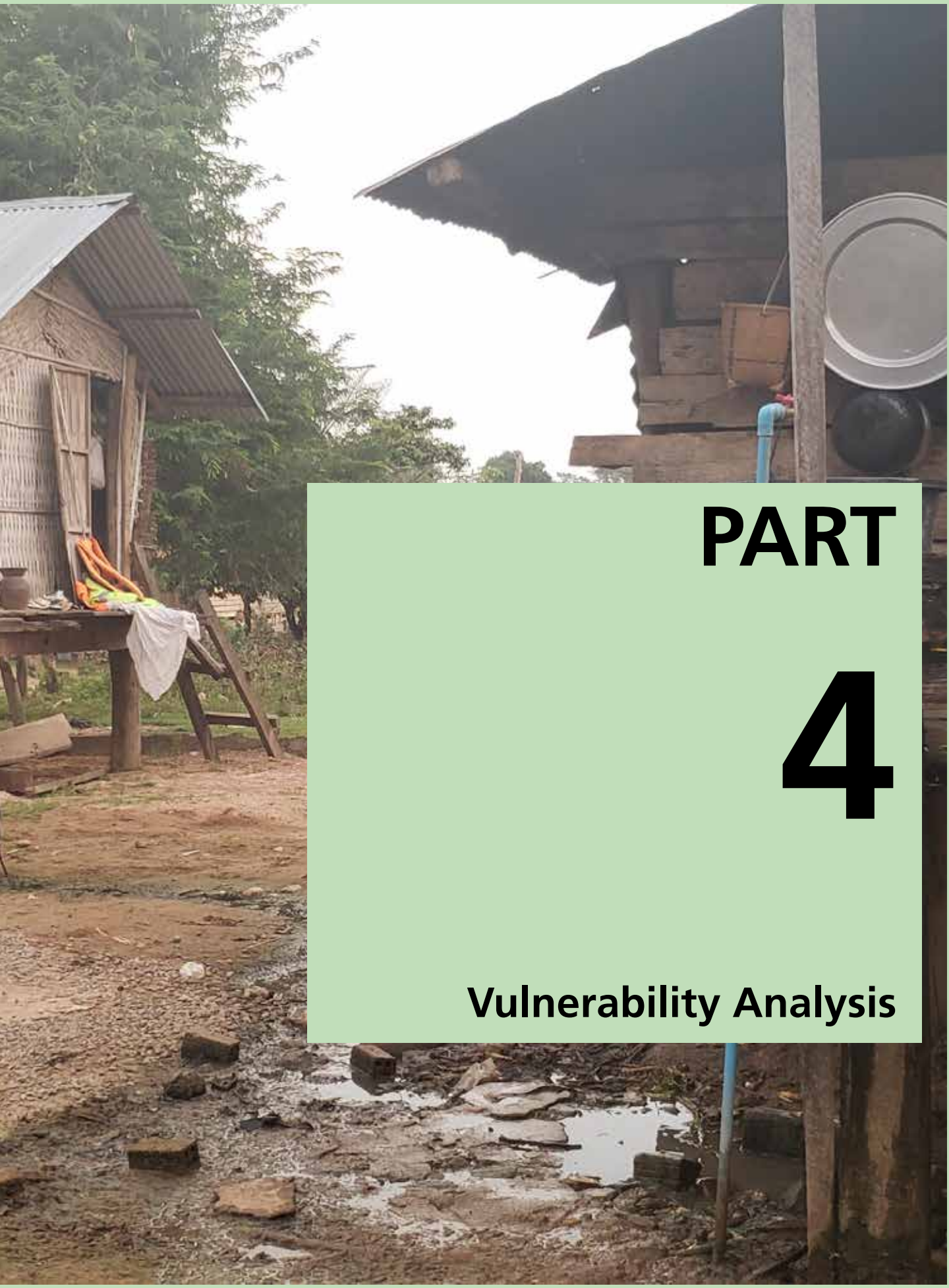

PART 4

Vulnerability Analysis

4 Vulnerability Assessment

4.1 Defining Vulnerability in the Context of Lao PDR and Attapeu Province

As outlined in Section 2, the project aims to strengthen the resilience of the most vulnerable settlements in southern Lao PDR. This report, therefore, aims to identify the most vulnerable settlements. The conceptual framework for this assessment, shown in Figure 7 [61], is based on the IPCC's 4th Assessment Report Framework, which has been chosen for its simplicity and to align with other vulnerability assessment work previously conducted in Lao PDR.

Vulnerability is defined as the degree to which a system is susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of exposure, sensitivity and adaptive capacity[62]. Exposure is defined as the presence of people and systems, such as infrastructure and livelihoods, in places and settings that could be adversely affected[63]. Sensitivity is defined as the degree to which people or systems are affected, either directly or indirectly, by climate variability or change. Adaptive capacity describes the ability of people and systems to adapt to the potential impacts and consequences triggered by climate change, or the ability to take advantage of opportunities that are linked to the changes[64].

In simple terms, vulnerability is heightened by increases in exposure and/or sensitivity, and by a reduction in adaptive capacity. Consequently, reducing people's vulnerability requires a reduction in their exposure and/or sensitivity, and/or an increase in their adaptive capacity. This is visualized in Figure 7, where the size of the exposure, sensitivity and adaptive capacity triangles determine the size of the vulnerability triangle.

Another important consideration is the progression of vulnerability, understood as the ways in which vulnerability is generated and how, in turn, it can be addressed. Vulnerability is often increased by unsafe conditions, such as unprotected buildings and infrastructure, weak local institutions, or a lack of disaster preparedness. Although these conditions increase people's vulnerability, they are not the underlying reason for their vulnerability. Planners must consider the root causes of vulnerability, when responding to climate change since these typically progress to dynamic pressures that finally result in unsafe conditions, as illustrated in 8[65].

As the project seeks to provide long-term solutions to address vulnerability, this report focuses both on the root causes of vulnerability and on unsafe conditions. Therefore, this report analyses the environmental, infrastructure, basic services and socio-economic conditions that drive risks and heighten the exposure and sensitivity of the target villages. These factors are analyzed in section 4.4.

Vulnerability =

(Exposure*Sensitivity)-Adaptive Capacity

Figure 7 - Vulnerability Framework

61 UN-Habitat (2014), Planning for Climate Change: A Strategic, Values-based Approach, p.46.
62 IPCC AR4, p.89.
63 IPCC AR5, p.1758.
64 Ibid., p.1765.
65 Wisner et al. (2003): At Risk: Natural hazards, people's vulnerability and disasters.

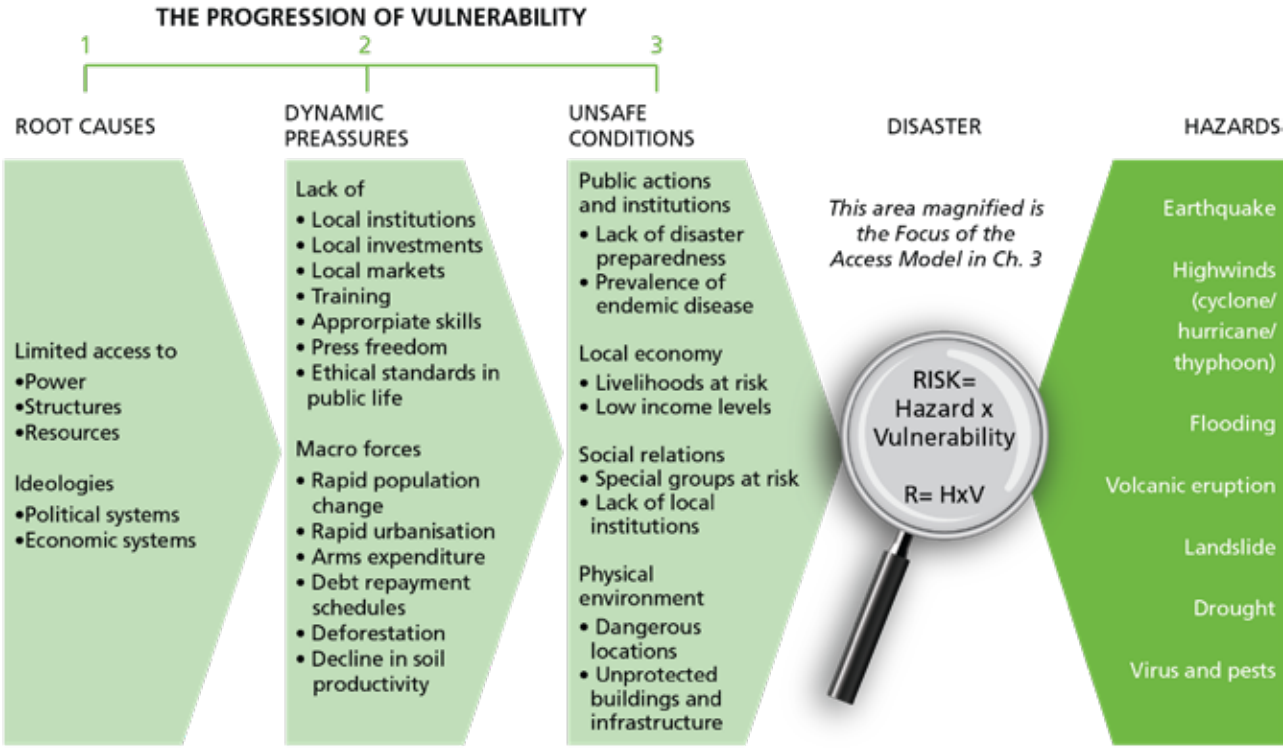

Figure 8 - The Progression of Vulnerability

4.2 Historical Trends in Climate, Hazards and Exposure

a. Climate

Lao PDR has a tropical, diurnal climate in which the weather is heavily influenced by the monsoons, with a rainy season between May and October and a dry season between November and April[66].

Rainfall

In Attapeu Province, the wet southwest monsoon brings a rainy season between May and October. 93 per cent of the province's annual rainfall occurs during this time[67] [68] and thus strong rainfalls are common[69]. According to data gathered from the weather station at the Provincial Department of Natural Resources and the Environment in Attapeu Town[70], the average annual rainfall is 2,203 millimetres per year, or 390 millimetres per month. August is typically the wettest month, receiving 566 milimetres of rain, on average.

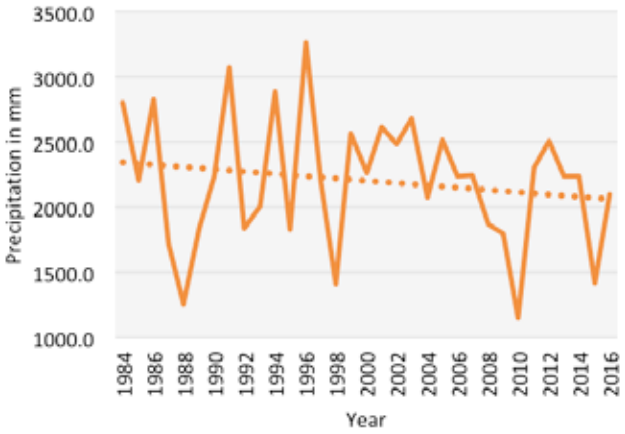

Figure 9 - Average Annual Rainfall in Attapeu Province[71]

66 Developing a National Risk Profile for Lao PDR, p.25.
67 https://en.climate-data.org/location/1365/.
68 Meteo Data (2017) Provincial Department of Natural Resources and the Environment, Attapeu Province.
69 Lao PDR Disaster Management Reference Handbook, p.20.
70 This section is based on data from Attapeu Town. Data from the individual districts doesn't exist.
71 Author's work, based on data from the Department of Meteorology, Ministry of Natural Resources and Environment, Vientiane.

The last 30 years has seen a significant decrease in rainfall in Attapeu, down from almost 2,400 millimetres in 1984. There is also a substantial variation in the total amount of rainfall per year, ranging from a low of 1,196 millimetres in 2010 to a high of 3,265 millimetres in 1996. This high variability of rainfall results in a high standard deviation from the mean of 494 millimetres annually, meaning that planners and residents in Attapeu can only be 68 per cent confident of receiving between 1,710 and 2,696 millimetres of rainfall in any given year.

July and August typically have the highest number of rainy days, averaging 23 and 25 rainy days in those months, respectively. On average, Attapeu has 132 rainy days per year, 88 per cent of which occur in the rainy season[72]. Overall, there has been a very slight drop in the number of rainy days, but this drop has not been as pronounced as the drop in average annual rainfall.

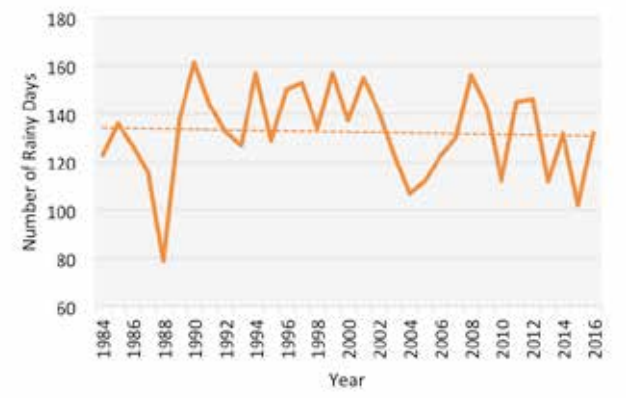

Figure 10 - Number of Rainy Days in Attapeu [73]

There is evidence that Attapeu is heavily influenced by the El Niño Southern Oscillation. There have been eight El Niño cycles since 1984, the first year in the dataset. During these years, the average rainfall was 1,640 millimetres, 809 millimetres less than the average for the remaining non-El Niño years. During La Niña years, the pattern is reversed, and rainfall is significantly higher. La Niña years saw an average rainfall of 2,407 millimetres per year, 304 millimetres more rainfall, on average, than in non-La Niña years. There were six La Niña events during the period of the dataset[74].

Analysis of changes in the rainfall at the start and end of the rainy season also reveals some insights. Rainfall in September showed a slight declining trend. This trend would appear more significant if the exceptionally wet years in 2011 and 2013 are excluded.
This is consistent with broader evidence for the Southeast Asia region, which shows that the rainy season is starting later and withdrawing earlier. The data for October showed no overall trend. Interestingly, the average number of rainy days in September has increased, from an average of 20 to 23, while the average number of rainy days in October has decreased, from 14 to 10. This would suggest that there are fewer heavy rain events in September, while October receives the same amount of rain over fewer rainy days.

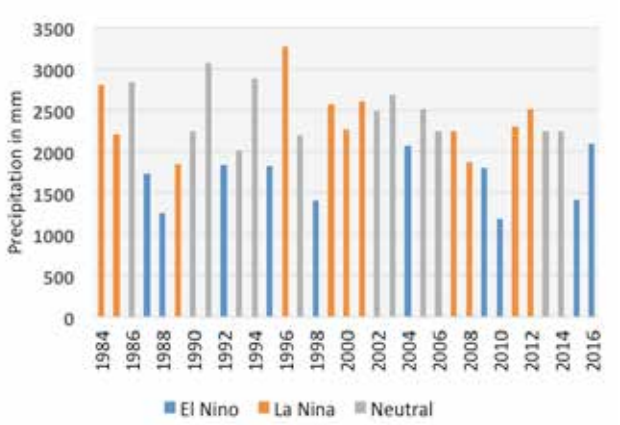

Figure 11 - Historical Rainfall in El Niño and La Niña years

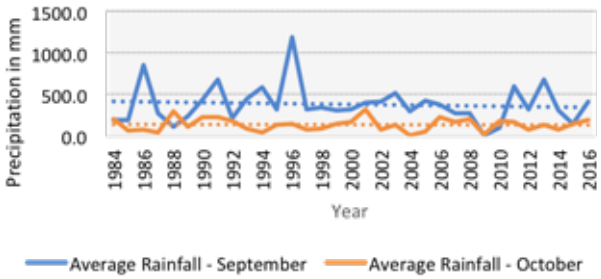

Figure 12 - Rainfall Trends During the Late Rainy Season

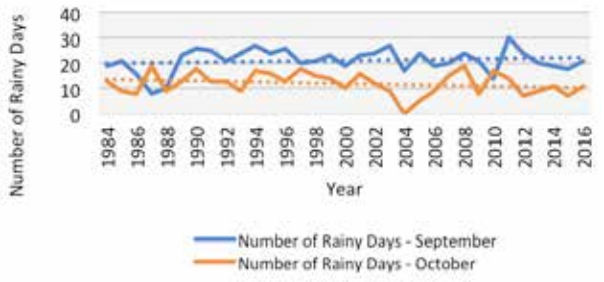

Figure 13 - Trend in the Number of Rainy Days in the Late Rainy Season

72 Note that the number of rainy days was missing for September 2009. The team controlled for this error by assuming the average number of rainy days (21) occurred during this month.

73 (in 1986-1988, 1991-1992, 1994-1995, 1997-1998, 2002-2003, 2004-2005, 2009-2010, and 2015-2016.

74 in 1984-85, 1988-89, 1995-96, 1998-2001, 2007-08, 2010-2012.

The data shows a slight decline in the average amount of rainfall received in April and May in Attapeu. This is also slightly skewed by the extremely wet year in 2011, when there was 700 mm of rain in one day in May alone. However, despite declines in average rainfall in April and May, and in Attapeu's overall amount of rainfall, the data shows a 20 per cent increase in the average monthly rainfall for June. June is the only month which saw in increase in the average amount of rainfall, despite a decline in the number of rainy days. This implies an increase in the number of heavy rain events in the month of June.

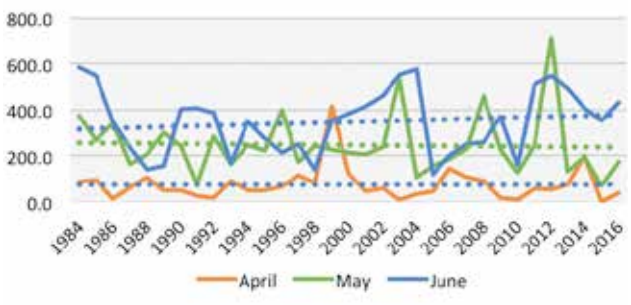

Figure 14 - Trend in the Early Season Rainfall in Attapeu

Evidence from Communities

The vulnerability assessment team cross-checked the data gathered from the Provincial Department of Natural Resources and Environment with the perceptions from survey respondents living in villages in the Province. This was important because it helped to 'ground truth' in the data, but also because official data is only recorded at one weather station in the province.

83 per cent of villages surveyed across the four districts in Attapeu Province reported that rainfall decreased during the rainy season, while 43 per cent reported a severe decrease in rainfall. Xaisetha and Phouvong Districts had the greatest number of villages that reported a severe decrease in rainfall.

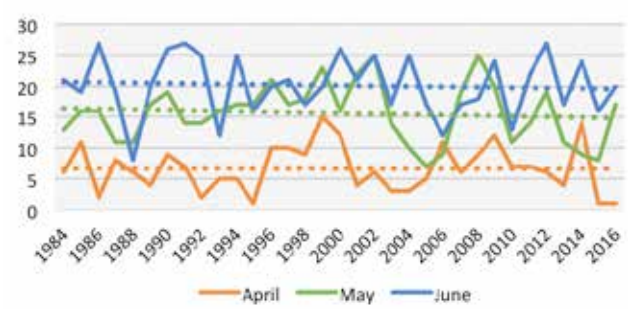

Figure 15 - Trend in the Number of Rainy Days - April – June

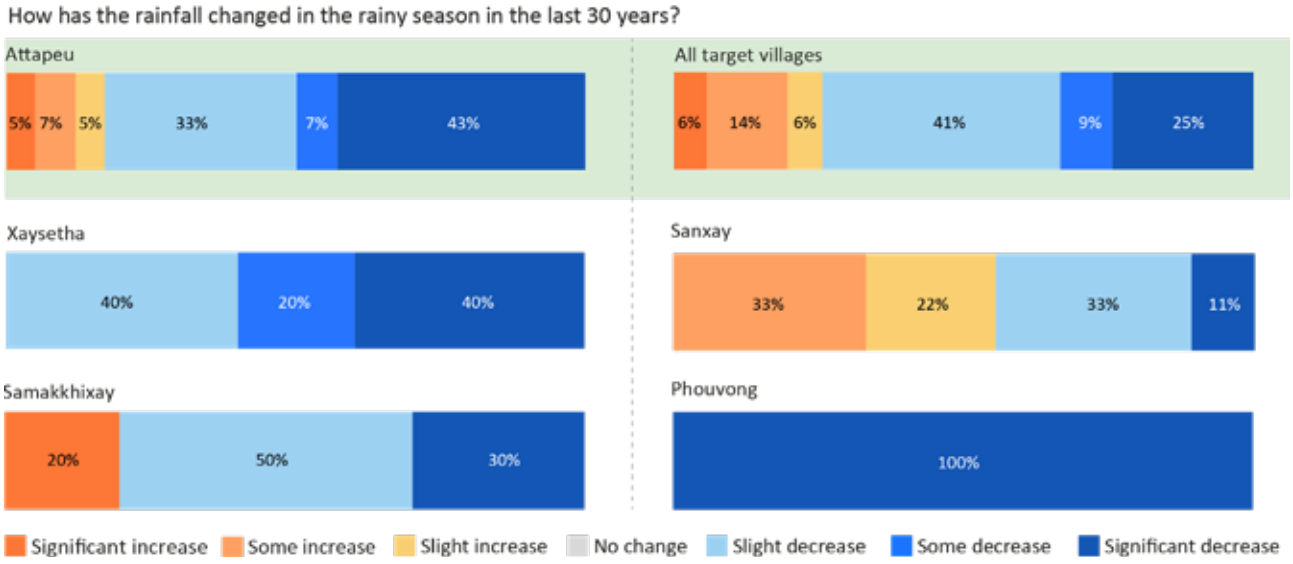

Figure 16 - Perceived changes in rainfall in the rainy season in the target villages

Temperature

According to the Provincial Department of Natural Resources and Environment dataset, temperature increase has been marked. The average annual temperature has shown an increase of around 1.2°C. The average temperature for April, the hottest month, has shown an increase of over 1.5°C in the same period. The average temperature for January, the coldest month, has increased by just over 1°C. This suggests a year-round temperature increase that is particularly marked in the hot part of the dry season.

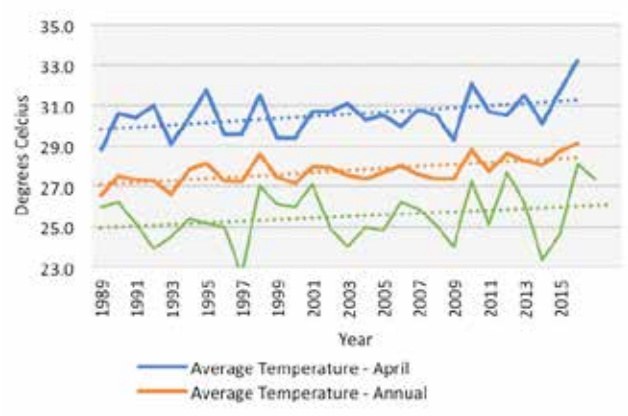

Figure 17 - Change in Average Temperature

Four of the five hottest years in the dataset were recorded since 2010 (in 2016, 2015, 2013 and 2010)[75]. Until 2013, Attapeu had never experienced a temperature over 40°C, when a temperature of 40.1°C was recorded. This record was since broken in 2016, when a temperature of 41.2°C was recorded.

In terms of minimum temperatures, the five coldest years were in the first six years of the dataset. Since 1994, the minimum recorded temperature average was never lower than 20°C in any year.

There is a slight difference in average temperatures between El Niño and La Niña years. The average temperature in all El Niño years in the dataset was 28°C, whereas in La Niña years the average temperature was 27.5°C. Both El Niño and La Niña years showed an increasing temperature trend.

The dry season is split into a cooler period, from November to February, and a hot season in March and April[76]. The average annual temperature in Attapeu is 26.4°C, with an average monthly temperature of 28°C in the hot dry season, and reaching a maximum average monthly temperature of 34.2°C in April[77].

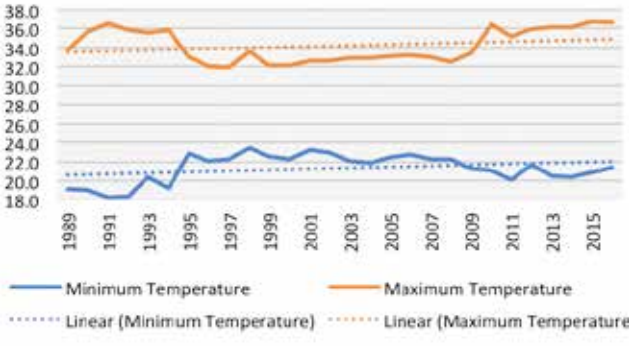

Figure 18 - Average of Maximum and Minimum Recorded Temperatures in Attapeu

74 per cent of villages reported substantial temperature increases in all seasons, a far greater number than in the other two provinces studied by this assessment. All villages in Xaisetha and Phouvong Districts, and 80 per cent of villages in Samakkhixai, reported significant temperature increases.

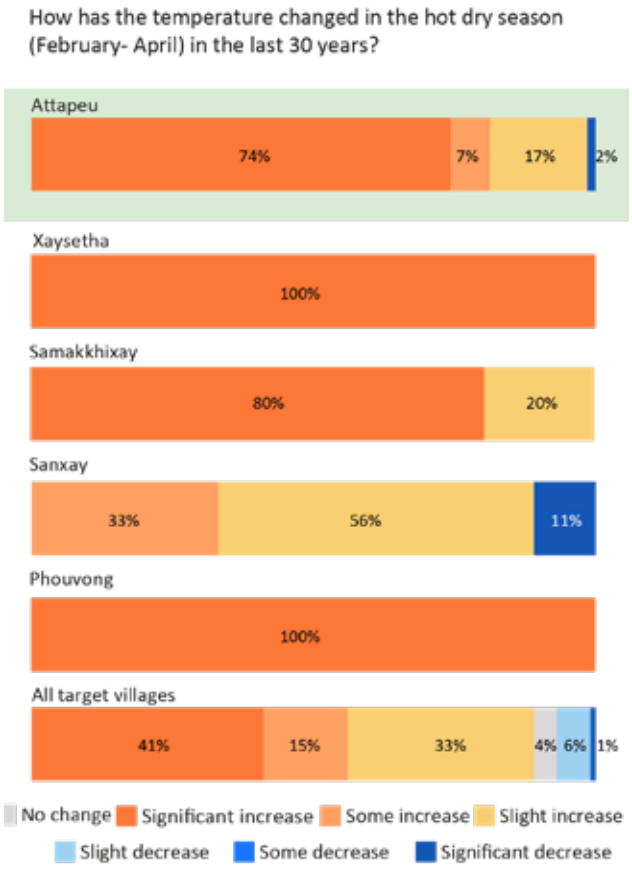

Figure 19 - Perceived changes in temperature in the hot dry season in the target villages

75 The annual average of the maximum temperature recorded in each month.
76 Lao PDR Disaster Management Reference Handbook, p.20.
77 https://en.climate-data.org/location/1365/.

b. Overview of Hazards and Exposure

Lao PDR is exposed to multiple natural hazards, with floods and storms having caused the most serious humanitarian impacts[78], followed by droughts and landslides, which also pose serious risks[79], and finally diseases, which are common throughout the country. These hazards are often interlinked, since storms and typhoons often come with heavy rainfall which can trigger landslides and cause flooding which, in turn, can lead to disease outbreaks. This multi-hazard environment poses a significant risk to people, livelihoods and infrastructure in Lao PDR.

Floods

Lao PDR was ranked as the sixth most flood prone country in the World according to the INFORM Country Risk Profile, withh a flood risk of 9.2 out of 10[80]. An estimated 58 per cent of the population has been affected by flooding at some point[81]. This is mainly linked to the intense precipitation triggered by the southwest monsoon in the rainy season, particularly throughout August and September[82]. These months also coincide with the typhoon season, which peaks in August and September,[83] significantly increasing the risk of flooding since tropical cyclones also bring heavy rainfall. This was last evident in 2013 when five consecutive major storms brought flooding to 12 out of Lao PDR's 17 provinces, including Attapeu, and affected approximately 347,000 people while causing losses and damages worth an estimated US$219 million[84].

High flood risk is particularly evident in the southern provinces, including Attapeu[85]. As outlined, Attapeu is traversed by the Xe Kong River, so that the province shares a large part of the inundation area with this major river system. This is particularly true in Samakkhixai District, where the inundation area is approximately 100 square kilometres, over 80 square kilometres of which are exposed to flooding levels of greater than 2 metres[86]. The other three target districts are also highly exposed, as shown in Figure 20.

Evidence from Communities

In the target villages, flooding was also reported as a major issue, posing significant risks to people by damaging houses, infrastructure, livelihoods, and health

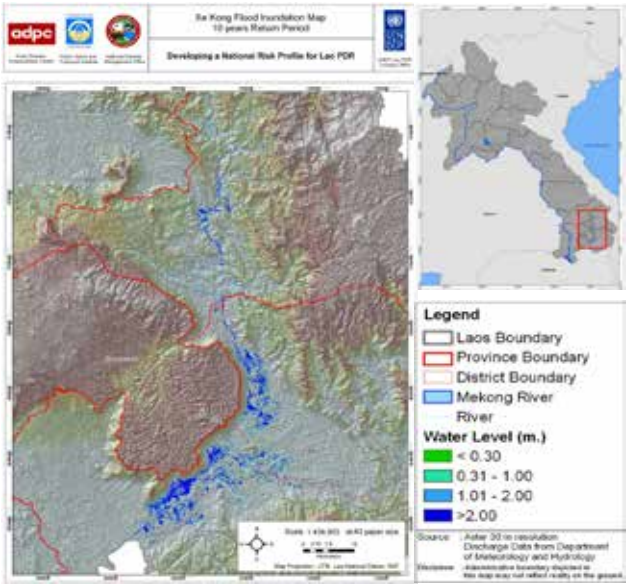

Figure 20 - Xe Kong flood inundation map for 10 years return period

reported by at least 80 percent of villages in each district. In contrast to the magnitude of the risk and the manifested impacts, flooding only occurs occasionally in Attapeu Province. Flooding recurs every three to five years in just over half of the target villages, and only every ten years in 33 per cent. Meanwhile, 14 per cent of the surveyed settlements have not been impacted by floods at all. This suggests that floods can be categorized as a medium frequency, high impact hazard for Attapeu Province.

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78 OCHA ().
79 Lao PDR Disaster Management Reference Handbook, p.24.
80 Ibid.
81 Developing a National Risk Profile, p.31.
82 Lao PDR Disaster Management Reference Handbook, p.24.
83 Ibid.
84 http://www.inform-index.org
85 Lao PDR Disaster Management Reference Handbook, p. 24.
86 Risk Assessment Report Vol I, p.38.

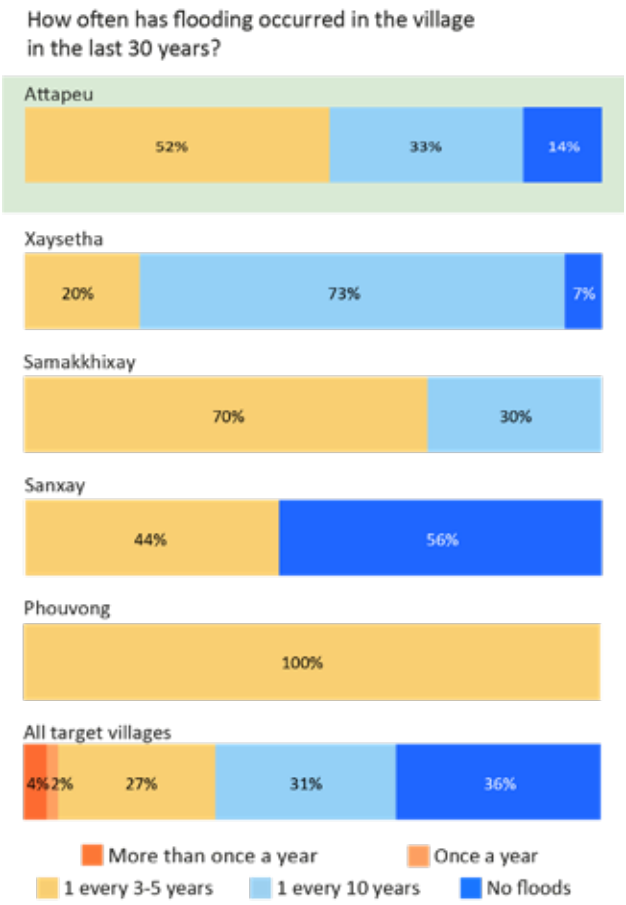


Figure 21 - Overview of perceived occurrence of flooding in the target villages

Storms

Floods in Lao PDR are often triggered by storms and tropical cyclones. Storms pose a serious risk due to their associated high wind speeds, which can cause significant damage for buildings and infrastructure. Storms mainly cause damage to houses and infrastructure, reported by 86 and 60 per cent of the target villages in Attapeu Province, respectively, while 52 per cent of target villages also reported income losses as a result. Typhoons and other storms cause the highest economic losses of all hazards in Lao PDR due to the diversity of their impacts, costing an estimated US$305.95 million[87]. The risk of storms is concentrated between June and November, with peak storm season occurring in August and September[88].

Attapeu Province is highly exposed to storms. 98 per cent of its area is exposed to class 1 typhoons, which have windspeeds between 119 and 152 kilometres per hour[89]. Fortunately, Attapeu is not currently exposed to category 2 typhoons, which only occur in a small part of Khammuane Province in central Lao PDR. The latest tropical cyclones to impact Attapeu Province were Typhoon Wutip in October 2013, and Typhoon Ketsana in September 2009[90]. The southern provinces, including Attapeu, were most affected by the devastating effects of Ketsana, with almost 32,000 hectares of crops and 144 irrigation systems having been damaged, affecting an estimated 3,178 households[91].

Evidence from Communities

31 per cent of villages surveyed in Attapeu Province reported being affected by more than one storm per year, with Phouvong District reporting the most serious impacts. A further 52 per cent of villages in the province reported experiencing a severe storm once every three to five years. These reports highlight that storms are the most frequently occurring hazard and a major threat in Attapeu.

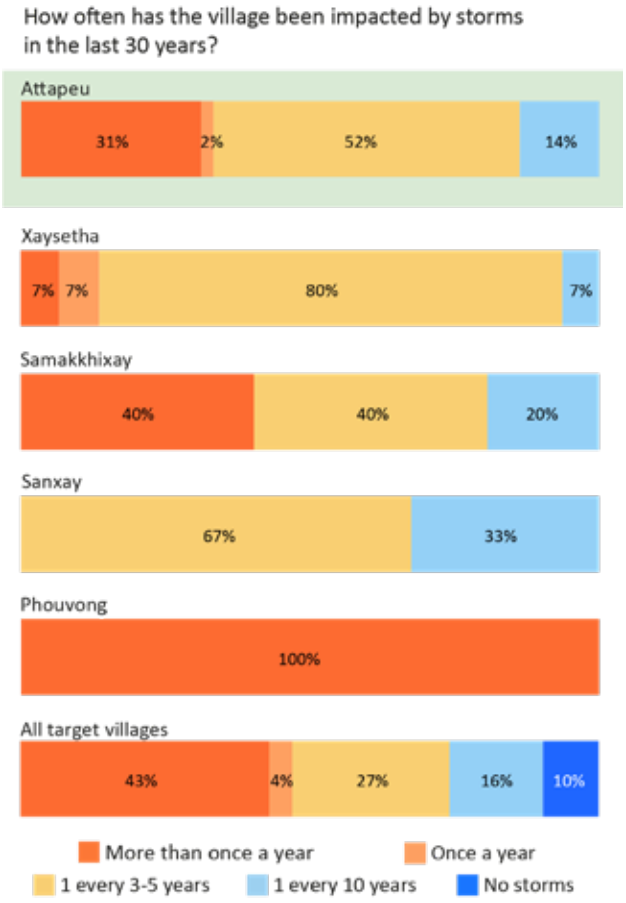


Figure 22 - Overview of perceived occurrence of storms in the target villages

87 Developing a National Risk Profile of Lao PDR, p.31.
88 Lao PDR Disaster Management Reference Handbook, p.24.
89 Risk Assessment Report Vol II, p.62.
90 https://reliefweb.int/country/lao.
91 DDMCC & UNDP (2016): L-CRVA. Final Summary Report, p.6.

Landslides

Most of Lao PDR is situated in low to medium landslide susceptibility zones. Only 5.24 per cent of the country is located in a very high landslide susceptibility zone, including some areas in the south-eastern and central part of Lao PDR. Rainfall is the main triggering factor for landslides, which is why their occurrence peaks during the rainy season. Apart from this hydro-meteorological factor, other principal causes of landslides include geological aspects such as slope gradient and rock condition, known as lithology, and land use, which also makes landslides a partially human induced hazard.

Evidence from Communities

Attapeu Province is the second most exposed province to landslides in Lao PDR. Around 13 per cent of the province's total area has a high landslide exposure, while another 57 per cent is moderately exposed[92]. However, only three of the 66 villages surveyed indicated that landslides had occurred, all in Xaisetha District.

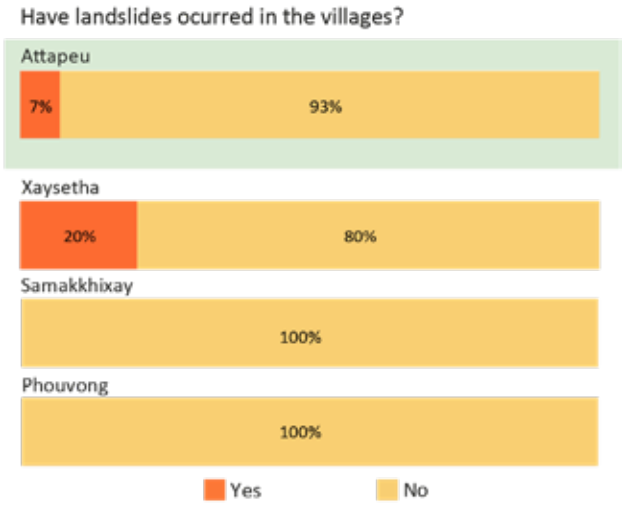


Figure 23 - Overview of perceived occurrence of landslides in the target villages

Droughts

Droughts are the third most commonly occurring natural hazard in Lao PDR, affecting 15 per cent of the population[93]. Droughts can occur in both the dry and rainy seasons. However, droughts that occur during the late season through to the southwest monsoon, from mid-July to September, are thought to have the greatest impact, reducing grain production, for example, by up to 30 per cent[9495]. Economic losses resulting from droughts can therefore be quite high, as evidenced by the last severe drought in Lao PDR's central and southern provinces in 2003, which resulted in an estimated US$ 16.5 million[96] worth of damages.

Evidence from Communities

The southern provinces, particularly those in upland areas, are among the most prone to droughts[97]. 43 per cent of the villages in Attapeu Province reported to have been affected by a drought occasionally, or every three to five years. Although droughts don't occur annually, most of the districts in Attapeu have greater exposure than the average for the entire project area. Nevertheless, the exposure is very scattered, with significant differences between nearby villages. 56 per cent of villages in Sanxai District, for example, reported experiencing a drought every three to five years. Meanwhile, Phouvong District has been assessed as having the country's second highest susceptibility to moderate droughts during the dry season, with all eight villages reporting to have experienced a drought once every three to five years[98]. Droughts are therefore a location-specific hazard.

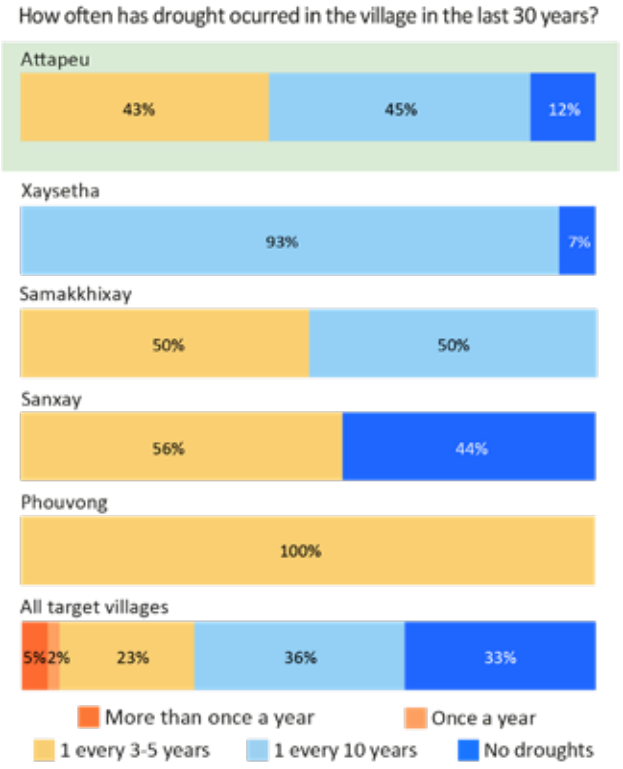


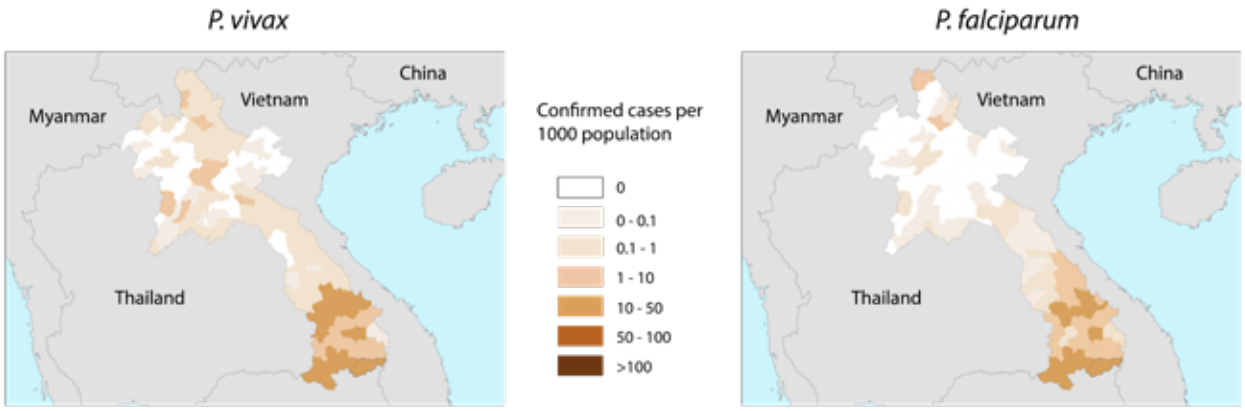
Figure 24 - Overview of perceived occurrence of droughts in the target villages

92 Risk Assessment Report Vol II, p.53.
93 Developing a National Risk Profile of Lao PDR, p.31.
94 Ibid., p.25.
95 Developing a National Risk Profile for Lao PDR, pp. 85-88.
96 Ibid., p.28.
97 Lao PDR Disaster Management Reference Handbook, p. 25.
98 Developing a National Risk Profile of Lao PDR, p.85.

Diseases and Epidemics

Diseases and epidemics are a widespread and very serious threat to people in Lao PDR. 86 per cent of all disaster-related fatalities in the country are reported to be due to epidemics[99]. The majority of these fatalities, and of illness-cases in Lao PDR more generally, were caused by communicable infectious diseases[100]. There are 24 epidemic diseases reported for Lao PDR, with acute watery diarrhoea reporting the largest number of cases, about 27,000 cases per year. Dengue fever and typhoid register about 24,000 and 10,000 annual cases, respectively[101]. Cholera and malaria are also recognised as a serious health issue, with only 7 per cent of Lao PDR's population living in a Malaria-free environment[102]. The last serious epidemic outbreak was a spread of dengue fever in 2013, which had over 4,000 reported cases in August of that year[103].

In Attapeu Province, malaria is among the most serious health issues as indicated in Figure 25. Although there has been a very positive trend in Lao PDR with a widespread decrease in reported Malaria cases in 15 out of its 17 provinces, Attapeu and Sekong Provinces registered an increase in the number of reported cases[104]. Consequently, Attapeu Province faces between 10 to 50 cases per 1000 people for the two most common malaria species (Plasmodium vivid and Plasmodium falciparum)[105]. The most negatively affected district in Attapeu is Phouvong, where 2 to 10 per cent of the population has suffered from at least one of the two main species of malaria. These figures only account for reported cases, however, and estimations by the World Health Organization (WHO) suggest that the actual number of cases is likely to be double that of the officially reported numbers[106].



1. Epidemiological profile

Population (UN)	2015	%
High transmission (> 1 case per 1000 population)	2,120,000	31
Low transmission (0 - 1 cases per 1000 population)	4,170,000	61
Malaria-free (0 cases)	503,000	7
Total	6,800,000	

Parasite and vectors			
Plasmodium species:	*P. falciparum (42%), P. vivax (58%)*		
Major anopheles species:	*An. dirus, An minimus, An maculatus, An. jeyporiensis*		
Reported confirmed cases (health facility)	36,056	Estimated cases:	88,000 [68,000 ; 110,000]
Confirmed cases at community level:	9,107		
Reported deads:	2	Estimated deads:	<50

Figure 25 - Geographical distribution and statistics of (reported) Malaria cases in Lao PDR

99 Ibid., p.31
100 Lao PDR Disaster Management Reference Handbook, p.26.
101 Developing a National Risk Profile of Lao PDR, p.65.
102 WHO (http://www.who.int/malaria/publications/country-profiles/profile_lao_en.pdf).
103 WHO (http://reliefweb.int/sites/reliefweb.int/files/resources/Dengue%2026Feb2014.pdf).
104 Developing a National Risk Profile of Lao PDR, p.71.
105 WHO (http://www.who.int/malaria/publications/country-profiles/profile_lao_en.pdf).
106 Ibid.

Evidence from Communities

These malaria trends are confirmed by the surveys conducted in Attapeu's villages. As illustrated in Figure 26, instances of malaria were the most reported of all diseases, and dengue fever was reported to be the second most common vector-borne disease in Attapeu Province. Official numbers show that Attapeu Province was among the worst affected provinces by dengue fever, and experienced the highest recorded number of dengue hemorrhagic fever cases. Further, the number of dengue fever cases in Attapeu has been increasing[107].

Water-borne diseases also seriously affect the target population, with diarrhoea occurring in 86 per cent of all settlements, followed by skin and eye diseases with an occurrence of 76 and 69 per cent, respectively.

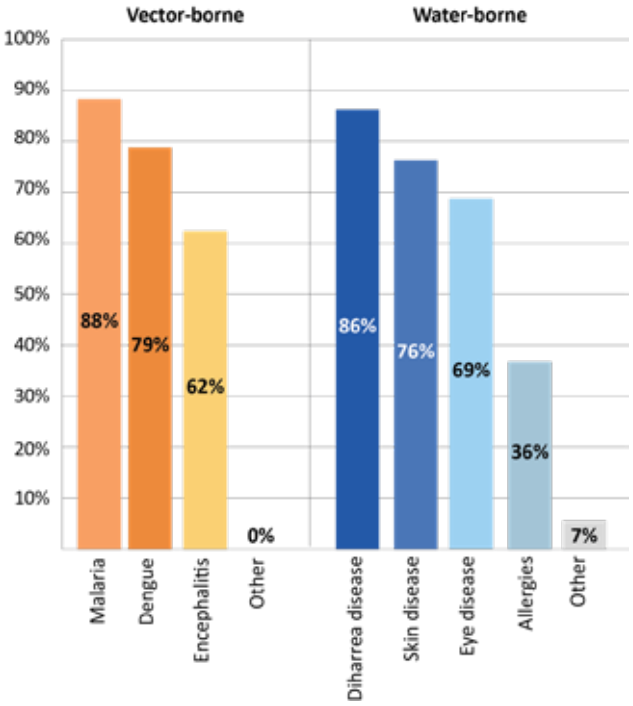


Figure 26 - Percentage of Villages that have experienced disease among the surveyed villages in Attapeu

Man-Made Hazards: UXOs

Attapeu Province has a large amount and wide distribution of unexploded ordinances (UXOs), which are remains from the second Indochina War (1964-73)[108]. These ordinances pose an immense threat to the lives and health of many people since they can explode when exposed to contact, movement or heat. The avoidance of potentially exposed areas can limit the expansion of agricultural production, which, under certain circumstances, can lead to food shortages[109]. Due to these and other serious impacts of UXOs, Lao PDR designated an 18th, country-specific Sustainable Development Goal to address this issue, which aims to ensure a safe environment by clearing the land of UXOs and educating the population about their risks[110]. Attapeu Province has one of Lao PDR's highest UXO densities, with 0.7 to 1.2 ordinances per square kilometre. Xaisetha and Phouvong Districts are the most seriously affected[111].

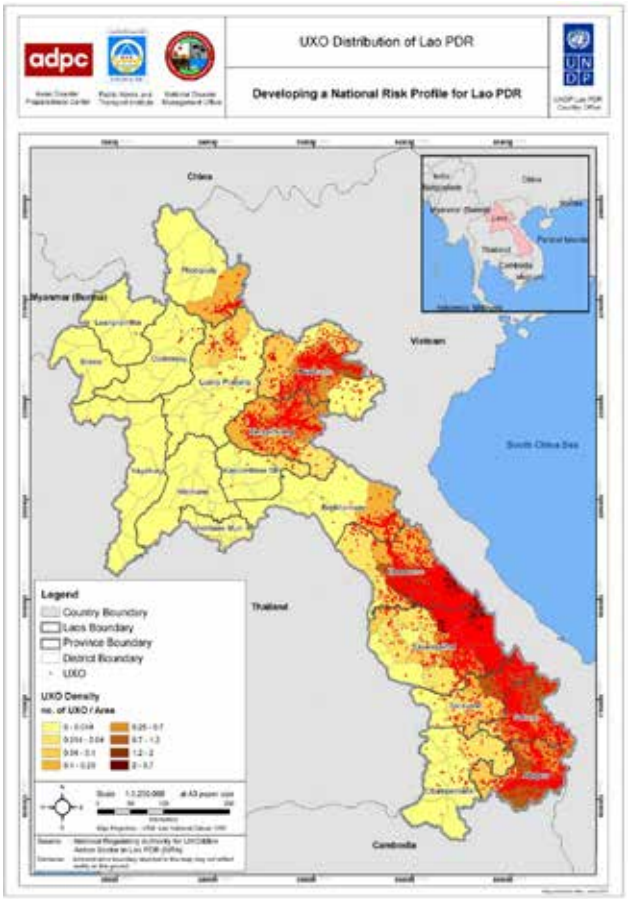


Figure 27 - Prevalence of Unexploded Ordinance

107 Developing a National Risk Profile of Lao PDR, pp. 69f

108 UXO-NRA (2017): UXO Problem. Retrieved from: http://www.nra.gov.la/uxoproblem.html (last accessed on 25/8/2017)

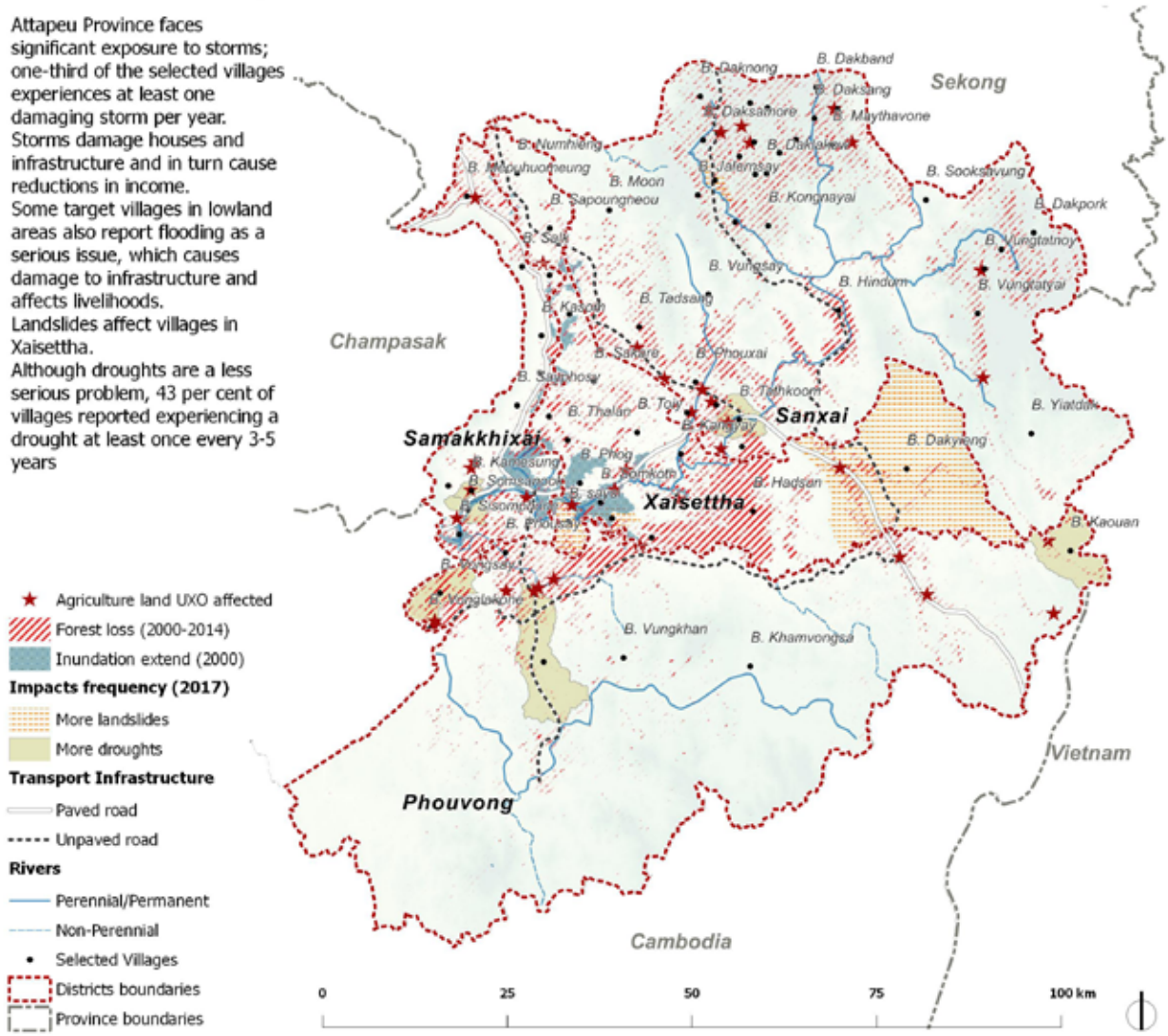
109 Lao national UXO programme (2013): UXO impact. Retrieved from: http://www.uxolao.org/index.php/en/the-uxo-problem/uxo-impact (last accessed on 25/8/2017)

110 UNDP Lao PDR (2017): Goal 18: Lives safe from UXO. Retrieved from: http://www.la.undp.org/content/lao_pdr/en/home/post-2015/sdg-overview/goal-18.html (last accessed on 25/8/2017)

111 Lao PDR National Disaster Management Committee & UNDP (2010): National Risk Profile of Lao PDR, p. 77

CLIMATIC FEATURES, NATURAL HAZARDS AND OBSERVED IMPACTS

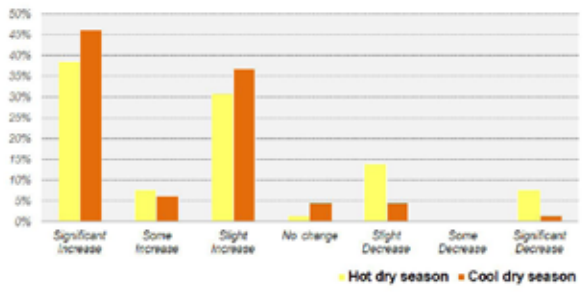
Attapeu Province faces significant exposure to storms; one-third of the selected villages experiences at least one damaging storm per year. Storms damage houses and infrastructure and in turn cause reductions in income.
Some target villages in lowland areas also report flooding as a serious issue, which causes damage to infrastructure and affects livelihoods.
Landslides affect villages in Xaisettha.
Although droughts are a less serious problem, 43 per cent of villages reported experiencing a drought at least once every 3-5 years



CHANGES IN CLIMATE OBSERVED OVER THE LAST 30 YEARS IN SELECTED VILLAGES

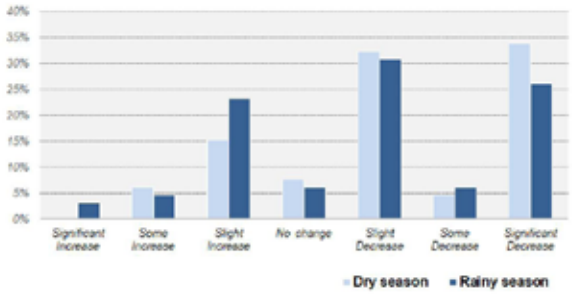
Temperature

Significant increase in temperature is perceived, both in hot and dry season



Rainfall

Decrease in rainfall is perceived, both in dry and rainy season.



Data Sources: Lao Decide (www.decide.la), Population and Housing Census 2015, Lao Census of Agriculture 2010/2012, UN Habitat (2017)
Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Concerning the legal status of any country,territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

4.3 Climate Change Projections

- Temperatures are forecast to increase sharply in Attapeu Province, up to 2.5°C, by 2050, relative to the baseline.
- Although rainfall is harder to predict, it is expected that there will be a slight increase in rain over a shorter rainy season.
- More extreme rainfall events are also highly likely.

The vulnerability assessment team did not undertake its own climate change projections as three sets of projections have recently been developed in Lao PDR; one for the Second National Communication to the UNFCCC (under the Ministry of Natural Resources and the Environment), one by UNDP and the International Centre for Environmental Management for the Lao PDR Community Risk and Vulnerability Assessment (L-CRVA), and another by USAID under the Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin, which covers Lao PDR. As a result, this assessment, and the project more generally, relies on already existing projections. as the existing projections give both the team and decision makers in Lao PDR sufficient information. Conducting new, original projections would be time-consuming, costly and would add little value to both the assessment and decision making at the sub-national level.

Second National Communication to the UNFCCC

The Second National Communication to the UNFCCC briefly introduces climate change projections that are partially based on earlier work by GIZ[112], which were based on 14 global circulation models (GCM) and three scenarios, A1B, A1 and B1 (see box text for a full explanation of climate change projections). The projections, based on the average of the GCM models in the GIZ report, show a substantial increase in temperature in Attapeu, Sekong and Saravan provinces by 2050, compared to the 1982-2002 baseline[113].

While temperatures are projected to increase throughout the country, there are greater geographic variations projected for changes rainfall. Much of southern Lao PDR, including the target provinces, shows an increase in projected rainfall, especially in the month of October (in the late rainy season). Rainfall projections for May (in the early rainy season) predict a minimal change, though in some models an increase for April has been identified, meaning that there is a greater chance of a 'false-start' to the rainy season in the future[114].

The global circulation models don't project the likelihood or magnitude of extreme weather events, including heavy rains, hot spells or tropical storms, but rather tell us about the changes in averages. The GIZ report notes, however, that previous trends are likely to continue, and that therefore 'the incidence of extreme events, such as hotter nights and days and heavy storms, is likely to increase'[115].

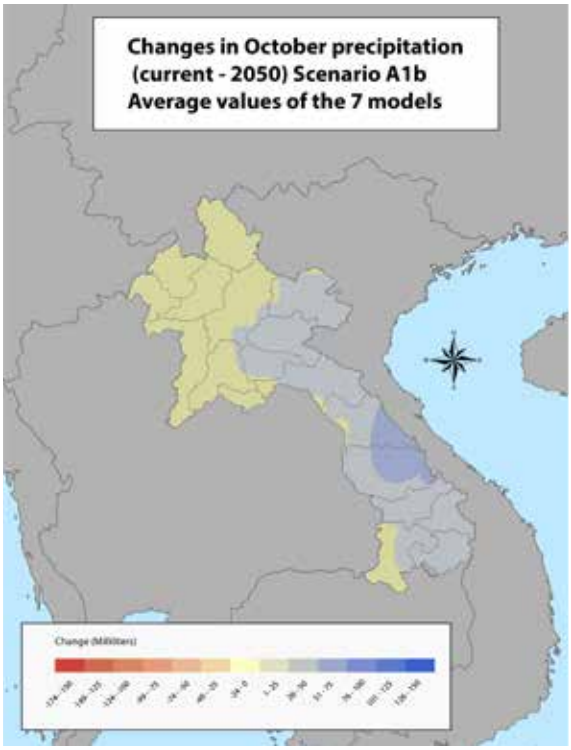


Figure 28 - Projected change in rainfall under the IPCC A1B scenario

112 Lao PDR Second National Communication to the UNFCCC, Ministry of Natural Resources and Environment p.60.
113 Lefroy, et al (2010) Study on Potential Impacts of Climate Change on Land Use in the Lao PDR, International Center for Tropical Agriculture/GTZ, p.20.
114 Ibid, p.26-27.
115 Ibid, p.27.

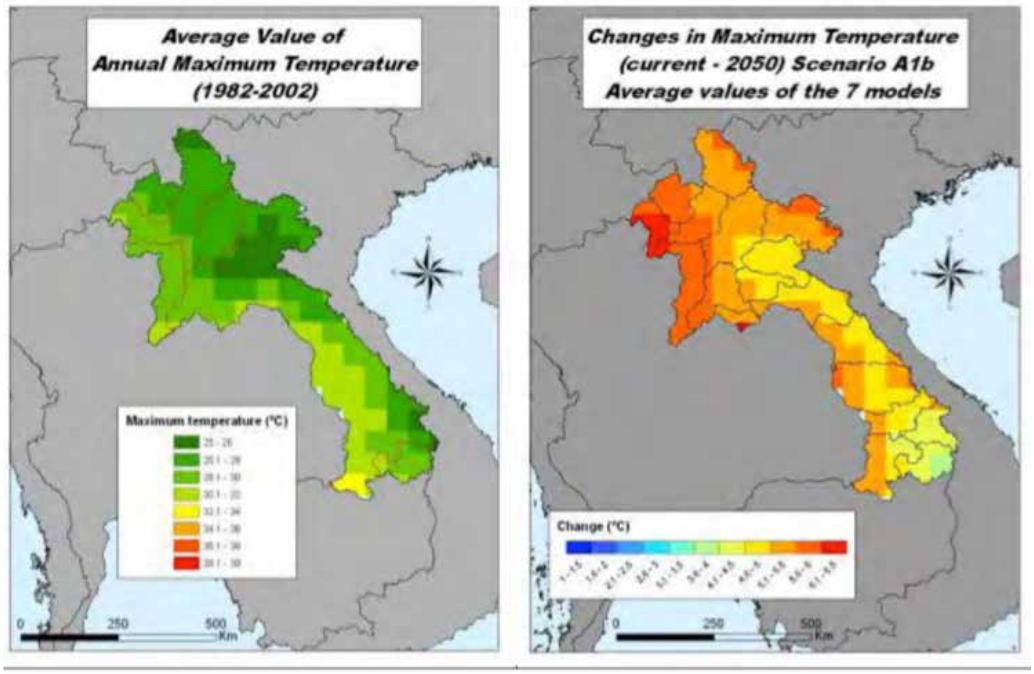


Figure 29 - Projected Change in Maximum Temperature under the IPCC A1B scenario

Lao Community Risk and Vulnerability Assessment (L-CRVA)

UNDP and the International Centre for Environmental Management also developed climate change projections as part of the Lao Community Risk and Vulnerability Assessment (L-CRVA) report, published in 2016. The L-CRVA conducted a model for the period 2045-2069, using 1980-2000 as a base. Like the GIZ modelling exercise, L-CRVA used data from various weather stations in the Lower Mekong Basin, the IPCC A1B scenario and six global circulation models.

The L-CRVA focuses on Sekong and Saravan Provinces, the other target provinces in this project, which border Attapeu to the north. The models show an increase in temperature, rainfall and drought in Sekong Province, with similar patterns expected for Attapeu Province[116]. Projections for Kaleum district in Sekong Province show that the average daily temperature during the rainy season could be at least 1.6°C higher in the period 2045-2069, compared to the baseline period. The projections also show that the average maximum rainfall during the rainy season could increase by 16 per cent, while there could also be an increase of up to 30 per cent in the number of drought months. The L-CRVA projections also suggest that Attapeu is likely to experience more extreme rainfall events, as more rain is projected over a shorter rainy season, which would lead to more flooding and associated damage.

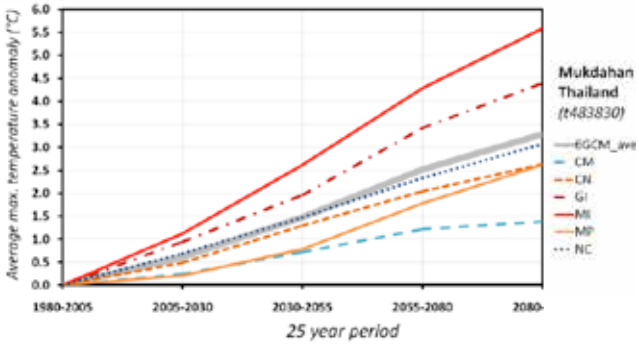


Figure 30 - Temperature projections in Southern Laos and Eastern Thailand

116 Ketelsen, T. et al (2016) Lao Community Risk and Vulnerability Assessment, UNDP/ICEM, p.31 (draft version).

Mekong ARCC Climate Change Impact and Adaptation Study

The USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin was published in 2013, and was based on six global circulation models, like the UNDP-ICEM study, and one future scenario (the IPCC A1B scenario). This was a regional study, and therefore the results are not specific to the target provinces in this assessment. However, there are projections downscaled to nearby locations that allow policy-makers to approximate changes in Attapeu Province.

The temperature projections shown in Figure 30 are based on data gathered from the weather station in Mukdahan, Thailand, about 300 kilometres away from Attapeu (straight-line distance). The average of the global circulation models shows an increase of about 2.5°C, relative to the baseline period.

As with the other models, the projections also show a slightly increasing trend in the overall amount of rainfall. The assessment downscaled rainfall models in neighbouring Champasack Province. The average of the six models shows that more rainfall could be expected in a typical year, with the average of the models showing no significant trend of late onset or early withdrawal of the rainy season, which has also been noted in other studies.

It should be noted that the models provide a range of projections, with the average of the six described above. Like the other studies, these models do not provide information as to the likelihood or magnitude of extreme events, including severe storms. The vulnerability assessment team surmises, however, that droughts will become more frequent and more extreme, and that there will be more heavy rainfall events in the rainy season.

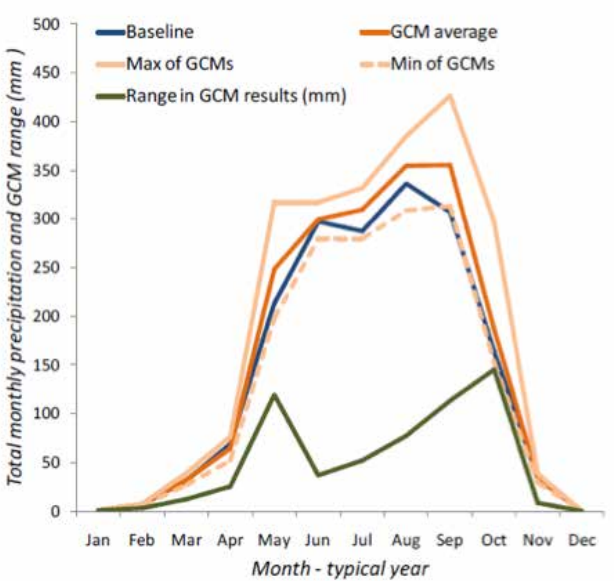


Figure 31 - Range of Precipitation Projections

Climate Change Projections

Climate change projections help us to understand the future climate will be like and can be used to estimate climate conditions up to 100 years from now. They are not a forecast – they don't tell us exactly what the climate will be like in the future or whether a given year will be hot or cold, wet or dry. Instead, they give us a broad projection of how the climate will change relative to today and the recent past. Climate change projections help policy-makers make informed decisions when planning the construction and maintenance of infrastructure and the provision of services, since projections tell them the likelihood of certain changes taking place. For example, in this assessment we see consistent evidence that both overall annual rainfall and the number of drought months will increase. This informs decision-makers that there will be a greater need to capture and store water in the future.

The science of developing climate change models is complicated. First, studies that develop climate change projections rely on emissions scenarios. The Intergovernmental Panel on Climate Change (IPCC) outlines various emissions scenarios in its assessment reports. In the 4th Assessment Report these were the A1FI, A1B, A1T, A2, B1, and B2 scenarios. In the IPCC Fifth Assessment Report, published in 2014, these six scenarios were replaced with four scenarios known as representative concentration pathways; RCP2.4, RCP4.5, RCP 6.0 and RCP8.5 (more information can be found in the link below).

In short, emissions scenarios estimate the level and intensity of greenhouse gas emissions, based on possible population and economic growth models and the extent to which human beings 'de-carbonise', that is, reduce their dependence on fossil fuels and other activities that release greenhouse gases.

When one or more emissions scenario(s) have been selected, assessments generally use General Circulation Models (GCMs). The science of GCMs is complex, but in simple terms, they are based on a mathematical equation that considers physics, fluid motion and atmospheric chemistry. Normally, assessments will use several GCMs and base their projections on the average of these, as was the case with the USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin, cited in this report.

The projection studies cited in this report use the older emissions scenarios (the USAID report is based on the A1B, for example). Studies based on the new scenarios (or representative concentration pathways, as they are now called) have not yet been conducted in Lao PDR.

4.4 Underlying Drivers of Vulnerability

a. Environmental Conditions, Ecosystems and Other Drivers

• Deforestation and forest degradation are reducing the ability of the surrounding ecosystem to provide critical resources and services, such as wood for construction and as protection against storms.

• Most people depend on surface water as their primary water source, and only use ground water when surface water is unavailable. However, this makes people highly vulnerable to any reduction in water availability that may occur as a result of climate change

Forests are a critical source of livelihoods and adaptation for people. They provide natural defenses and absorption, preventing floods and reducing their impacts, and non-timber forest products, which are critical for livelihoods. Nationwide, Laos produced 2.16 million units of bamboo in 2012-2013, for example[117].

Understanding forest cover is challenging because of the various ways a forest can be defined and because of the difficulty of obtaining relevant and recent data. According to the results from the latest reconnaissance survey of forest cover, conducted in 2002, the total land area of Lao PDR covered by natural forest (canopy density greater than 20 per cent and height above 5 metres) was 9,824,700 hectares, or roughly 41.5 per cent of the total land area. The drylands (lowland dry dipterocarp forest) covered approximately 1,317,200 hectares, or 13.9 per cent of the total land area, almost all of which is located in the central and southern parts of the country[118].

The Mekong River Commission developed a land use cover map for the Greater Mekong Sub- region using 2010 satellite imagery[119]. The land cover data set included both the dry and wet seasons in 2009 and 2010, as well as a separate annual dataset comprising the average of the two seasons. The annual map for 2010 of the annual average showed that broadleaved deciduous forest accounted for almost 70 per cent of the total land area in each district within the Mekong sub-region. Paddy rice was the next most common land cover in Xaisettha District (20 per cent) and Samakkhixai District (25 per cent), while in Sanxai District shrubland was the next most common, covering 23 per cent, and in Phouvong District evergreen forest was the next most common land type. See Table 1 for a further breakdown of land cover types.

Table 1 – Land use cover 2010

District	Land uses in 2010	%
Xaisettha	Annual crop	0.55%
	Broadleaved deciduous forest	**70.15%**
	Orchard	5.60%
	Paddy field	**19.40%**
	Shrubland	3.45%
	Water body	0.85%
Samakkhixai	**Broadleaved deciduous forest**	**69.60%**
	Orchard	0.60%
	Paddy field	**25.00%**
	Shrubland	1.90%
	Water body	3.00%
Sanxai	Annual crop	0.01%
	Bare land	0.65%
	Broadleaved deciduous forest	**69.75%**
	Broadleaved evergreen forest	0.02%
	Industrial Plantations	0.10%
	Orchard	1.70%
	Paddy field	4.00%
	Shrubland	**23.00%**
	Water body	0.69%
Phouvong	Annual crop	4.85%
	Broadleaved deciduous forest	**74.50%**
	Broadleaved evergreen forest	**16.00%**
	Orchard	0.60%
	Paddy field	2.50%
	Shrubland	1.25%
	Water body	0.25%

Source: http://portal.mrcmekong.org/tech report

117 8th Five Year National Socio-economic Development Plan (2016), p.15.

118 Forest cover and land-use changes in Lao PDR according to the National Forest Reconnaissance Survey (2002) Vongdeuane Vongsiharath Department of Land Planning and Development National Land Management Authority, Lao PDR.

119 Landuse/Landcover of the Greater Mekong Subregion developed by Mekong River Commission (MRC) using 2010 satellite imagery and extensive field ground-truthing by National Government partners in Cambodia, Laos, Thailand & Vietnam. (http://portal.mrcmekong.org/tech_report).

Deforestation Trends

Lao PDR is experiencing long-term deforestation trends. In the 1940s, forest cover was around 70 per cent, but was reduced to 41.5 per cent by 2002. Though deforestation has stabilized somewhat - the UN Reduced Emissions through Deforestation and forest Degradation (UN-REDD) programme estimates that, if the current deforestation trend continues, 7.4 million hectares – about 31 per cent of total forested area – of forest will be gone in five years. According to a study conducted by USAID, "In addition to deforestation, many natural forests with lower productivity and impaired environmental functions suffered from intensive degradation… The exploitation of natural forests during recent decades did little to benefit the rural poor and instead contributed to the degradation of the natural resource base upon which the majority of the population depends for their livelihood[120]".

The predominant forest type, derived by an automatic and regionally-tuned classification of a time series of global MERIS FR mosaics for the year 2009[121], is closed to open forest (>15%) in all districts, covering around 60 per cent of the land area in Xaisettha and Samakkhixai Districts and around 95 per cent of the land in Sanxai and Phouvong Districts.

Table 2 - Type of Forest Cover in 2009[122]

District	Forest type	%
Xaisettha	Closed forest (>40%)	0.55%
	Closed to open forest (>15%)	**63.96%**
Samakkhixai	Closed forest (>40%)	1.30%
	Closed to open forest (>15%)	**57.68%**
	Open forest (15-40%)	5.60%
Sanxai	Closed forest (>40%)	0.94%
	Closed to open forest (>15%)	**94.66%**
	Open forest (15-40%)	1.66%
Phouvong	Closed forest (>40%)	0.41%
	Closed to open forest (>15%)	**96.89%**
	Open forest (15-40%)	0.95%

Forest loss between 2000 and 2014 is defined as a stand-replacement disturbance, or a change from a forest to non-forest state[123], and was greatest in Sanxai District at 348 square kilometres, followed by Xaisettha (246km2), Phouvong (160km2) and Samakkhixai Districts (73km2). Deforestation was mainly observed close to mining concessions and in the floodplains along the Xe Kong River (see map ATA04).

The drivers of deforestation are numerous and complicated. In Lao PDR, the primary drivers are natural and human-induced fires, commercial and illegal logging, shifting cultivation, agricultural and agro-industry expansion, plantations, mining and hydropower[124].

Hydropower Production

Hydropower can be both a direct and indirect driver of deforestation. New hydropower dams result in deforestation due to their construction as well as in their inundation areas. Moreover, indirect deforestation occurs because illegal logging often takes place adjacent to inundation areas. Resettlement resulting from hydropower development puts more pressure on deforestation, as land may be cleared for new settlements, and as illegal logging or shift cultivation may be taken up in new areas.

As the USAID study notes, "Hydropower development and its impact on flood regimes will impact traditional systems based on fertilisation through sediment deposition during the annual flood. The gap in fertilization will exacerbate the drop-in yield due to climate change". Well-managed hydropower developments can offset some of the impacts of climate change by expanding opportunities for irrigation, which reduces vulnerability to drought[125]. However, increased dam construction along major rivers has led to more frequent village resettlements. The government has established criteria to select villages for relocation, which includes a population below 200, lack of access to roads or potable water, and reliance on slash and burn cultivation[126].

The Xe Kong Basin has not seen extensive hydropower development in comparison to other areas in Lao PDR.

120 Ibid.
121 ESA GlobCover Version 2.3 2009 300m resolution Land Cover Map.
122 Ibid.
123 Global forest cover loss 2000–2015: V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53.
124 http://theredddesk.org/countries/laos (last accessed 8/9/17).
125 USAID (2013) Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin: Main Report, p.175.
126 Lao PDR Disaster Management Reference Handbook, p.17.

However, according to 2016 data from the Ministry of Energy and Mines, there are two hydropower dams in operation (one in Samakkhixai District and one in Phouvong District) and four under construction (two in Sanxai and two in Phouvong Districts), which were expected to be completed by 2020[127].

Mining Concessions

In recent years, the scope and scale of mining operations has increased in Lao PDR, particularly in the southern regions. Mining can be beneficial by providing stable, year-round incomes to communities that were previously dependent on seasonal income from agriculture.

However, mining directly contributes to deforestation as land needs to be cleared for mining operations; as well as indirectly, as land clearance is also required for access roads and other supporting infrastructure. There are two main types of mining operations in Southern Lao PDR: thousands of small, artisan mines that have likely led to a larger net loss of forest, and the planned Bauxite mine mega-project[128]. In the target districts, only Sanxai has seen large-scale mining concessions.

Forestry and Agro-Industrial Expansion

Agricultural activity has expanded in recent years. This has brought benefits from increased incomes and greater food security through increased production but has also brought agricultural land into greater competition with wetlands and forests. However, climate change threatens the benefits seen by agricultural communities as floods cause damage to agricultural infrastructure and disrupt planting seasons, and as droughts cause crop failure and thus increase food insecurity[129].

In many areas dramatic increases in the extent of coffee, rubber and industrial tree plantations have resulted in the fragmentation and loss of large areas of natural forest[130]. As of mid-2013 the total area of Attapeu used for rubber plantations was more than 27,700 hectares. The rubber is mainly aged between 5-6 years and tapping will start within the next 1-2 years. The Hoang Anh Ga Lai Group recently finished the construction of a large rubber processing factory in Xaisettha District. The factory has a processing capacity of around 7,000 tons[131].

According to USAID, "Timber harvesting for household consumption is assumed to have increased in line with population growth from 630,000 cubic metres per year in 1992-2002 to 770,000 cubic metres per year in 2002-2009. Total domestic timber demand was recently estimated at 1.57 million cubic metres per year. Ten Families are normally entitled to cut up to five cubic metres of timber per year from village utilization forests for their own use. In theory, an application to the village authorities may also be required, which will be checked and decided upon by the village head or the Village Development Committee (VDC)[132]."

Forests are also under pressure from illegal cutting by individuals and households. According to the 2015 census, firewood is the main source of cooking fuel for households throughout the four target districts, with fewer than 3 per cent relying on grid electricity. In addition, 92.5 per cent of buildings in Attapeu Province are non-engineered, which means that they consist of clay, wood, bamboo, zinc or corrugated iron with flexible roofs[133]. This makes them highly susceptible to various hazards, especially landslides, flooding and storms. Since many of these buildings are built in areas characterised by a high exposure to these hazards, people living in them face a significant risk of being adversely affected.

Table 3 - Use of forest products for construction materials in the four districts[134]

District	Housing materials			Cooking Fuel
	Roof	Wall	Floor	
Phouvong	7.5	78.3	64.26	95.19
Sanxai	15.54	86.50	78.18	95.36
Samakkhixai	1.75	48.38	38.01	90.72
Xaisetha	2.91	56.76	47.88	94.55

127 Map for Hydropower development July 2016, Ministry of Energy and Mines, Department of Energy Policy and Planning. http://www.laoenergy.la/download_free.php.
128 Thomas (2015) Drivers of Deforestation in the Greater Mekong Sub-region; Lao PDR Country Report, p.8.
129 ICEM. (2016). Lao Climate change risk and vulnerability assessment for small scale rural infrastructure: Final Summary Report. ICEM, Hanoi Viet Nam, 30th May 2016.
130 Thomas (2015) Drivers of Deforestation in the Greater Mekong Sub-region; Lao PDR Country Report, p.7
131 http://www.dpia.gov.la/la/component/content/article/50.html - accessed 11-9-17
132 Thomas (2015) Drivers of Deforestation in the Greater Mekong Sub-region; Lao PDR Country Report, p.10.
133 Ibid., Vol. II p.116.
134 Housing Population Census 2015.

Water Supply

Most people depend on surface water as their primary water source, and only use ground water when surface water is unavailable. However, this makes people highly vulnerable to any reduction in water availability that may occur as a result of climate change.

While Lao PDR has abundant water resources, the water supply capacity of the country remains limited. According to the 2015 census, only 10 per cent of households in the target districts have direct access to water supply in their homes.

Water Contamination and Pollution

Waste-water and run-off from agricultural activities are both a source of nutrients and harmful chemical deposits, where agriculture is dependent on non-organic fertilisers. While mining activities and hydropower generation are the major sources of pollution in the Xe Kong River Basin, mostly due to sediment deposits, agricultural activities have resulted in some evidence of arsenic contamination in Attapeu Province[135].

Groundwater

Information about groundwater, including its potential for further extraction and quality, is very limited in Lao PDR. Since surface water supply is abundant, groundwater is regarded as a viable source only when and where surface water is not available[136].

As previously stated, rubber plantations are common throughout Attapeu Province, including in the four target districts. The expansion of rubber plantations and agricultural crops have changed extensive areas of land cover in the Xe Kong Basin. These activities are predicted to be depleting groundwater resources as well as affecting surface water quality by increasing erosion[137].

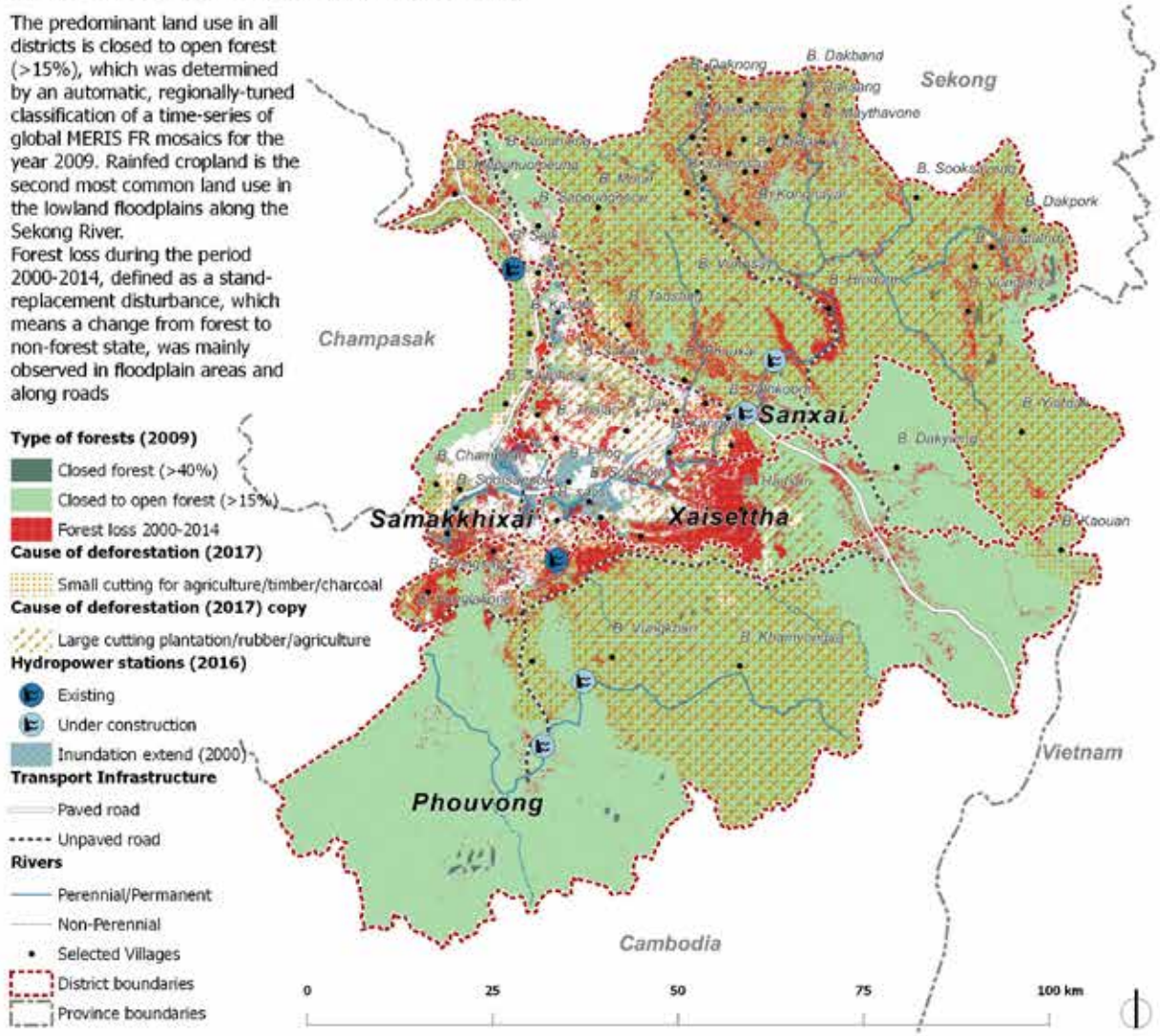
Irrigation Systems and Flooding

There are a total of 53 irrigation headworks in Attapeu Province[138], which provide water for a total irrigated area of 2,750 hectares[139]. Since irrigation infrastructure and irrigated land are both mainly concentrated in Samakkhixai District along the Xe Kong River, they are often highly exposed to flooding[140]. In Attapeu Province, almost one third (32 per cent) of irrigated land is exposed to flooding inundation of more than 2 metres[141].

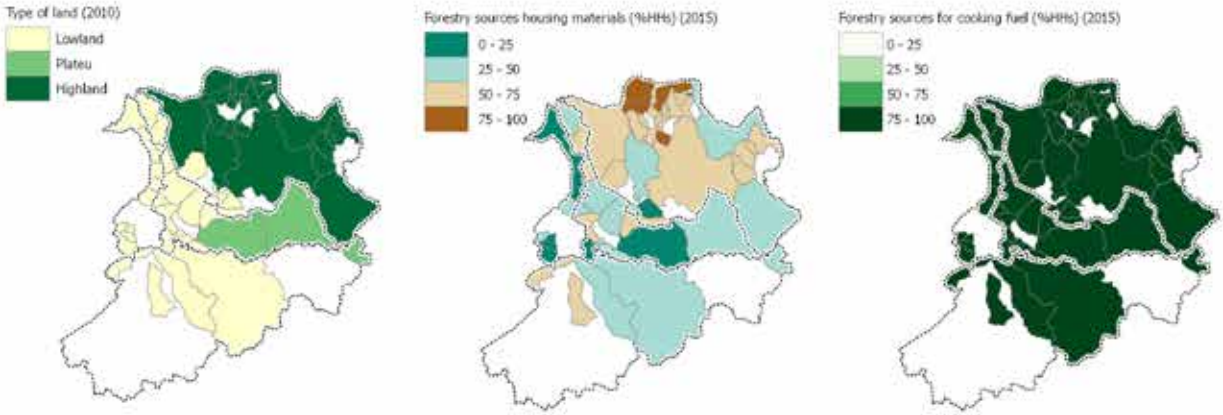
135 Ministry of Environment, Japan (2015), State of Water Resources, Outlook on Water Environmental Management in Asia 2015, p.62.
136 Ibid, p.62.
137 http://www.waterandnature.org/sites/default/files/sekong_basin_fact_sheet.pdf.
138 Risk Assessment Report Vol I, p.73.
139 Ibid, p.76.
140 Ibid, p.71.
141 Risk Assessment Report Vol II, p.28.

LAND COVER AND ENVIRONMENTAL ISSUES

The predominant land use in all districts is closed to open forest (>15%), which was determined by an automatic, regionally-tuned classification of a time-series of global MERIS FR mosaics for the year 2009. Rainfed cropland is the second most common land use in the lowland floodplains along the Sekong River.
Forest loss during the period 2000-2014, defined as a stand-replacement disturbance, which means a change from forest to non-forest state, was mainly observed in floodplain areas and along roads



TYPE OF LAND AND FORESTRY SOURCES FOR HOUSING MATERIALS AND COOKING FUEL



Data Sources: Lao Decide (www.decide.la), Population and Housing Census (2015), Lao Census of Agriculture (2010/2012), Lao Energy and Mines, 3S Rivers Protection Network (2012), Hansen/UMD/Google/USGS/NASA (2014) C-ADAPT World Food Program (2015), UN Habitat (2017)
Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Concerning the legal status of any country,territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Climate Change Vulnerability Assessment of Phouvong, Samakkhixay, Sanxay and Xaysetha Districts in Attapeu Province **ATA04**

b. Infrastructure and Basic Service Conditions

• Transport infrastructure is currently highly vulnerable to hazards. This reduces people's mobility during hazard events, particularly in the upland areas of Sanxai district.

• Limited mobile communication and electricity access in the upland areas of Sanxai District reduce communities' disaster management capacity.

• Availability of fresh water mainly relies on underground water sources, with a high proportion of households exposed to unprotected water sources and unimproved toilet facilities, which can lead to water source contamination, increasing water borne and vector diseases.

• Coverage of disaster and security services is still very limited across the province. Basic health coverage is very limited, reducing communities' potential resilience to climate hazards. Elementary schools, meanwhile, are very good at reinforcing communities' awareness and coping capacity to deal with climate hazards and have large coverage throughout Attapeu Province.

Transportation Infrastructure

Transport infrastructure is currently highly vulnerable to hazards. This reduces people's mobility during hazard events, particularly in the upland areas of Sanxai district.

Only 10 per cent of the roads in Attapeu Province were paved in 2012, all of which were national roads[142]. Current transport links to rural settlements are a network of unpaved roads and trails, where seasonal closures are frequent, especially in Sanxai and Xaisettha Districts (see map ATA5b), making these communities especially sensitive to extreme events. Since these rural areas are often located in the inundation areas of river systems, the roads and other related transportation infrastructure that they contain are highly exposed to floods.

There are 39.1 km of national roads alone in Attapeu Province that are exposed to flooding with an inundation level of above 2 metres, which is the highest inundation value in Lao PDR[143]. This also applies for a majority of Attapeu's bridges, of which 26 – about one third of the total bridges in the province – are affected by the same inundation level[144]. Samakkhixai is the most exposed district, having bridges that are subject to Lao PDR's second highest flood risk level[145]. Bridges in Samakkhixai District also face a high landslide risk[146]. Together, transportation infrastructure in this district face significant multi-risk exposure.

Overall, the selected villages in Attapeu province are very remote in terms of access by land. Only 20 per cent of the villages studied in this assessment have access to paved roads and only 15 per cent have a bus stop.

Differences among the districts are significant, however. The selected villages in Samakkhixai District are far more accessible by road than those in Sanxai or Phouvong Districts, for example, while road coverage in Xaisettha District is around the provincial average; 60 per cent of the target villages in Samakkhixai District are accessible by paved road, while 73 per cent, 88 per cent and 100 per cent of villages surveyed in Xaisettha, Sanxai and Phouvong Districts, respectively, are accessible only by a gravel road, as shown in Figure 32.

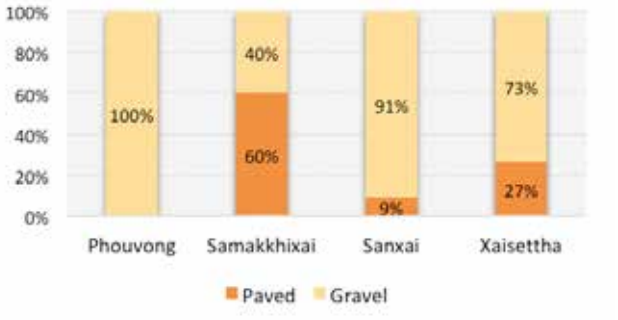


Figure 32 - Proportion of selected villages by district and type of road access

Source: Vulnerability Assessment, 2017

142 Road network statistics from 2012. Ministry of Public Works and Transport.
143 Risk Assessment Report Vol II, p.8.
144 Ibid., p.18.
145 Ibid., p.45.
146 Ibid., p.77.

According to the Vulnerability Assessment, most villages in Attapeu Province, particularly in Samakkhixai and Phouvong Districts, have reported significant damage to infrastructure from storms and floods. In Attapeu Province, 32 of the 66 target villages reported having experienced damage to infrastructure due to storms. All ten villages in Samakkhixai District, half of the target villages in Xaisetha and Phouvong Districts, and ten of the 33 villages in Sanxai District reported infrastructure damage resulting from storms.

Similarly, 29 villages across Attapeu Province reported damage to infrastructure resulting from flooding: ten each in Xaisettha and Samakkhixai Districts, six in Phouvong and four in Sanxai Districts. Only five villages in the entire dataset reported that they experienced neither floods nor storms,while 12 villages reported that they receive both a storm every year and flooding at least once every three-five years, damaging infrastructure. Eight of these villages were in Phouvong District.

Formalized collective transportation is very limited in all districts; about 75 per cent of the selected villages across Attapeu province do not have access to any kind of transportation service. In fact, only villages in Samakkhixai District, all located along the regional paved road, have bus stops, and only one has a bus station (see Map ATA05a). However, none of the villages are served by a daily bus.

Stronger storms and unusually heavy rainfall will inevitably reduce people's mobility; especially in those villages only accessible by unpaved roads along sloping land, which in turn are more exposed to landslides and flash floods. These factors isolate villagers from markets, medical facilities, schools, and other core community services. In lowland floodplains, more frequent and larger flood events will inundate vast areas, rendering transport networks inoperable or push them to failure. None of the villages surveyed in Attapeu Province have storm water drainage systems along their roads, increasing these communities' vulnerability to climate hazards.

Electricity Access

Limited mobile communication and electricity access in the upland areas of Sanxai District reduce communities' disaster management capacity

The Government of Lao PDR is focusing on expanding the electricity network into rural areas to encourage development and poverty reduction, particularly among indigenous people[147]. Access to electricity has improved considerably over the last decade, from 57 per cent in 2005 to 84 per cent of households in 2015.[148]

About 80 per cent of households in Attapeu Province have electricity access, in line with the national average. However, this hides a disparity between districts; 95 per cent of households in Samakkhixai are connected to the electricity grid, while only 70 per cent in Sanxai District are connected. Sanxai is also the district with the highest dependence on own-source of electricity in Attapeu Province, in which 10 per cent of households use either batteries or generators. In the other three districts, self-generated electricity only makes up around 3 per cent of total electricty use. The need for a personal generator increases a household's dependence on external infrastructure, particularly roads, and puts a greater burden on already fragile household incomes.

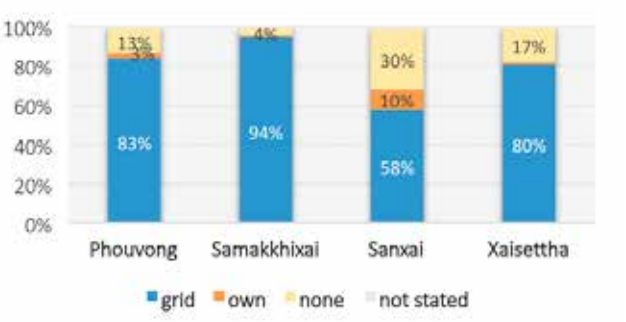


Figure 33 - Proportion of households by type of electricity source and by selected district[149]

147 http://news.xinhuanet.com/english/2017-01/09/c_135967940.htm.
148 The 4th Population and Housing Census (PHC) 2015. Lao Statistics Bureau.
149 Ibid.

The mobile repeater and communication network are well distributed across all the target districts in the province (see map ATA5a). According to the 2015 Census, however, household ownership of cell phones is unevenly distributed., which is a problem as cell phones can play a vital role in disaster preparation and for early warning and communication during and after emergencies. While Samakhixai and Xaisettha's household coverage of cell phone possession (89 per cent and 83 per cent, respectively) is close to the national average (86 per cent), Phouvong and Sanxai's access to cell phones is considerably more limited (74 per cent and 66 per cent, respectively).

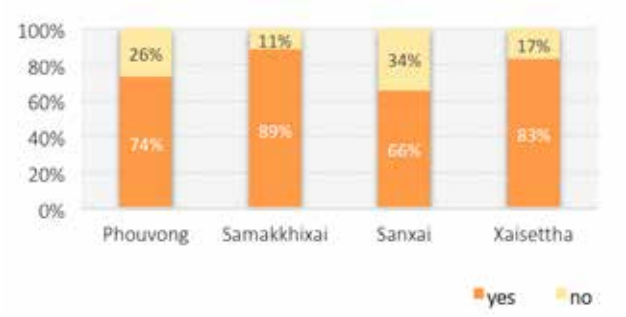


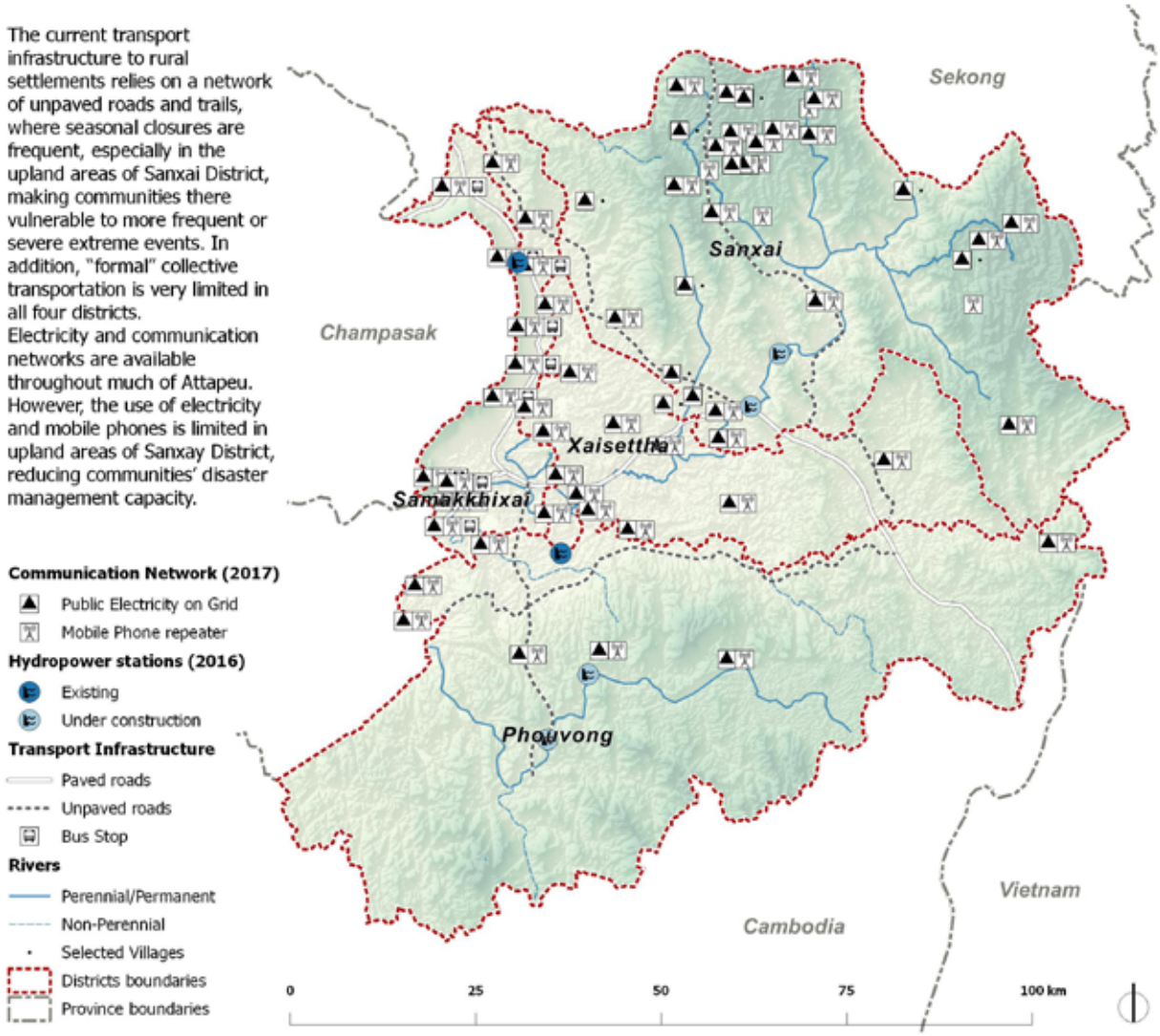
Figure 34 - Proportion of households having mobile phones by selected district[150]

Considering access to transport, electricity and communication infrastructure together, as shown in map (ATA05a), villages in the northern area of Sanxai District are more sensitive to climate hazards, and are therefore more likely to be seriously impacted when hazards occur. These constraints already jeopardise rural livelihoods, particularly during and after extreme events, which will become more frequent due to projected changes in the climate.

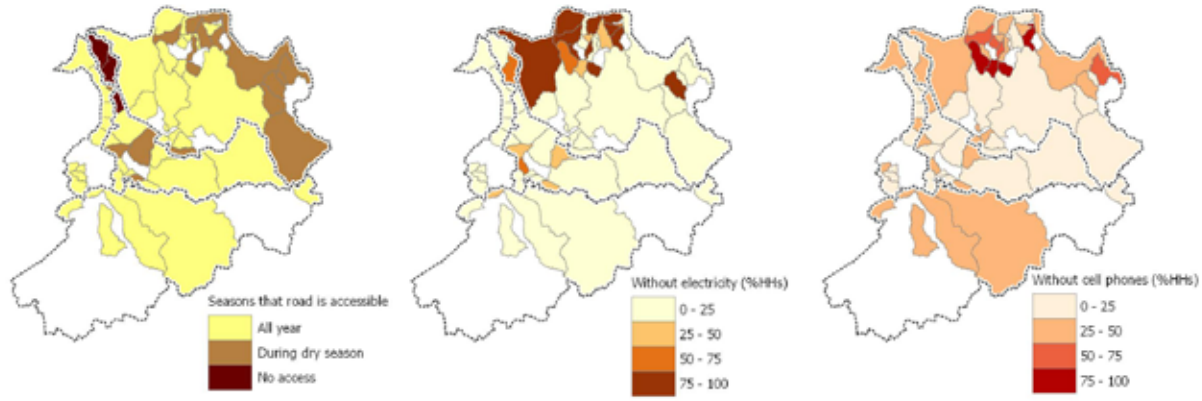
150 Source: The 4th Population and Housing Census (PHC) 2015.

SPATIAL DISTRIBUTION OF MAIN TRANSPORT AND COMMUNICATION INFRASTRUCTURE

The current transport infrastructure to rural settlements relies on a network of unpaved roads and trails, where seasonal closures are frequent, especially in the upland areas of Sanxai District, making communities there vulnerable to more frequent or severe extreme events. In addition, "formal" collective transportation is very limited in all four districts.
Electricity and communication networks are available throughout much of Attapeu. However, the use of electricity and mobile phones is limited in upland areas of Sanxay District, reducing communities' disaster management capacity.



ACCESS TO ROADS, ELECTRICITY AND CELL PHONES IN SELECTED VILLAGES



Data Sources: Lao Decide (www.decide.la), Population and Housing Census (2015), Lao Census of Agriculture (2010/2012), Lao Energy and Mines, Global Energy Network Institute, 3S Rivers Protection Network (2012), UN Habitat (2017)
Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Concerning the legal status of any country,territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Freshwater Availability

Availability of fresh water mainly relies on underground water sources, with a high proportion of households exposed to unprotected water sources and unimproved toilet facilities, which can lead to water source contamination, increasing water borne and vector diseases.

According to the 2015 Census, three quarters households in the targeted districts across the province depend on underground sources for drinking water. Wells and/or boreholes are the main underground source of water in all of the districts, followed by bottled water. Bottled water is especially common in the lowland districts where incomes tend to be higher. The proportion of bottled water as the main source of drinking water is especially high in Samakkhixai (45 per cent) and Xaisettha (26 per cent) Districts. The fact that households with disposable income choose bottled water is evidence of poor water quality.

Villages in Xaisettha and Phouvong Districts mainly depend on underground water sources[151], the proportion of which is similar to the Province's average of about 80 per cent. Households in Samakkhixai are the least dependent on surface water sources, with only 7 per cent using them[152]. Sanxai District is the most dependent on surface water sources, with 63 per cent of households relying on surface water as their primary water source, due to its mostly upland geography.

Wells and/or boreholes are the main underground source of water in all the districts followed by bottled water. Bottled water is especially common in the lowland districts, where incomes tend to be higher. The proportion of bottled water as the main drinking water source is especially high in Samakkhixai (45 per cent) and Xaisettha (26 per cent) Districts, respectively. That households with disposable income choose bottled water is evidence of poor water quality. Piped water is rare in Samakkhixai and Xaisettha, and almost non-existent in Sanxai and Phouvong Districts. Sanxai District is the most dependent on surface water sources, because of its upland geography. While surface water is simpler to extract than underground water, it is also less reliable and more prone to drought and contamination, and is therefore more likely to be unavailable in the future, when the dry season is projected to be longer and hotter[153].

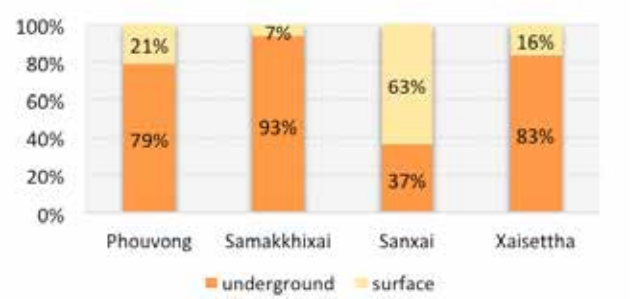


Figure 35 - Proportion of households by district and by main natural source of drinking water

According to the survey conducted for the vulnerability assessment, villages in Sanxai District are the most dependent on gravity-fed water systems and rainwater harvesting as their main source of drinking water; 67 per cent and 15 per cent of villages, respectively. In Phouvong and Samakkhixai Districts, hand pumps were the most common means to access water; in 90 per cent and 100 per cent of villages, respectively. Xaisettha District had the highest proportion of villages with formal water supply infrastructure (20 per cent), but also the highest proportion of villages without any access to a regular water source (27 per cent).

Some villages in Xaisettha (27 per cent of those surveyed) reported having irrigation systems, thanks to their location along the Xe Kong river banks. However, these systems are impacted by flooding during the rainy season.

Access to protected water sources is mixed across the districts. While the provincial average is 63 per cent, 84 per cent of households in Samakkhixai District get their water from protected sources. Sanxai, Xaisettha and Phouvong Districts were closer to the provincial average with 71, 68 and 62 per cent of households, respectively, getting their water from protected sources.

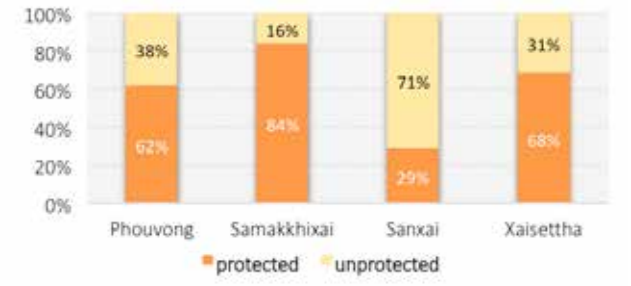


Figure 36 – Proportion of households by type of water facility and by district[154]

151 Underground water sources: wells; boreholes; piped and bottled.
152 Surface water sources: river, stream, dam, mountain, rain.
153 The 4th Population and Housing Census (PHC) 2015.
154 Source: The 4th Population and Housing Census (PHC) 2015.

Table 4 - Proportion of selected villages by district and by type of water supply and distribution systems

	Deep well	Rain harvesting	Rand pump	Water network	Gravity System	SWS Tank + Well	Small water system (SWS)	Irrigation	None
Phouvong	100%	0%	0%	13%	0%	13%	0%	0%	0%
Samakkhixai	90%	0%	0%	10%	10%	0%	10%	0%	0%
Sanxai	24%	15%	3%	0%	67%	0%	0%	3%	6%
Xaisettha	13%	7%	13%	20%	13%	0%	0%	27%	27%

Source: Vulnerability Assessment, 2017

Around 50 per cent of selected villages in Attapeu province reported that temperature increases, rainfall variation and drought had impacted water availability. This has been particularly observed in Phouvong and Samakkhixai Districts, where all villages surveyed reported that climate change is causing a lack of water. The current proportion of households exposed to unprotected water sources, along with the projected changes in precipitation patterns and the projected increase in mean temperature, can easily lead to higher risks of water borne diseases. This is especially so once we consider the projected increase in the occurrence of droughts, which reduce the overall quantity of water[155].

In addition, numerous sources indicate very limited sanitation coverage in all four target districts. According to the 2015 Census, nearly 50 per cent of households in Sanxai, Xaisettha and Phouvong Districts use unimproved sanitation facilities that are more likely to contaminate water sources, which can lead to water and vector-borne diseases. Phouvong District has the greatest level of sensitivity to these hazards, as only 35 per cent of households have access to improved sanitation facilities, compared to 66 per cent in Samakkhixai District. Villages in Phouvong District are particularly sensitive to contaminated water due to their location in lowland areas and the frequency floods experienced by a high proportion of its villages[156].

Northern and central villages in Sanxai District show the highest levels of unreliable and unsafe drinking water as well as very limited use of sanitation facilities (see map ATA5b). Most of the selected villages in the province depend on groundwater sources, which will be affected by climate change as aquifers take longer to recharge, resulting in the need for further investments in infrastructure improvement, such as increased tank capacity and borehole depth.

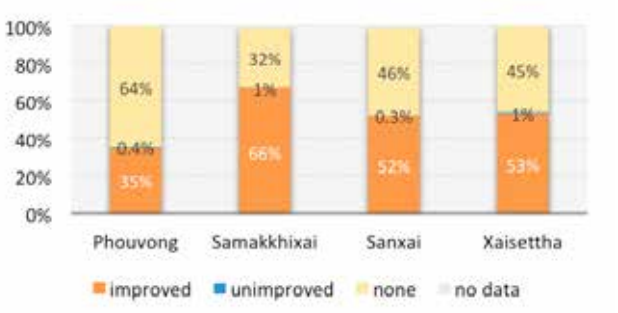


Figure 37 - Proportion of households by district and by type of toilet in targeted districts[157]

Health and Education Facilities

The coverage of disaster and security services is still very limited across the province. Basic health coverage is very limited, reducing communities' potential resilience to climate hazards. Elementary schools, meanwhile, are very good at reinforcing communities' awareness and coping capacity to deal with climate hazards and have large coverage throughout Attapeu Province.

The network of health services in Lao PDR is structured into four levels: (i) Primary health-care services; (ii) Intermediate level health-care services; (iii) High-level health-care services; and (iv) Advanced health-care services[158].

Primary health-care services include the medical treatments provided at the community and sub-district level. Village drug kits provide essential drugs and health care to people in remote areas, mostly inhabited by ethnic minorities, and in geographic locations where there are no health centres. Health staff consist of village assistant physicians or village public-health volunteers and traditional birth attendants, all of whom have

155 ICEM Database, 2014.
156 Vulnerability Assessment, 2017.
157 The 4th Population and Housing Census (PHC) 2015.
158 Law on Health Care, No. 09/NA. 9 November 2005.

basic medical instruments. They distribute drugs, offer consultations and treatment for non-life-threatening illnesses, including diarrhoea, malaria, flu and minor wounds, and assist in home births.

Health centres have trained medical staff[159] and provide health care service for a village or for a group of villages. Higher-level treatments than those provided by the village drug kits are available at health centres, such as treatment for chronic diarrhoea, prolonged flu, wound suture, vaccination and assistance with more complicated childbirth.

Phouvong has the lowest coverage of primary health care of the four targeted districts, having only one health centre in the entire district and otherwise relying on village drug kits (in 75 per cent of selected villages). In Xaisettha, 27 per cent of the selected villages have a health centre. However, communities reported a continued lack of physicians and midwifes. Similarly, in Sanxai District, only 15 per cent of the villages have access to a doctor, meaning that only half of the health centres have a doctor on duty, as well as a lack of trained midwives. Samakkhixai District performs slightly better than the average, with 30 per cent of villages having a health centre. Some of the villages in Samakkhixai without a health centre or doctor do have midwives and birth attendants, however.

Table 5 - Basic Health Services by District[160]

	Drug / 1st Aid kits	Health Centre	Doctor	Midwife
Phouvong	75%	13%	13%	13%
Samakkhixai	40%	30%	30%	50%
Sanxai	3%	27%	15%	0%
Xaisettha	0%	27%	0%	0%

Education

Compulsory education in Lao PDR comprises elementary, lower-secondary and upper-secondary school. Elementary school takes five years to complete and is compulsory. Lower-secondary school takes four years to complete and upper-secondary school takes three years to complete, for a total of 12 years of compulsory basic education[161]. There are two types of primary school: complete and incomplete. Due to some infrastructure constraints, incomplete primary schools do not provide a complete primary education up to grade 5. Most of the incomplete primary schools are rural and remote areas. Students who are unable to travel to a complete primary school in another location often drop out of school before their primary education is complete[162]. The National School Construction Guidelines set the minimum standards that must be met in school construction, including key safety measure to protect against natural hazards[163].

All surveyed villages in Attapeu Province have good primary school coverage, forming a good basis to reinforce communities' awareness and coping capacity to deal with climate hazards.

The Prime Minister's Decree No. 220/PM[164] established Disaster Prevention and Control Committees (DPCCs) at national, provincial, district and village levels to look after Disaster Risk Management (DRM) issues in Lao PDR. At community level, Village Disaster Prevention Units (VDPU) and Village Disaster Prevention and Control Committees (VDPCC) are responsible for the implementation of their village's Community-Based Disaster Risk Reduction (CBDRR) planning and for training communities on what to do before, during and after disaster events.[165]

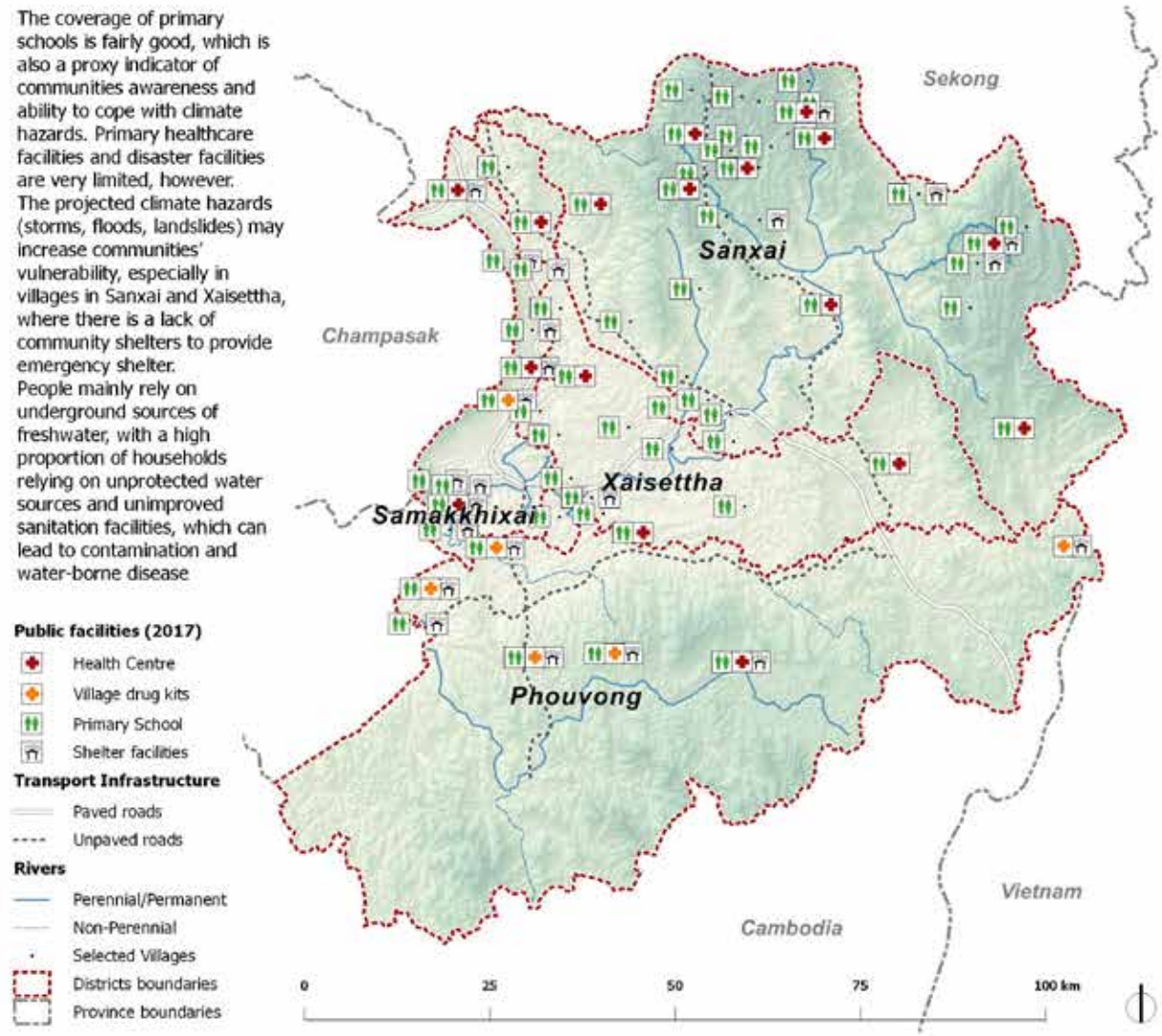
79 per cent of the target villages in Attapeu Province have a disaster committee and 61 per cent have some form of disaster facility. However, in Samakkhixai and Phouvong Districts, despite the existence of disaster committees (in 90 per cent and 63 per cent of the villages, respectively), neither have any disaster facilities. Comparatively, in Sanxai District, 79 per cent of the villages have both a disaster committee and disaster facilities. In Xaisettha District, on the other hand, there are some villages (13 per cent) without a disaster committee despite the existence of the respective disaster facilities.

The projected stronger rains and cyclones may increase communities' vulnerability, especially those villages which lack community shelters, such as critical emergency shelter or public buildings (health centres and schools), or for villages who's buildings are not disaster resilient and therefore cannot be used in the case of storms and floods.

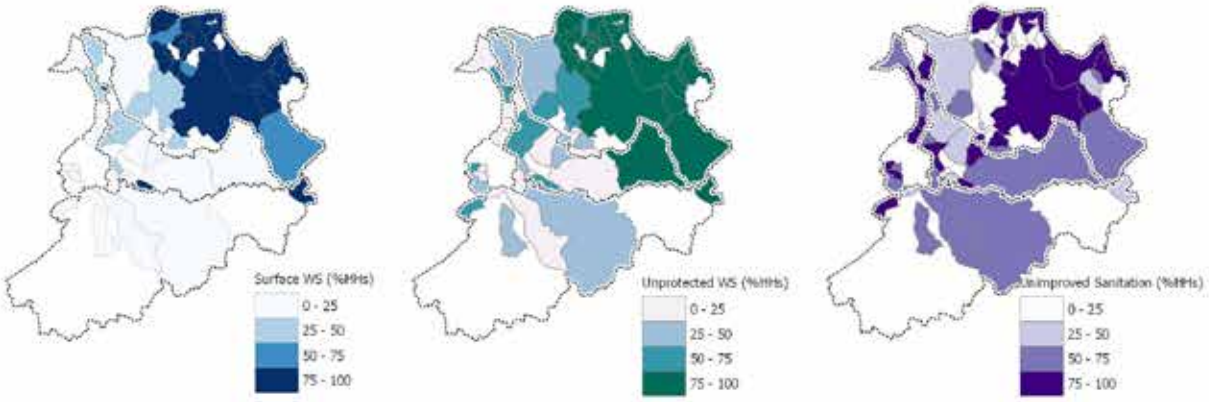
159 physicians, assistant physicians, nurses, and midwives.
160 Source: Vulnerability Assessment, 2017
161 Law on Education No. 149/PDR Vientiane Capital City dated 17/07/2007
162 Education for All 2015 National Review. National EFA 2015 Review Report, Lao PDR August 2014
163 MoES, 2009.
164 28 August 2013.
165 Community-Based Disaster Risk Reduction (CBDRR) Manual in Lao PDR, MoNROE.

SPATIAL DISTRIBUTION OF MAIN PUBLIC FACILITIES AND BASIC SERVICES

The coverage of primary schools is fairly good, which is also a proxy indicator of communities awareness and ability to cope with climate hazards. Primary healthcare facilities and disaster facilities are very limited, however. The projected climate hazards (storms, floods, landslides) may increase communities' vulnerability, especially in villages in Sanxai and Xaisettha, where there is a lack of community shelters to provide emergency shelter. People mainly rely on underground sources of freshwater, with a high proportion of households relying on unprotected water sources and unimproved sanitation facilities, which can lead to contamination and water-borne disease



ACCESS TO WATER SOURCES AND SANITATION FACILITIES IN SELECTED VILLAGES



Data Sources: Lao Decide (www.decide.la), Population and Housing Census 2015, Lao Census of Agriculture 2010/2012, UN Habitat
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UN HABITAT FOR A BETTER URBAN FUTURE

Climate Change Vulnerability Assessment of Phouvong, Samakkhixay, Sanxay and Xaysetha Districts in Attapeu Province **ATA05b**

c. Socio Economic Conditions

Poverty continues to be a pressing challenge for Attapeu Province. However, on the surface, Attapeu's poverty rate of 18.9[166] per cent is low compared to the national poverty rate of 24.8 per cent[167]. Xaisettha and Samakkhixai have fairly low poverty rates, 12.9 and 13.4 per cent respectively, whereas the poverty rate in Sanxai and Phouvong Districts are closer to the national average, at 22.5 and 22 per cent, respectively[168]. Attapeu's poverty gap index is also fairly low, at 4.6 per cent, with Xaisettha and Samakkhixai having especially low poverty gaps, of 2.8 and 3.1 per cent. Sanxai and Phouvong have higher gaps, however, at 6.1 and 5.2 per cent[169], respectively, closer to the national average of 6 per cent[170].

The assessment team was not able to conduct a local income survey due to the time and complexity of conducting such an exercise. However, the main sources of livelihoods were analysed. Livestock farming was the most common livelihood source, with 63 of the 66 villages indicating a dependence on it. 43 of the villages also reported dependence on agriculture, including almost all of the villages in Xaisettha, Samakkhixai and Phouvong. Curiously, only eight of the 33 villages surveyed in Sanxai District reported dependence on agriculture (compared with 30 villages in Sanxai which are dependent on livestock). 37 villages also reported dependence on casual labour.

This assessment assumes that having multiple sources of incomes makes a village more resilient. If people are flexible to move between agriculture, livestock and manual labour as conditions dictate, they are less likely to be seriously affected by climate related hazards or disasters. Dependence on only one livelihood, however, increases vulnerability. If, for example, a family (or an entire village) is dependent on agriculture, and a flood damages their crops, those villagers would not have other income sources to fall back on.

The assessment surveyed the presence of seven different types of livelihood. Figure 38 shows the number of villages in each of the four districts that reported dependence on each of the seven different livelihood sources. Villages could select more than one livelihood source per village. This simple analysis shows that agriculture and livestock farming are the dominant income sources across the four districts. This is indicative of high levels of sensitivity to climate change, as agriculture especially is generally more highly impacted by both extreme events and slow-onset changes such as temperature change

Only two villages in Attapeu reported dependence on manual labour in industry, and only 5 on trading goods. Seven villages throughout Attapeu reported dependence on only one livelihood source. This lack of diversification (especially when the primary livelihood source is agriculture) is also indicative of a high level of sensitivity.

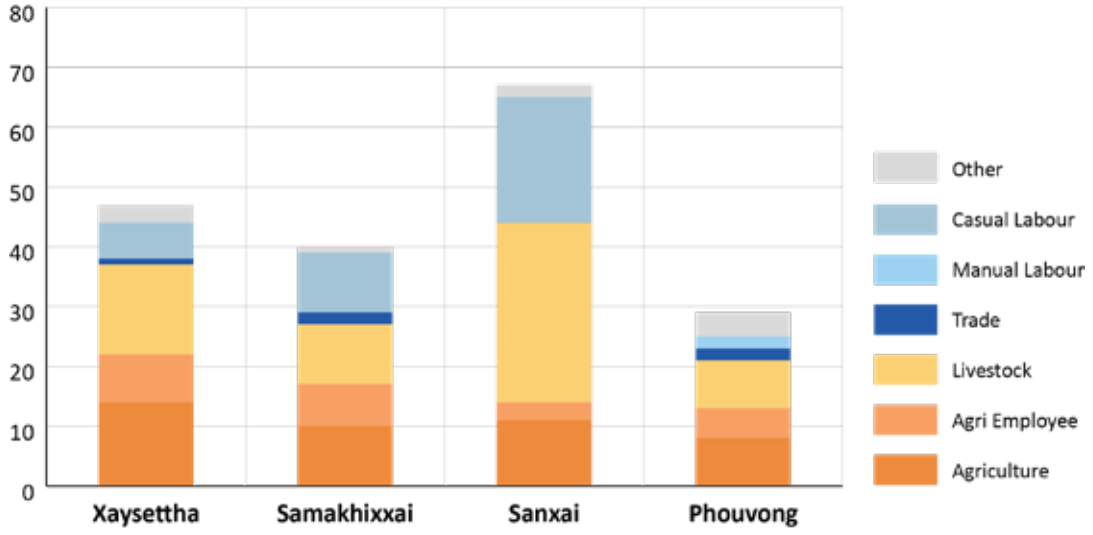


Figure 38 - Number of Villages in each district dependent on a given livelihood source

166 Coulombe et al (2016) Where are the Poor? Lao PDR Census-based Poverty Map: Province and District level Results, Lao Statistics Bureau, the World Bank, p.98.
167 Ibid, p.21.
168 Ibid, p.99.
169 Ibid, p.98-99.
170 Ibid., p.21.

Unemployment rates are very low in Attapeu – averaging 1 per cent across the province. Even the district with the highest rate of unemployment, Samakkhixai, has an unemployment rate of only 2 per cent.

The dependency rate (also described as the percentage of people who are economically inactive) is 40.6 per cent in Attapeu Province, which is slightly higher than the national average of 37.2 per cent. Sanxai and Phouvong Districts have higher dependency rates, at 48.1 and 40.6 per cent, respectively. Dependency is lower in Xaisettha and Samakkhixai, at 36.5 per cent and 36.9 per cent, respectively. A high dependency rate is indicative of a greater level of sensitivity and lower adaptive capacity because there are fewer income earners per household. Under this assumption, Sanxai District shows the highest level of sensitivity as it has little livelihood diversity and a high dependency rate – more than 10 per cent higher than other districts in Attapeu Province.

The data on dependency is not gender disaggregated. However, evidence from Lao PDR and elsewhere suggests that high rates of economic inactivity generally correlate with large numbers of women outside of the formal economy. This assumption is supported by the percentage of women in non-agricultural employment, which is below the national average of 37.2 per cent in all four target districts in Attapeu (see table 6). If we assume that those outside the formal economy (i.e. without their own source of income from a livelihood) are more vulnerable, then women's vulnerability is greater than that of men.

Table 6 - Percentage of women in non-agricultural employment[171]

District	Percentage of Women in non-agricultural employment
Xaisettha	32.2
Samakkhixai	33.6
Sanxai	28.1
Phouvong	25.9
National Average	37.2

The literacy rate in Attapeu Province for 15-64 year olds was 76.2 per cent in 2015. This is slightly worse than the national average of 79.4 per cent for the same age group. However, Xaisetha, Sanxai and Phouvong Districts have literacy rates below that of the provincial average, and well below the national average:

Table 7 - Literacy Rates in Attapeu Province, percentage[172]

	Literacy Rate – 15-25 year olds	Literacy Rate – 15-64-year olds
Xaisetha	81.7	71.4
Samakkhixai	95.5	90.2
Sanxai	84.5	64.3
Phouvong	75.7	64.2
National Average	92.0	82.5

Net school enrolment rates remain low throughout Attapeu Province, and are particularly low in the more remote areas of Sanxai District. The national average net school enrolment rates for primary, lower secondary and upper secondary were 75.5 per cent, 41 per cent and 21.7 per cent, respectively, in 2015 with virtually no gender disparity[173]. The corresponding rates for Attapeu were 70.1 per cent, 31.3 per cent and 14.9 per cent for primary, lower secondary and upper secondary[174]. As shown in the Table 8, access to secondary schools, particularly upper secondary schools, is still virtually non-existent outside of the main district towns in Xaisetha, Sanxai and Phouvong Districts.

Table 8 - School Enrolment in Attapeu Province

	Primary Enrolment	Lower Secondary Enrolment	Upper Secondary Enrolment
Xaisetha	68.2	31.3	13.8
Samakkhixai	79.3	47.6	27.5
Sanxai	58.7	20.2	8.1
Phouvong	59.9	18.5	6.71
National Average	75.5	41.0	21.7

At least some of this low school enrolment can be explained by access. In Sanxai District, only 5 of the 33 villages surveyed (15 per cent) had even a partial high school, and none had access to a technical or vocational college. Of the five villages that do have a high school, only two are connected by a paved road, which makes access challenging, especially in the rainy season.

171 Ibid. p.114-115.
172 Ibid, p. 106-107.
173 Ibid, p.21.
174 Ibid, p.106.

4.5 Adaptive Capacity: Spatial Structure of the Province

• Sanxai District has the highest percentage (40 per cent) of selected villages categorised as Local Rural Villages (LRV), which have the lowest level of socio-economic and infrastructure development.

• The territorial and socio-economic development of the region is mainly centred on the village of Meouhuomeung Village in Samakkhixai District and the set of settlements between Saysi in Xaisettha and Vungkhan in Phouvong. All of these villages or settlements are strategically located in lowland areas and at the junctions of international and national main roads.

• Meouhuomeung Village has greater levels of education facilities and security services and acts as the main market for neighbouring rural communities. Saysi and Vungkhan Villages are the most productive areas in the region, with a timber processing factory and large-scale rice and maize plantations.

• Better transportation infrastructure across villages in lowland areas enables better access to socio-economic services than in highland villages.

The aim of this chapter is to present a comprehensive spatial analysis of the current situation, in order to guide the socio-economic and infrastructure development of the region in the short and medium-term and to influence planners at the provincial and district levels, who will be able to use the findings to make more informed, strategic planning decisions in the long-term. At this initial phase, the spatial analysis only considers the selected villages in the four target districts. However, understanding the spatial and territorial linkages at the village level provides a good basis for future analysis of the linkages at provincial and district levels.

The spatial and territorial analysis uses the **Matrix of Functions (MoF)** to:

- Determine a functional hierarchy of human settlements among the selected villages, based on the current availability of critical infrastructure and socio-economic services.
- Visualize how balanced the infrastructure and socio-economic development of the region is and, most importantly, identify the degree of territorial linkages between settlements.
- Support national, regional, and local government decision-making to focus and prioritize strategic interventions towards more balanced territorial development patterns.

Functional Hierarchy of Human Settlements

The analysis is based on the data collected in the selected 189 villages for inventorying the presence of 86 functions, categorized by economic, administrative, social, or cultural function. The complete list of functions inventoried is presented in Annex A1.

Data collected was fed into an unordered Matrix of Functions spreadsheet, where columns show functions and rows are villages. Sorting by *function weight*[175] and *centrality score*[176], the "ordered matrix" established the groupings of basic, intermediate, and central human settlements, and determined a "set of functions" that should be covered for each category in the context of the region[177].

The Matrix of Functions and the centrality index show that basic, intermediate, and central villages are identified by establishing one or more levels of separation whenever an important gap appears between two successive values of the index. For further information, refer to Annex A1 Methodology of the Matrix of Functions.

The functions were then analyzed to define a profile of each category based on the combination and diversity of specific provisioning eco-system services, physical infrastructure, and social and economic activities.

Of the 86 functions inventoried, only 67 functions are present in at least one of the selected villages in Attapeu

175 It is obtained by adding up the number of times a function occurs, which is the function frequency, divided by 100 to obtain the function weight.
176 The "centrality score" is calculated by adding up the weights of all functions present in each administrative unit.
177 Refer to Annex MoF for a complete explanation of the methodology and detailed matrix of ordered functions.

Province, and mostly pertain to eco-system provisioning services, basic infrastructure and public services.

All settlements show weak economic development as they primarily rely on agriculture and livestock farming, with only some villages having mining operations and hydropower production.

Table 9 - Types of human settlements identified

Type	Local Rural Villages (LRV)					
Centrality Score	13.3-56.9	Level of hierarchy		1	2	
Main characteristics	This type of village shows the lowest level of socio-economic and infrastructure development. Transportation infrastructure is limited to tracks/trails and unpaved roads. However, mobile repeaters and electricity from the grid are widely accessible. Gravity feed systems and deep hand pump wells are the main water facilities available. Only basic education coverage is provided, and residents' basic needs are provided through small groceries and street sellers. Livestock farming is the main economic activity, together with some casual labour work and vehicle repair garages.					
Functions	15 functions					
Villages	27 Villages (41%), mainly located in highland areas					
Type	Intermediate Rural Villages (IRV)					
Centrality Score	59.2-324.8	L of hierarchy	3	4	5	6	7
Level of Development	These villages have access to better transportation and communication facilities (paved roads, daily bus transportation, bus stops and petrol stations), which allow for the presence of health facilities and services (drug kits, health centres, doctors and dentists), and for more education facilities (kindergarten and high schools) than the previous category. The greater number of agricultural crops (rice, coffee, maize) allow employment jobs related to agriculture and to farmer cooperatives.					
Functions	39 functions (15 from the previous category)					
Villages	35 villages (53%), mainly located in lowland areas					
Type	Main Rural Villages (MRV)					
Centrality Score	359.9-522.10	Level of hierarchy	8	9	10	
Level of Development	This type of village has the highest level of socio-economic and infrastructure development, including greater availability ofwater supply facilities. The presence of commercial establishments (construction material shops, furniture shops, restaurants, general markets and ATMs) and business and industrial opportunities (hydroelectric power production, mining exploitation and a wood processing factory) allow a greater range of private industry professionals, such as electricians, plumbers, industry/ manufacturing employment and vocational training centre instructors. In addition, this category provides more security services (the presence of a police station) and cultural and recreational facilities (the presence of a library)					
Functions	67 functions (39 from the previous category)					
Villages	3 villages (6%), Meouhuomeung in Samakkhixai District and the set of settlements between Saysi in Xaisettha and Vungkhan in Phouvong					

Territorial Linkages and Infrastructure and Socio-Economic Development

As shown in map ATA06, an analysis of the spatial distribution of the types of settlements, representing hierarchy levels based on isopleths[178], allows for drawing some assumptions regarding the balance of spatial development in the region, as well as the degree of "territorial influence" of each settlement over neighbouring settlements (if any):

The territorial and socio-economic development of highland areas in Sanxai district is lower than in the lowland areas in Xaisettha, Samakkhixai and Phouvong districts.

The territorial and socio-economic development of the region is mainly centred around the village of Meouhuomeung in Samakkhixai District and the cluster of settlements around Saysi in Xaisettha District and Vungkhan in Phouvong District. All three of these settlements are strategically located in lowland areas and at the cross-junctions of main roads (international and national roads). Meouhuomeung (Samakkhixai) provides the highest levels of education facilities and security services and acts as the main market for its neighbouring rural communities. Saysi and Vungkhan are the productive area of the region, with timber processing factories and large-scale rice and maize plantations.

40 per cent of villages in Sanxai District are categorized as Local Rural Villages (LRVs), which are those with the lowest level of socio-economic and infrastructure development. The lack of adequate transportation infrastructure coupled with access to only basic education are the main constraints for the socio-economic development of northern highland areas. Further, residents in these settlements mainly rely on subsistence agriculture in the form of shifting cultivation and livestock.

Better transportation infrastructure across villages in lowland areas enable better access to socio-economic services compared to highland villages.

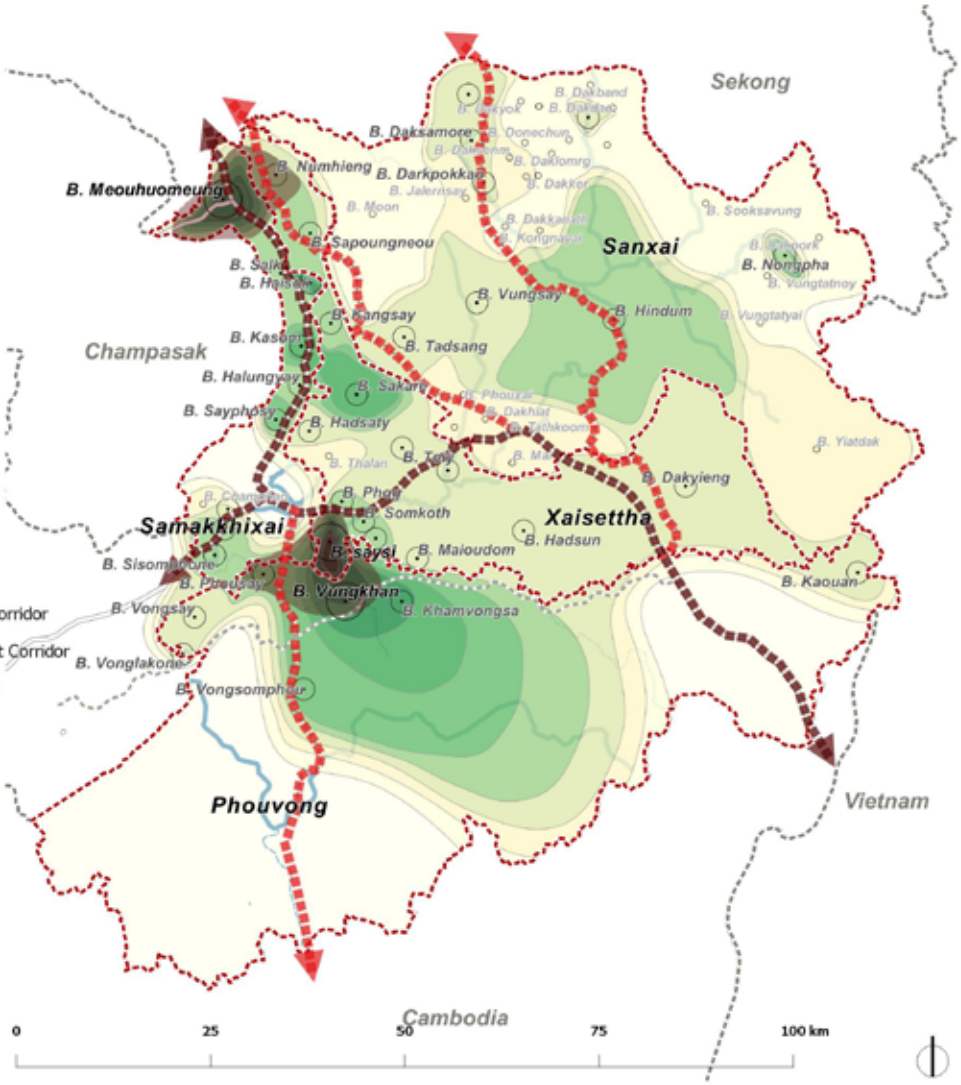
In villages with greater access to main roads and therefore to transportation, there tends to be greater coverage of public services and more economic opportunities.

Most of the Intermediate Rural Villages (IRVs) are located along the Xe Kong River and at the junction of national and international roads, which facilitates better public service coverage, especially of health and education services. These villages also have a greater diversity of economic activity than more isolated settlements, where only basic education and few other public services are available.

178 NB: In meteorology, an isopleth indicates a geographical line connecting points showing an equal level of incidence of a specific meteorological feature. In the case of the MoF, the term is used to indicate a geographical line representing a specific aggregate ranking.

TERRITORIAL LINKAGES AND SPATIAL STRUCTURE

The territorial and socio-economic development of the region is mainly centred on the village of Meouhuomueng in Samakkhixai District and the cluster of settlements around Saysi in Xaisettha District and Vungkhan in Phouvong District, strategically located in the lowland areas and at the junctions of major roads. The lack of adequate transportation infrastructure is the main constraint for the socio-economic development of northern highland areas in Sanxay District.



Spatial structure

- Primary Development Corridor
- Secondary Development Corridor
- Main clusters of villages

Type of villages

- CRV
- IRV
- LRV

Level of hierarchy

- Level 1
- Level 2
- Level 3
- Level 4
- Level 5
- Level 6
- Level 7
- Level 8
- Level 9
- level 10

Transport Infrastructure

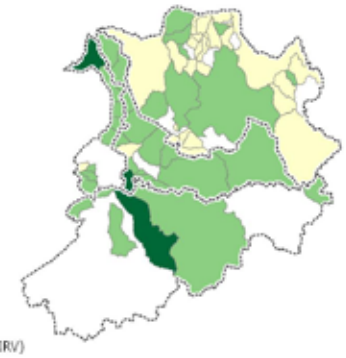
- Road
- Trail

Rivers

- Perennial/Permanent
- Non-Perennial
- Districts boundaries
- Province boundaries

SPATIAL DISTRIBUTION OF THE TYPE OF VILLAGES

Sanxai district concentrates the highest percentage (40%) of selected villages categorised as Local Rural Villages (LRV). While most of the Intermediate Rural Villages (IRV) are located located along the Xe Kong river and national/internationa/pr axes of transportation in in Xaisettha, Samakkhikay and Phouvong districts



Type of villages

- Central Rural Village (CRV)
- Intermediate Rural Village (IRV)
- Local Rural Village (LRV)

Data Sources: Lao Decide (www.decide.la), Population and Housing Census 2015, Lao Census of Agriculture 2010/2012, UN Habitat
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4.6 Impact Index

To understand and visualize villages' vulnerability, the assessment prepared impact and vulnerability indices. A more detailed methodological note on these tools is provided in Annex 3.

The impact index was calculated using the indicators shown in Figure 40. The index attempts to find which villages have experienced the greatest impacts, based on data from the census and the vulnerability assessment survey.

Mapping the calculations derived from the index show that villages throughout the four districts face severe impacts (shown in Map ATA07a). In particular, each of the four districts has a cluster of villages that have faced repeated extreme events. This is very problematic because where an isolated village is impacted, people may still be able to access markets and services in neighbouring villages, whereas when clusters of villages are affected it affects not only a greater number of people, but means people are unlikely to be able to access markets and services nearby. This means that where there are clusters of impacted villages, the effects are greater and the capacity of people to recover is reduced..

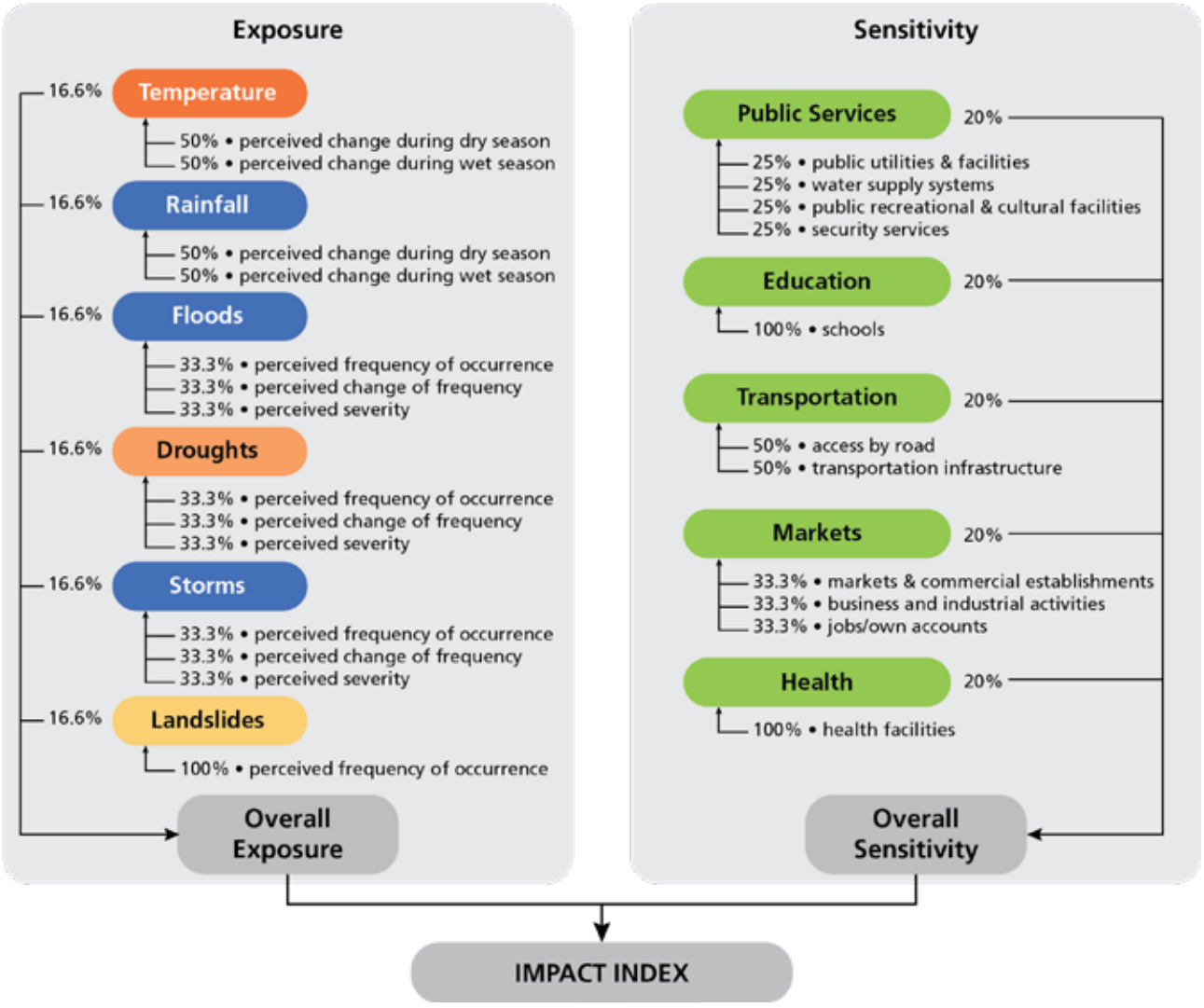
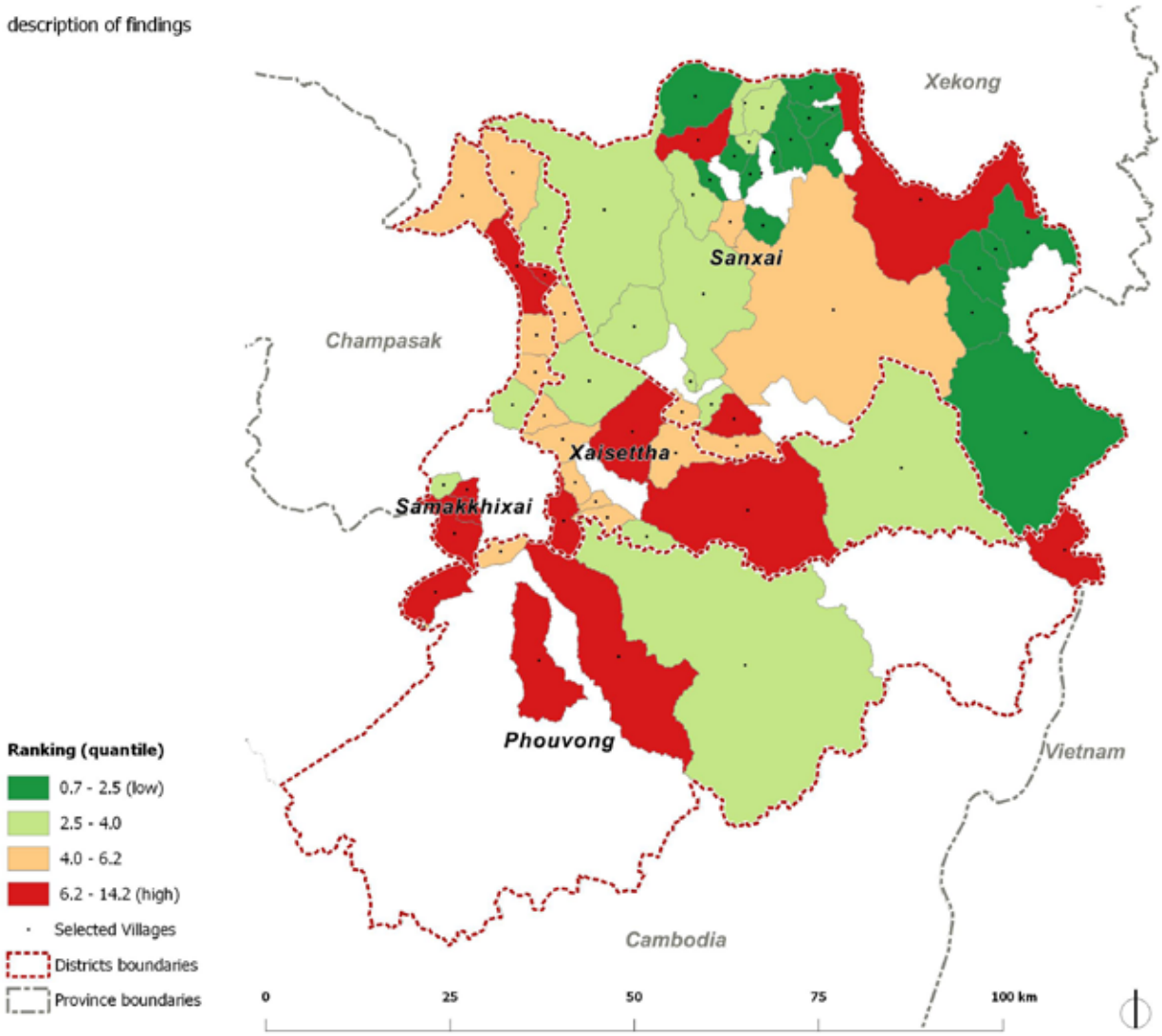


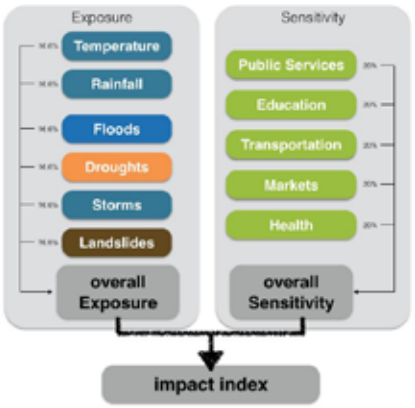
Figure 40 - Method for calculating the Impact Index

IMPACT INDEX

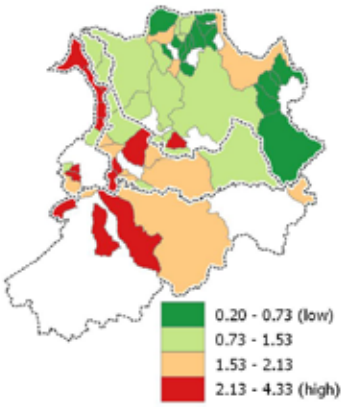
description of findings



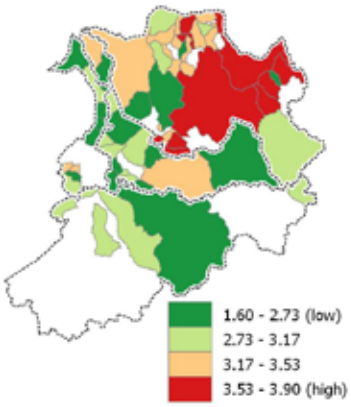
VULNERABILITY



EXPOSURE



SENSITIVITY



Data Sources: Lao Decide (www.decide.la), Population and Housing Census 2015, Lao Census of Agriculture 2010/2012, UN Habitat (2017)
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4.7 Vulnerability Index

The impact index does not, however, reveal villages' and people's capacity to respond to climate change impacts. As outlined in Section 3, vulnerability is composed of three elements: exposure, sensitivity and adaptive capacity. To gain a more complete picture of vulnerability, and thereby inform resilience building activities, the assessment team also developed a vulnerability index for the target villages, shown in Figure 41. Exposure was calculated in the same way, but sensitivity was expanded, and the equation then considered adaptive capacity. The difference in the methodology is also explained in Annex 3.

The vulnerability index shows high vulnerability levels in clusters throughout Attapeu Province, with each of the four districts having highly vulnerable villages. In Sanxai and Phouvong Districts, this is because people have very little capacity to respond to climate change, as indicated by limited public services, economic activities and very weak socio-economic indicators. In Samakkhixai and Xaisettha Districts, despite higher levels of development, indicating greater adaptive capacity, people are exposed to regular flooding and storms, which contributes to high overall vulnerability.

Overall vulnerability is lowest in the Attapeu, compared to the other provinces studied by this assessment. However, that is not to say that Attapeu is resilient to climate change. However, if we look across the whole project to villages classified as having moderate or greater levels of vulnerability – those that appear in the top half of rank-ordered villages in the index, 20 of the 66 villages surveyed in Attapeu appear, including three in Samakkhixai District, two in Xaisettha District, eleven in Sanxai District and four in Phouvong District. This shows that while, according to the vulnerability index analysis, overall vulnerability is slightly lower in Attapeu, there are still clusters or highly vulnerable villages in all four districts surveyed in Attapeu province, that require the attention of planners and policymakers.

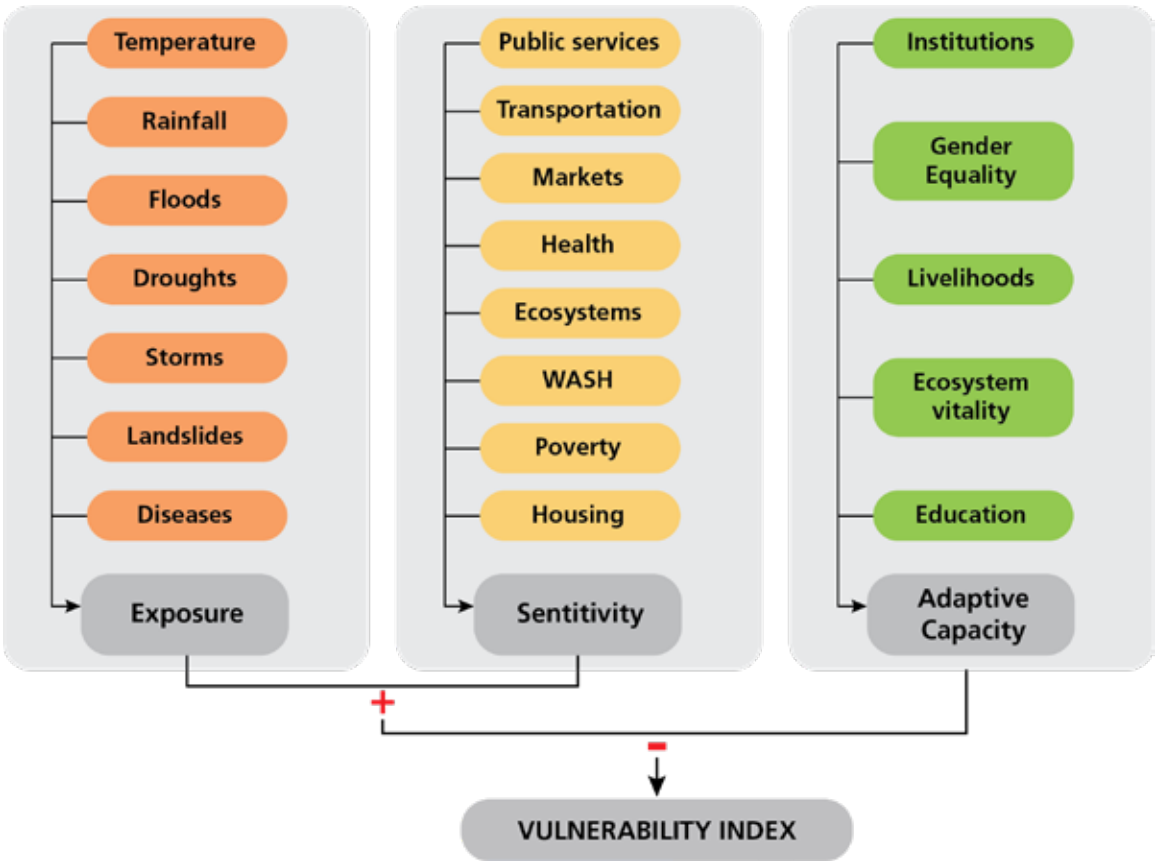
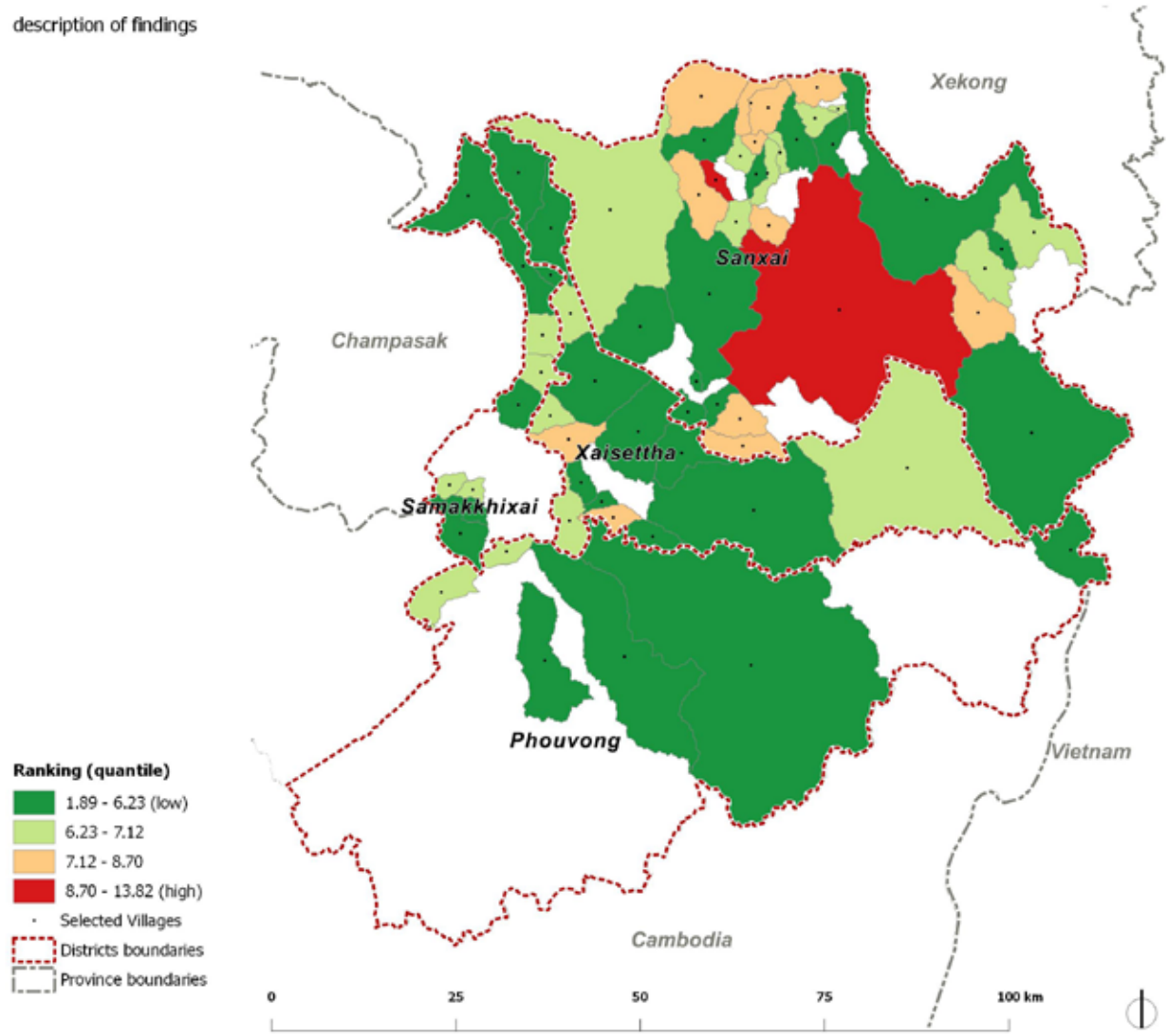
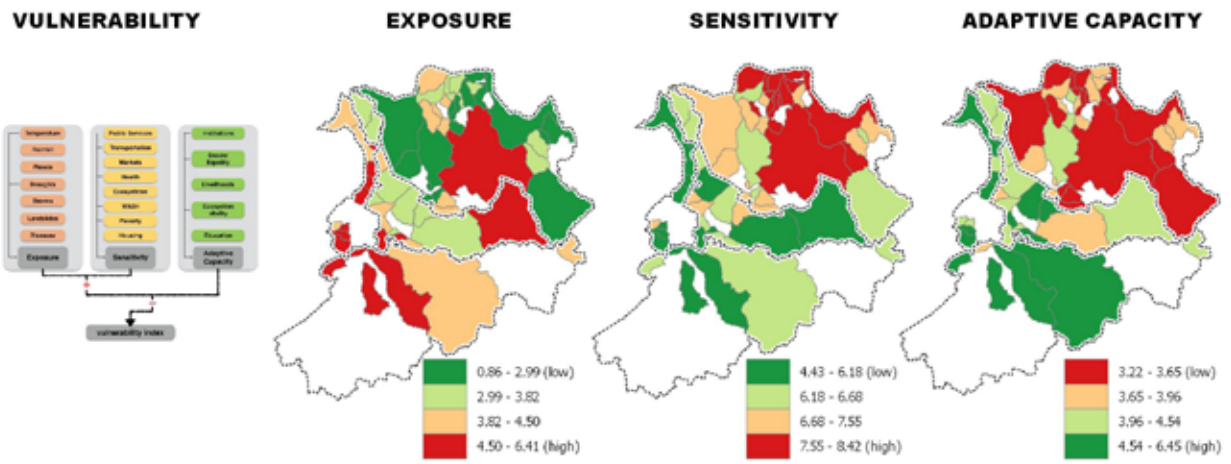


Figure 41 - Calculating the Vulnerability Index

VULNERABILITY INDEX

description of findings





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Climate Change Vulnerability Assessment of Phouvong, Samakkhixay, Sanxay and Xaysetha Districts in Attapeu Province

ATA07b

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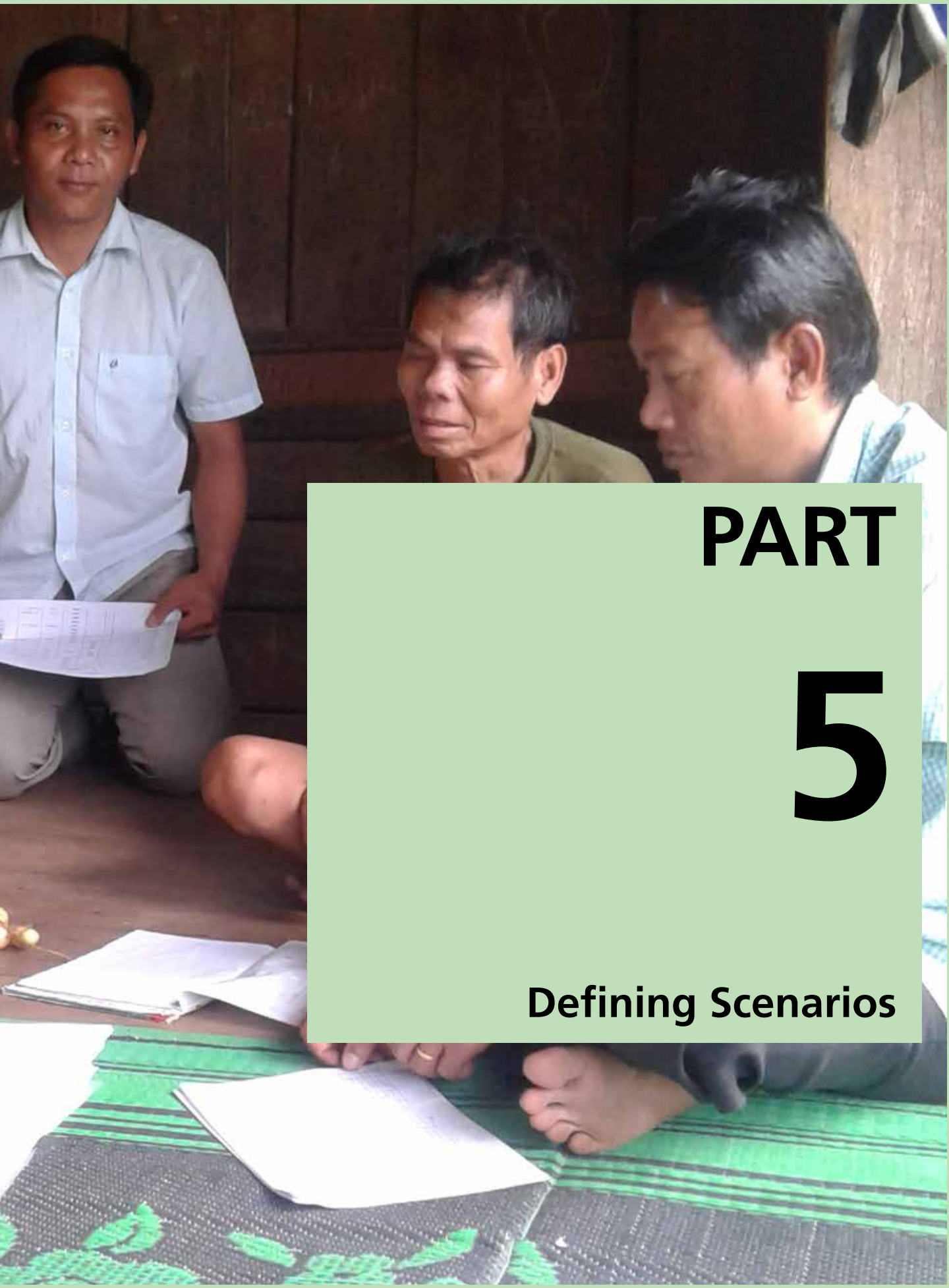


PART 5

Defining Scenarios

5 Defining Scenarios

Scenario	Required response and impact
A: Business as Usual	**Situation:** The authorities and communities don't recognize the urgent need to address current and future climate change impacts and vulnerabilities, and no additional action, beyond existing government programmes and initiatives is taken. **Impact:** Climate change will increasingly affect people's life, livelihoods, health and safety until 2050 and beyond; current socio-economic and environmental vulnerabilities will aggravate; development will be impeded.
B: Resilience is built to maintain current living standards by 2050	**Situation**: The authorities and communities recognize the urgent need to address current and future climate change impacts and vulnerabilities. However, there are limited financial, technical and human resource capacities capacities for large-scale investments and climate change adaptation responses. Under this scenario, local adaptation plans can focus on: • Improved environmental management, sustainable natural resources utilization and land-use planning, ecosystems restoration and conservation, introduction of climate-smart agricultural practices • Limited investment in infrastructure but sufficient to ensure that functionality is maintained to present levels, through improving transport infrastructure and networks, and access to public services, particularly water; and diversification of water and energy sources at a community or household level. • Small-scale socio-economic measures such as agricultural production diversification, and improved access to loans or microfinance. **Impact**: While climate change will affect people's lives, livelihoods, health and safety until 2050, provinces and districts can maintain current living standards. However, climate change would continue to be a challenge to social development and economic growth.
C: Resilience is built that enables economic and social development at least in line with national priorities and SDG targets, despite changes in climate, by 2050	**Situation**: The authorities and communities recognize the urgent need to address current and future climate change impacts and vulnerabilities and are committed to implement a wide range of low- and high-cost climate change adaptation measures. Provinces and Districts have the support of national authorities and international partners to achieve environmental, infrastructural and socio-economic objectives. These could be: 1) Healthy ecosystem that sustains life; 2) Resilient infrastructure that protects people and promotes development; 3) Diversified economy that supports sustainable and resilient economic and social development. 4) An educational system that provides people with skills to adapt to economic change. **Impact**: Climate change will affect people's life, livelihoods, health and safety until 2050, and beyond; however, provinces and districts will be able to maintain current living standards and to achieve Laos's national development priorities and the Sustainable Development Goals.

5.1 Future Impacts and Vulnerabilities Under a Business as Usual Scenario

a. Potential Impact Pathways graph

Through an analysis of the surveys and secondary data generated by the assessment, a Pathway to Impact graphic was created, shown below in Figure 42. This graphic shows the primary and secondary impacts of climate change that can reasonably be expected in Attapeu Province by 2050, assuming no actions are taken to adapt. In many cases, we see a worsening of existing conditions. The Pathway to Impact graphic also shows the complex interrelationship between hazards and impacts, including how a given primary impact can cause multiple secondary impacts.

The left-hand column lists the projected changes in the climate as discussed in Section 3 of this report. The second column lists the four major hazards that already affect Attapeu Province and that are likely to become more severe in the future because of the projected climate changes.

The primary impacts that result from these hazards are listed in the next column. In understanding the relationship between climate changes, hazards and impacts by 2050, planners can determine which people are most likely to be vulnerable to which impact. Secondary impacts consider the broader, knock- on effects in the target districts. For example, crop failures arising from storms or flooding could contribute to worsening nutritional outcomes (especially when failures occur over consecutive years). However, they also cause other issues, such as increasing the potential for mass migration, which has not yet been seen in the four target districts. Primary and secondary impacts can worsen the cycle of poverty. For example, crop failure and a lack of water can reduce productivity, raise food prices and worsen people's health. This can result in either out-migration to more productive areas, or borrowing to cover the basic expenses required to avoid malnutrition. This cycle can be exacerbated by severe climate related hazards.

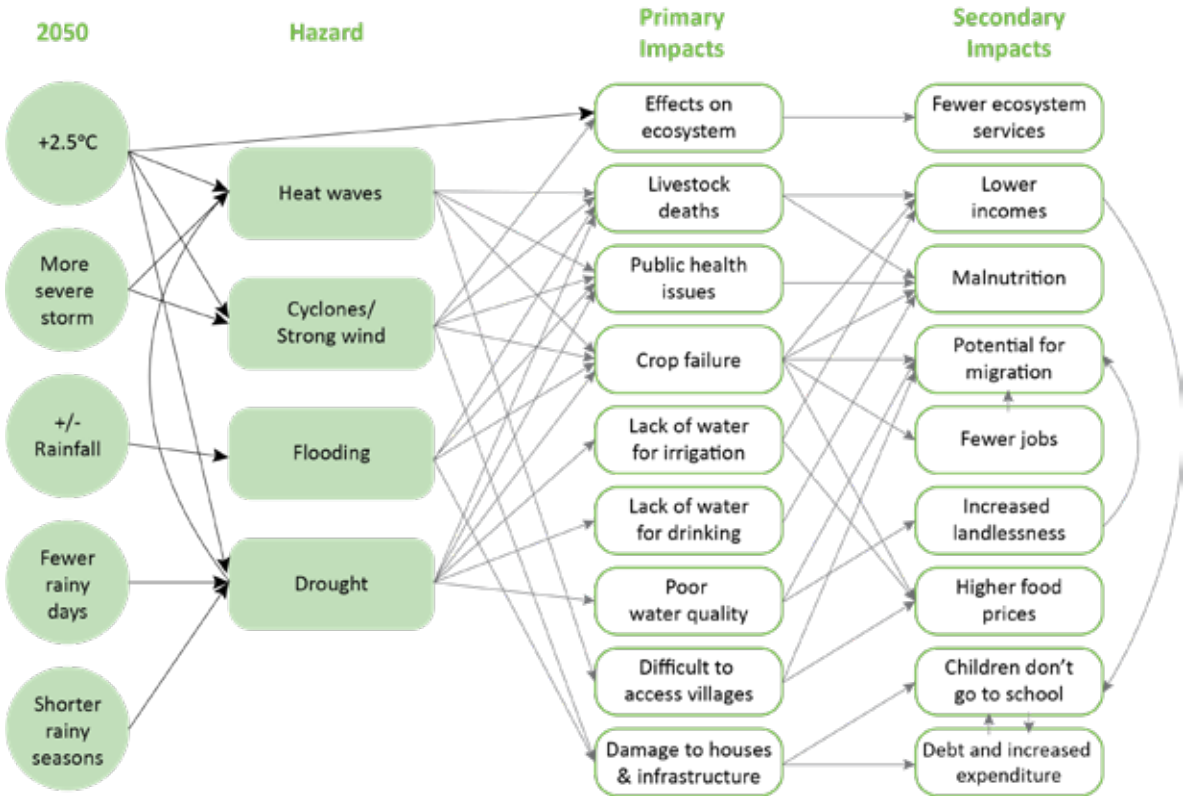


Figure 42 - Pathway to Impact graphic

b. Future Impacts under BAU

The assessment developed coefficients of change, based on current trends, to show the worst-case scenarios for 2050 if no adaptation actions are implemented. As such, the results are the estimated reduction against the 2015 baseline, given the projected change in temperatures and rainfall.

Future vulnerabilities were determined by applying coefficients of change to people's current capacities to benefit from the main eco-system and infrastructure services identified; agriculture, forestry resources, water sources and transport services.

Agriculture Production Will Be Reduced in Lowland Floodplains by 2050

The predominant crop in Lao PDR is rice, accounting for 71 per cent of all household livelihood activities in 2010[179], with rainfed paddy crops being the most common type. Rice yields depend not only on climate conditions but also on field soils and management capability, such as cropping techniques, irrigation, fertilizer, tillage and harvesting[180].

Changes in temperature and rainfall will affect the suitability of key crops, particularly rainfed rice, coffee, maize, and cassava. Rainfed paddy practices are highly diverse, so it is difficult to assess the potential impacts of climate change on rice production. However, an evaluation of multiple models suggests that while an increase in precipitation will increase the suitability of rice, changes in the onset of the rainy season may affect the suitability of traditional paddy varieties, at least in certain localized areas of different livelihood zones[181] [182] [183].

	Hazard	Eco-system service	Main projected impacts
+ drought	Dry season will get longer and more frequent, and droughts will be more severe	*Soil*	Reduced soil moisture and increased erosion of already degraded, loose, sandy soils, reducing agriculture productivity
		Freshwater	Current rice production systems rely on an ample water supply and thus are more vulnerable to drought stress than other crop systems[182]
		Crops	Extremely high temperatures during flowering, even for a few hours, can cause complete sterility, while high temperatures during ripening can lead to reduced grain filling and poor milling quality (i.e., more broken grains)[183]

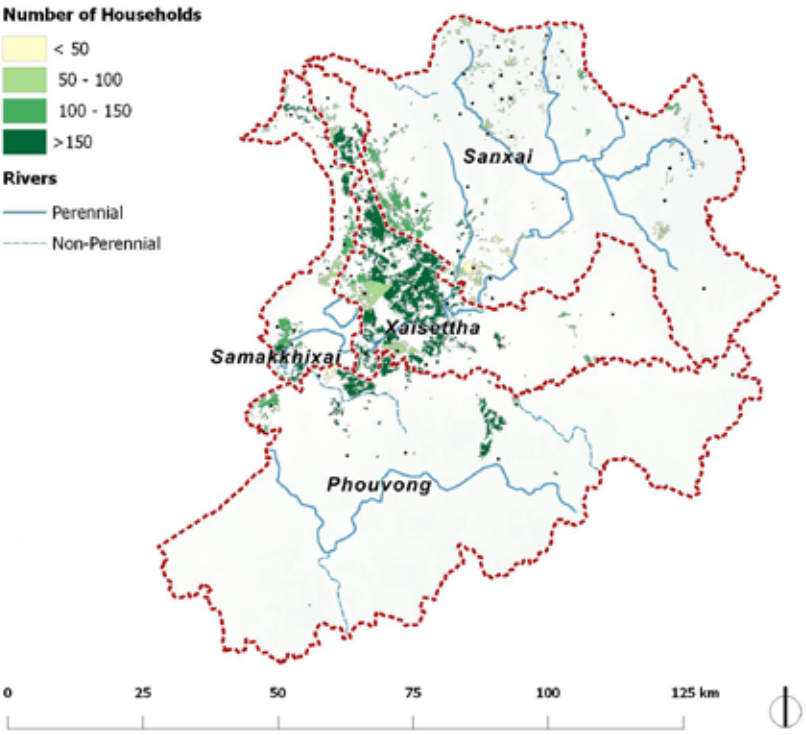
179 Lao Agriculture Census 2011-2012.
180 USAID Mekong ARCC.
181 CLEAR,2015-WFP.
182 Mohanty S, Wassmann R, Nelson A, Moya P, and Jagadish SVK. 2013. Rice and climate change: significance for food security and vulnerability. IRRI Discussion Paper Series No. 49. Los Baños (Philippines): International Rice Research Institute. p.14.
183 http://irri.org/rice-today/rice-feels-the-heat

+ 2°C warmer	Higher average temperatures	*Soil*	Increased temperatures will result in more frequent, intense, and in some cases longer dry spells, thereby reducing soil moisture and increasing erosion for already degraded, loose, sandy soils, and in turn reducing agriculture productivity[184]
		Freshwater	Higher temperatures will increase the evaporation of surface water, leading to reduced water availability, especially during the dry season and in rainfed areas
		Crop	Lowland rainfed rice and irrigated rice crops will experience reduced yields due to the introduction of temperatures greater than 35°C during the growing stage[185] Temperatures beyond critical thresholds not only reduce the growth duration of rice crops but also increase spikelet sterility, reduce grain-filling duration, and enhance respiratory losses, resulting in a lower yield and lower quality rice grains[186]
+ / - rainfall	There will be more intense rainfall events, and more frequent and severe floods	*Soil*	Intense rains following longer dry periods will increase the runoff rate and soil erosion
		Freshwater	Severe inundation will further damage water infrastructure, such as pumps, shallow dug wells and tube wells, and irrigation systems
		Crop	The lowlands will experience a higher incidence of floods and flash floods, increasing damages and crop losses[187] Unpredictable flood events can lead to complete submergence (often referred to as "flash flooding") causing plant mortality after a few days, or partial submergence over longer time spans (often referred to as "stagnant flooding") triggering substantial yield losses[188]

• If no adaptation measures are implemented, the number of people who can depend on paddy rice for their livelihood and/or food supply will decrease by 2050, especially in the lowland plains, that will face more floods, landslides and intense runoff due to the projected increase in heavy rain.

CAPACITY OF THE POPULATION TO BENEFIT FROM RAINFED PADDY RICE IN 2017

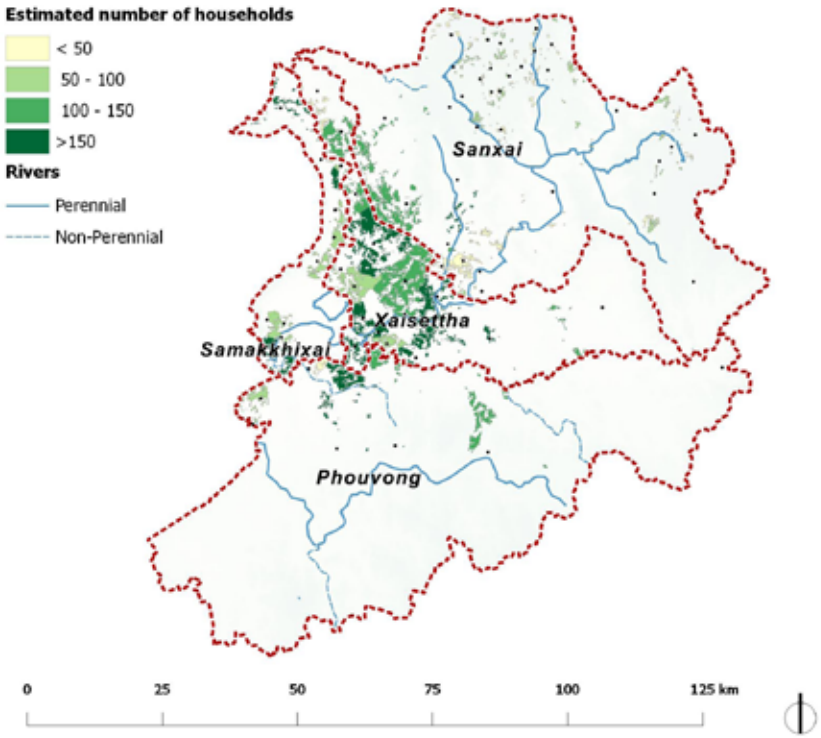
The number of people benefitting from agriculture is dependent on three ecosystem services; soil, crops and water resources. The predominant crop in Lao PDR is rice, accounting for 71 per cent of households in 2010. Paddy fields were the second most common type of land cover in Xaisettha and Samakkhixai Districts, at 20 per cent and 25 per cent, respectively.



ESTIMATED CAPACITY OF THE POPULATION TO BENEFIT FROM RAINFED PADDY RICE IN 2050

+ 2ºC warmer | +/- Rainfall | + drought

Rice is very sensitive to different abiotic stresses that will be exacerbated by extreme weather patterns resulting from climate change. Higher temperatures coinciding with critical growth phases will reduce yields. Floods that cause partial or complete submergence will also cause reductions in yields or even total losses of rice crops.
The capacity of the population to benefit from agriculture in 2050 is estimated by applying a coefficient of reduction in yield against the 2017 baseline, given the projected changes in temperature and rainfall, which will result in lower soil productivity, lower yields and more frequent damage to crops



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Increased Forest Degradation Would Reduce People's Capacity to Depend on Forestry Resources as a Viable Livelihood Option by 2050

Forests supply timber and non-timber products that provide critical incomes and food sources for rural communities.

National forest cover is reported to have declined dramatically between 1992 and 2002, at an average rate of 134,000 hectares per year (equivalent to 1.2 -1.3 hectares annually). This same period also saw widespread deterioration in forest quality, with dense forest declining from 29 per cent of all forest cover in 1992 to 8.2 per cent in 2002, and open forest increasing from 16 per cent to 24.5 per cent. The main drivers of forest and habitat loss are linked to shifting cultivation, legal and illegal logging, conversion to agriculture and forest plantations, and infrastructure development.

The UN-REDD Programme estimates that if the current deforestation rate continues, the forest coverage area will decrease to 7.4 million hectares (31.3 per cent of the total land) in the next few years.

	Hazard	Eco-system service	Main projected impacts
+ 2°C warmer	Higher average temperatures	Vegetation cover	Increased temperatures could enhance the frequency of forest fires as well as pest and disease infestations in forests.
+ / - rainfall	There will be more intense rainfall events, and more frequent and severe floods	Soils	Increased magnitude and frequency of extreme events, such as flooding, is expected to cause soil erosion, watershed degradation, and a significantly increased potential for landslides
		Vegetation cover	Changes in precipitation patterns might affect the survival of seedlings and saplings

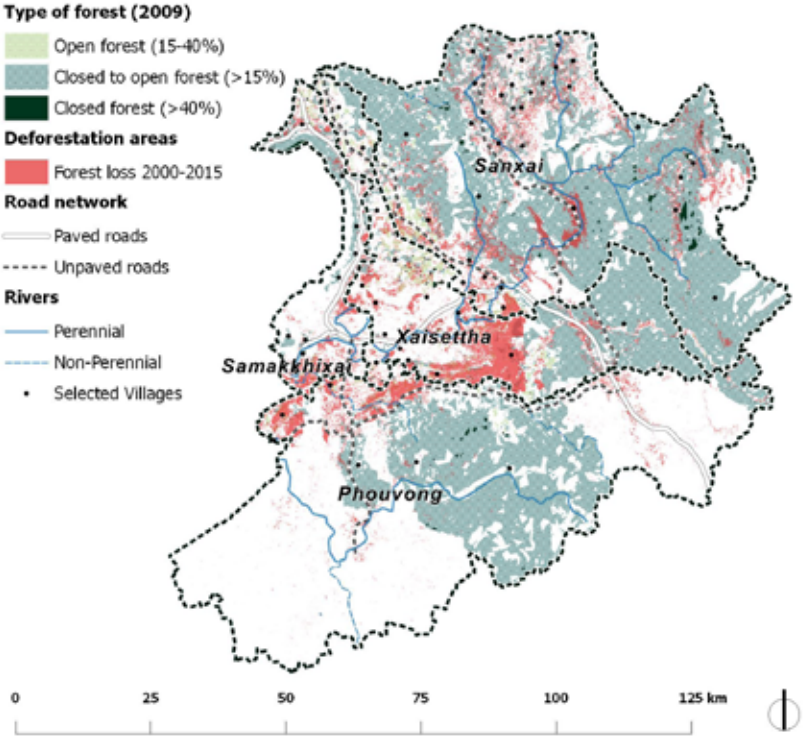
- If no adaptation measures are implemented, increased forest degradation will continue in highland areas, and in the worst-case scenario would mean a total loss of forest coverage in lowland areas (Samakkhixai and Xaisettha Districts), increasing vulnerability to flooding events, especially as rainfall intensity and variability increases.

- As forests are cleared in mountainous areas, the numerous ecosystem services they provide that support climate resilience – erosion control, defence against severe storms and natural habitats – may also be lost. In addition, further deforestation in upstream areas would increase flooding exposure in the already highly exposed floodplains along the Xe Kong River (Xaisettha and Samakkhixai Districts).

- The occurrence of deforestation both upstream and in lowland areas, especially in floodplains which provide an important natural flood barrier, makes communities highly vulnerable to more frequent and severe intense rainfall events.

FOREST COVERAGE IN SELECTED VILLAGES IN 2017

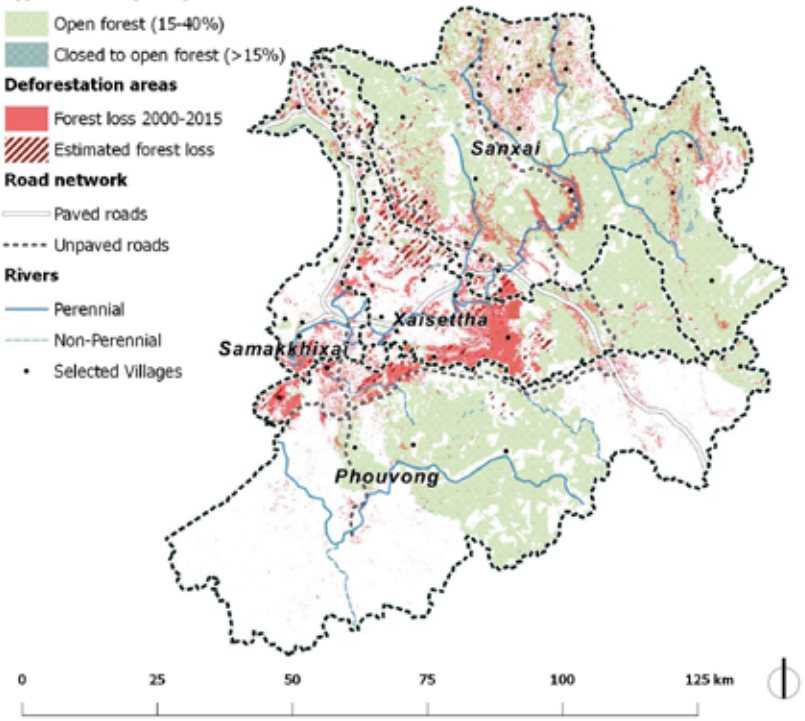
Forests are the source of timber and non-timber products that are critical income sources for rural communities. National forest cover is reported to have declined by 134,000 hectares (about 1.2%) per year between 1992 and 2002.
The main drivers of forest and habitat loss are shifting cultivation, legal and illegal logging land conversion for agriculture and plantations and infrastructure development.
In the absence of more updated data, the forest coverage for 2017 has been calculated based on the GlobCover land-cover map for 2009



ESTIMATED FOREST COVERAGE IN SELECTED VILLAGES IN 2050

+ 2°C warmer | +/- Rainfall | + drought

If no adaptation measures are implemented, the current deforestation trends would increase forest degradation in highland areas, and in the worst-case scenario would mean a total loss of forest in lowland areas (particularly in Samakkhixai and Xaisettha Districts), increasing vulnerability to flooding events as rainfall intensity and variability increases.
As forests are cleared in upland areas, ecosystem services that contribute to climate resilience, such as erosion control, defence against severe storms, and natural habitats, may also be lost. Continued deforestation in upstream areas will increase exposure to flooding in the plains along the Sekong River, which is already highly prone to flooding



Data Sources: Lao Decide (www.decide.la), Lao Census of Agriculture (2010/2012), Hansen/UMD/Google/USGS/NASA, ESA 2010 and UCLouvain
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Roads and water supply infrastructure are important elements of the rural infrastructure sector that have been identified as highly vulnerable to climate change. The most prominent climate threats to rural infrastructure are flooding, flash flooding and landslides.

Access to Freshwater Drinking Sources Will Decrease by 2050

Most of the surveyed villages in Phouvong, Xaisettha and Samakkhixai Districts depend on groundwater sources, in the form of wells and boreholes, as their main source of drinking water, while Sanxai District's upland villages mainly rely on surface water sources, namely mountain sources, streams, rivers and dams. Communities in the target districts reported that droughts are already reducing water availability, while storms and floods damage water infrastructure almost every year, particularly in Phouvong and Samakkhixai Districts.

The projected changes in precipitation patterns and an increase in mean temperature can lead to higher rates of surface water evaporation and more months of drought. In the medium-term, groundwater sources will also be affected as aquifers take longer to recharge, leading to the need for further investments in infrastructure improvement, particularly in tank capacity and boreholes depth. In addition, stronger storms and unusually heavy rainfall will inevitably damage water infrastructure.

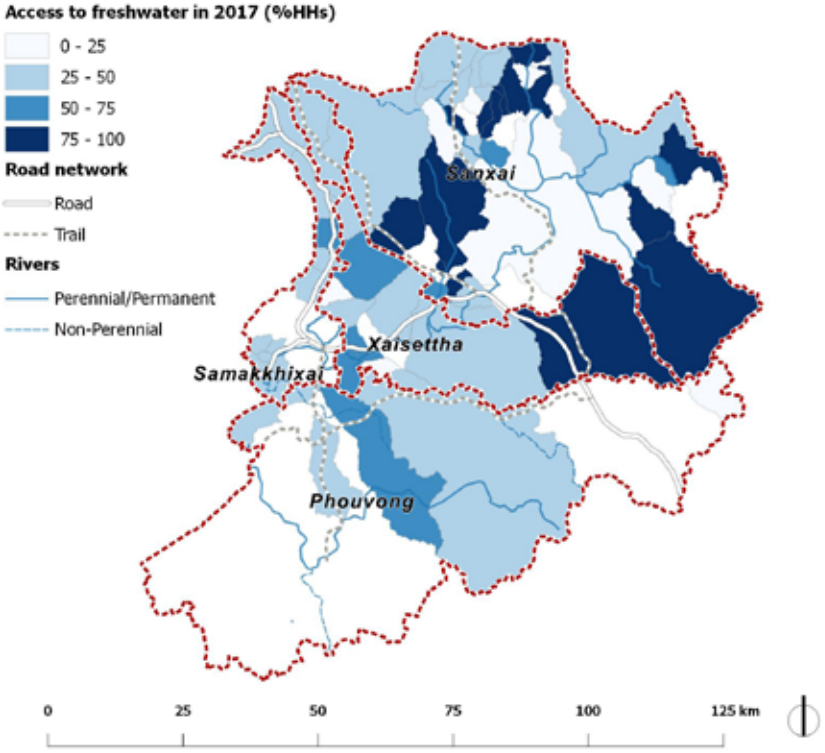
Access to freshwater for drinking use may be highly impacted by projected climate change:

	Hazard	Eco-system service	Main projected impacts
+ 2°C warmer	Higher average temperatures	*Type of vegetation*	Higher temperatures will lead to even greater evaporation and aridity, as water availability and soil moisture decline, limiting vegetation growth, which will limit groundwater recharge and flood retention services
		Surface water	Availability of freshwater will decline as evaporation increases
- days of rain	Fewer rainfall days and shorter rainy season	*Groundwater sources*	Fewer rainy days will result in reduced recharge during the wet season, reducing groundwater availability during the dry season
		Surface water	Less time for rain water harvesting and storage will reduce availability, especially toward the end of the dry season
+ / - rainfall	More heavy rain, making rainfall less useful and more damaging	*Type of vegetation*	Loss of vegetation cover, increased runoff rate, soil erosion and damage to water storage facilities
		Groundwater sources	Decreased sub-surface flow and recharge as most flows run-off downstream rather than recharging local aquifers
		Surface water	Reduced availability, as flows from intense rainfall events are difficult to capture and can damage storage infrastructure

- If no adaptation measures are implemented, the number of people depending on paddy rice will decrease by 2050, especially in lowland plains areas where they will face more floods, landslides and intense runoff due to the projected increase in intense rains.

ACCESS TO FRESHWATER FOR DRINKING WATER USE IN 2017

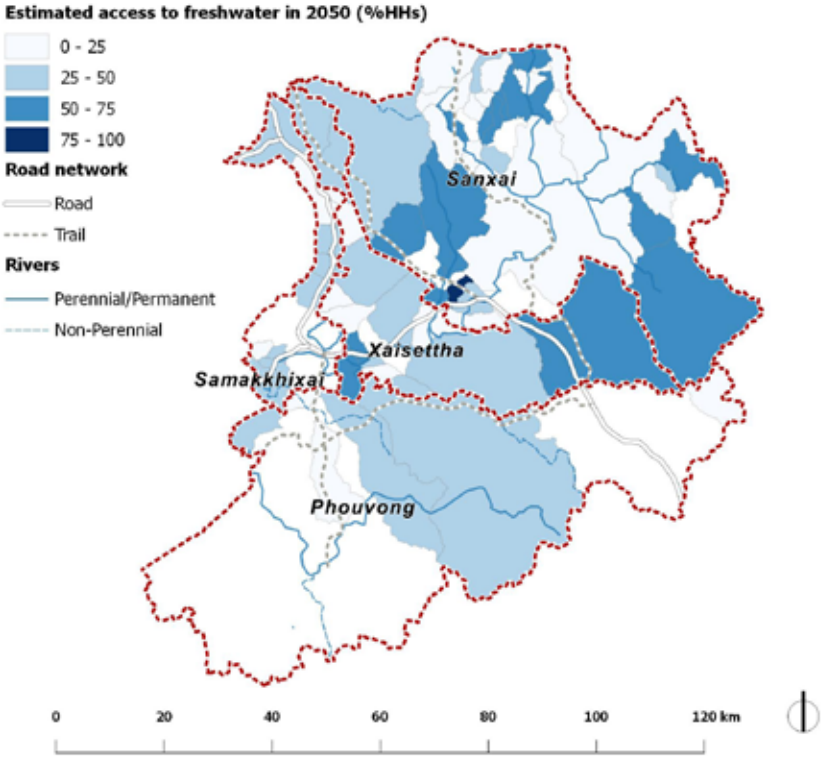
Most of the surveyed villages in Phouvong, Xaisettha and Samakkhixai depend on groundwater sources (wells and boreholes), while Sanxai's upland villages mainly rely on surface water sources, mainly water from the mountains, streams, rivers and dams.
The percentage of households having access to freshwater was calculated by applying a coefficient of change based on current impacts to the 2015 census data.



ESTIMATED ACCESS TO FRESHWATER FOR DRINKING WATER USE IN 2050

+ 2ºC warmer | +/- Rainfall | + drought

Access to freshwater for drinking use in 2050, if no adaptation measures are implemented, is calculated by applying coefficients of impact on the 2017 baseline by type of water source and infrastructure in use, which will result in longer, more frequent and more severe droughts, increased evaporation and more intense rainfall events, causing floods that damage water facilities for longer periods



Data Sources: Lao Decide (www.decide.la), Population and Housing Census 2015, Lao Census of Agriculture 2010/2012, UN Habitat
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Access to the Transportation Network Will Be Significantly Reduced in Lowland Floodplains and in Highland Areas by 2050

In both highland and lowland areas, mobility is a main constraint for the socio-economic and livelihood development of rural communities. In highland areas, frequent landslides, flash floods and steep hillslopes isolate mountain villages from markets, medical facilities, schools, and other core community services. In lowland floodplains, regular and large flood events inundate vast areas, rendering transport networks inoperable or pushing them to failure.

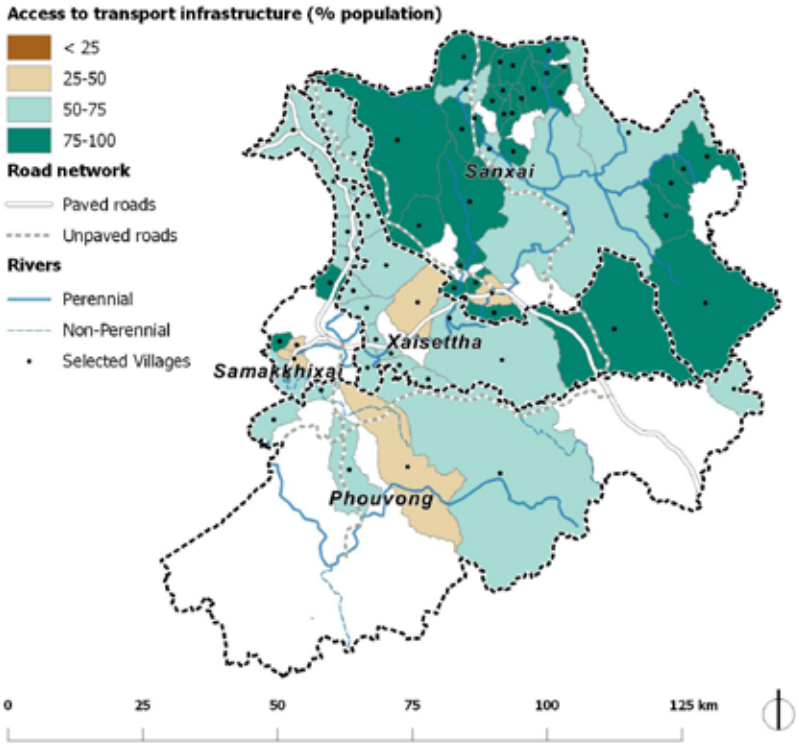
Rural road networks are critical infrastructure and are highly exposed to climate change as they depend on the interaction between two main eco-system services (types of vegetation and soil), which are highly impacted by climate change.

	Hazard	Eco-system service	Main projected impacts
+ 2°C warmer	Higher average temperatures	*Soils*	Higher temperatures will increase the rates of evapotranspiration and reduce the moisture content of the soil, making it vulnerable to erosion. This will worsen as the dry seasons become drier and the wet seasons become wetter, causing the first large rains of the wet season to negatively impact on dry, loose soils. . This means, inter alia, that unpaved roads will be more prone to erosion and disrepair
+ / - rainfall	There will be more intense rainfall events, and more frequent and severe floods	*Soils*	In highland areas, steep slopes are more vulnerable to landslides and flash flood events The lack of strong embankments and unsealed road surfaces in remote areas increases the impact of flooding The proximity of roads to rivers and lakes in lowland plains makes them susceptible to floods
		Vegetation cover	Deforestation increases exposure to erosion and slope instability – meaning that mudslides are more likely to occur during the rainy season. Landslides in riverbank areas damage vegetation cover and destroy roads and bridges

- If no adaptation measures are implemented, the lack of capacity and formal infrastructure to mitigate erosion, coupled with weak transportation and communication networks, will increase communities' vulnerability to floods and inundation.
- Villages located in lowland floodplains along the Xe Kong River (in Xaisettha and Samakkhixai Districts) will experience more frequent flood events, rendering transport networks inoperable or pushing them to failure.
- In highland areas, where the transportation and communication networks mainly rely on rural unpaved roads on steep slopes, more intense rainfall events will increase road and bridge degradation because of landslides and flash floods.

ACCESS TO TRANSPORT NETWORK IN SELECTED VILLAGES IN 2017

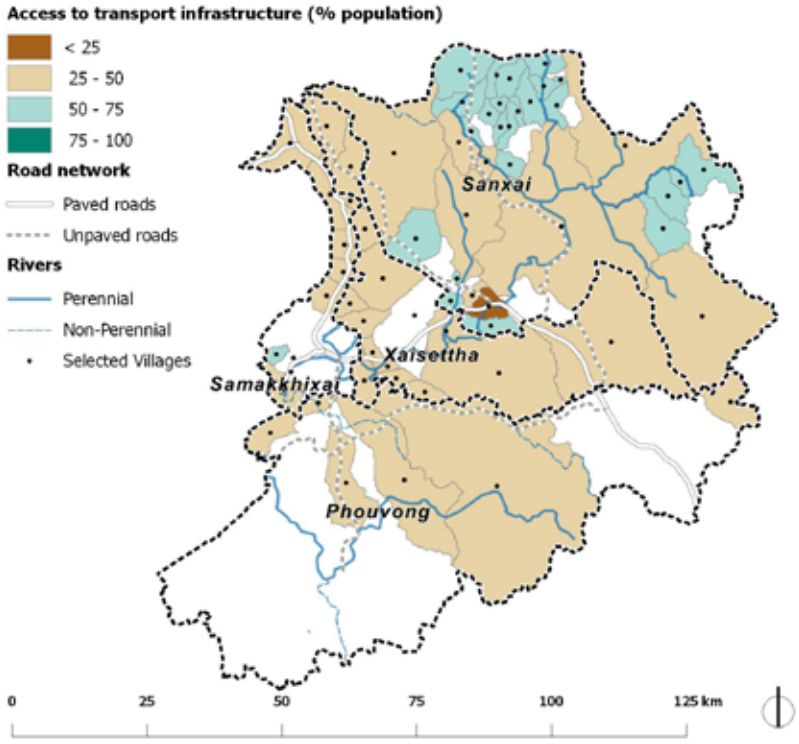
The current rural transport network mainly relies on secondary and tertiary unpaved roads, which makes rural communities vulnerable to storms and unusually heavy rainfall.
In highland areas, landslides and flash floods isolate mountain villages from markets, medical facilities, schools and other community services.
In lowland floodplains, regular, large flood events inundate vast areas, rendering transport networks inoperable.
Access to the transportation network in 2017 is determined by combining landslide susceptibility zones with Sekong River inundation areas for a 10-year period (according to the National Risk Profile of Lao PD, 2010) and landslides and floods' impacts on infrastructure reported in selected villages (as determined by the present survey)



ESTIMATED ACCESS TO TRANSPORT NETWORK IN SELECTED VILLAGES IN 2050

+ 2ºC warmer | +/- Rainfall | + drought

If no adaptation measures are implemented, the lack of capacity to prevent erosion through infrastructure, coupled with weak transportation networks, will cause communities to be more vulnerable to floods and inundation.
Villages located in lowland floodplains along the Sekong River (Xaisettha and Samakkhixai Districts) will experience more frequent flood events, rendering transport networks inoperable or less effective. In upland areas, where transport mainly relies on a network of rural unpaved roads on sloping land, more intense rainfall events will increase instances of road degradation and damage. Bridges in these areas will also be more seriously affected by floods and landslides



Data Sources: Lao Decide (www.decide.la), Population and Housing Census (2015), Lao Census of Agriculture (2010/2012), National Risk Profile of Lap PDR (2010), VA survey UN Habitat (2017)
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PART 6

Conclusions

6 Conclusions – Planning for Adaptation

6.1 Towards Action Planning

The target villages in the four districts of Attapeu Province show attributes that make them vulnerable to climate change. As this report has explained, the projected climate changes will have very significant impacts in all areas of Attapeu Province unless adaptation actions are identified and programmatically implemented in the coming years.

At present, limited livelihood options, underdeveloped infrastructure, especially in the more rural areas of Sanxai and Phouvong Districts, long-term deforestation and other environmental damage and stresses create a very vulnerable situation. These will be exacerbated by future climate change, including higher temperatures, changing rainfall patterns and more extreme weather.

- **Deforestation trends will make communities highly vulnerable to more frequent and intense rainfall events**

The exploitation of natural forests in recent decades has contributed to the degradation of the natural resource base upon which most of the population depends on directly or indirectly for their livelihood. Forests are also under pressure from the expansion of agricultural activities, rubber plantations, industrial tree plantations and illegal cutting by individuals and households. If current deforestation trends continue, forest degradation will reduce the numerous basic ecosystem services that forests provide and that support climate resilience, such as erosion control, as a defence against landslides, as providing natural habitats for , and most importantly, and as a source of housing contruction material and of fuel wood.

- **Freshwater availability will decline**

The projected changes in precipitation patterns and an increase in mean temperature will lead to higher rates of evaporation and longer months of drought. In addition, stronger storms and unusually heavy rainfall will inevitably damage water infrastructure. Without any measures to improve water storage infrastructure and distribution management, the amount of water available to communities will decrease, especially during the dry season.

- **Landslides and floods will become more frequent, more severe, and last for longer, thereby isolating communities for longer periods**

The lack of capacity to mitigate erosion through formal infrastructure, coupled with weak transportation and communication networks, will render communities highly vulnerable to more frequent floods, landslides and inundation by damaging roads and bridges, and, in the worst cases, by isolating communities for longer periods following extreme weather events.

- **More intense climate hazards will jeopardise communities' coping capacities to deal with them**

The lack of disaster management committees and disaster facilities in some villages, which are crucial for planning and for training communities on what to do before, during and after disaster events, will increase communities' vulnerability. In addition, limited access to mobile repeater and communication networks, which can be vital in disaster preparation and for early warning and communication during and after an emergency, increases communities' exposure to climate hazards and risks.

Under these circumstances, building villages' resilience to climate change is a great and urgent challenge, on which the life and welfare of thousands of people depend.

a. Strategic Adaptation Measures

The assumption in this assessment is that villages where fewer functions are present are more sensitive to climate change, and their sensitivity would be reduced by providing the services that are largely missing.

From a regional planning perspective, in which a region is not only a system of functionally diversified settlements but also acts as a network of social, economic, and physical interactions, the vulnerabilities of larger villages are also felt in smaller villages. This means that strategic investments in the main villages, where vulnerability is very high, will help build resilience in both main and basic settlements as they are strongly interconnected.

The territorial and socio-economic development of the region is mainly centred on the village of Meouhuomeung in Samakkhixai District and the cluster of settlements around Saysi in Xaisettha District and Vungkhan in Phouvong District. All three of these settlements are strategically located in lowland areas and at the junction of international and national main roads. If we overlay vulnerability to climate change – as identified through a vulnerability index exercise by combining exposure, sensitivity and adaptive capacity – these main villages show high levels of vulnerability (orange to red colors in ATA12 map), which already suggest some strategic adaptation measures at regional and district level:

Improve water storage infrastructure and distribution management by diversifying freshwater sources and increasing water facilities in all selected villages.

- **Enhance road infrastructure and transport services to and from main villages to the surrounding rural villages in the district**, to allow better access to markets for agricultural products.

- **Establish and enhance Vocational Training Centres in main villages** to provide relevant skills to people in the agro-industries and to enhance agricultural practices at household level.

- **Improve access to electricity and to renewable sources of energy** to reduce deforestation (because people cut forests to collect fuel wood or make charcoal).

- **Increase the coverage of disaster facilities and services meant** to reinforce communities' awareness and coping capacity to deal with climate hazards in each village.

Furthermore, analysis of the existing functions for each village type, against the proposed spatial structure (clusters) and the vulnerability ranking to climate change, suggests some "specific functions" (adaptive measures) that, if implemented, could reduce districts' vulnerability, as shown in Figure 43.

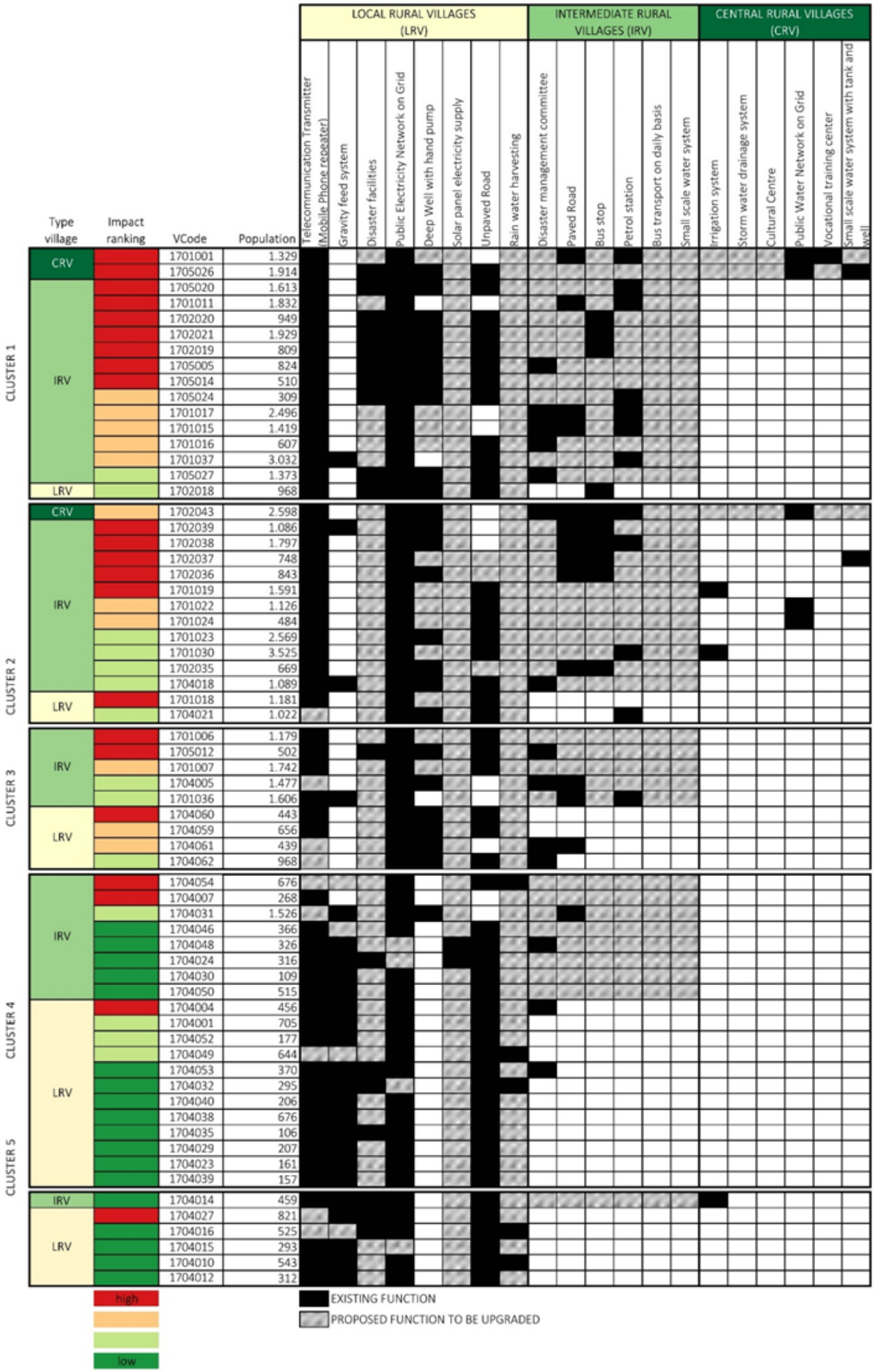
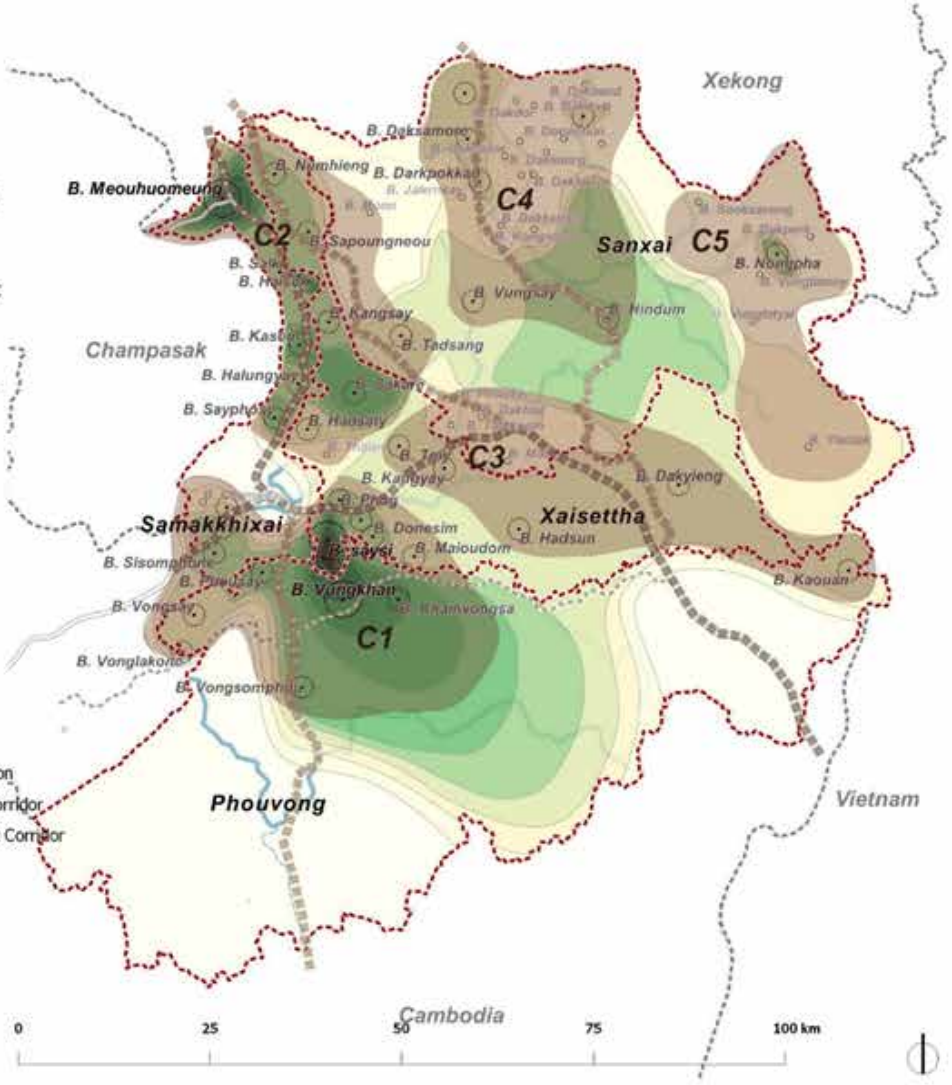


Figure 43 - Priority functions to be added in selected villages

PLANNING FOR ADAPTATION AND BUILDING RESILIENCE: STRATEGIC AREAS OF INTERVENTION

Building resilient villages to climate change is a great and urgent challenge, on which the life and welfare of thousands of people depend.
Under a regional planning perspective, where a region is not only a system of functionally diversified settlements but also a network of social, economic, and physical interactions, larger villages' vulnerabilities are also felt in smaller villages. This means that strategic investments in main villages, where vulnerability is very high, will reduce district's vulnerabilities.
In addition, upgrading basic functions in upland local rural villages will build more resilient villages andwil improve communities' living conditions



Main areas of intervention
Primary Development Corridor
Secondary Development Corridor

Type of villages

CRV
IRV
LRV

Level of hierarchy

Level 1
Level 2
Level 3
Level 4
Level 5
Level 6
Level 7
Level 8
Level 9
level 10

Transport Infrastructure

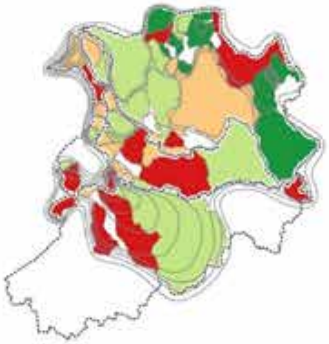
Road
Trail

Rivers

Perennial/Permanent
Non-Perennial
Districts boundaries
Province boundaries

IMPACT INDEX AND SPATIAL STRUCTURE

By overlaying the proposed spatial structure and the vulnerability ranking to climate change – as identified through a vulnerability index exercise by combining exposure and sensitivity –, suggests "priority areas of intervention" where building infrastructure will reduce district's vulnerabilities



Level of hierarchy (isopleths)
Ranking (quantile)
0.7 - 2.5 (low)
2.5 - 4.0
4.0 - 6.2
6.2 - 14.2 (high)

Data Sources: Lao Decide (www.decide.la), Population and Housing Census 2015, Lao Census of Agriculture 2010/2012, UN Habitat
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ADAPTATION FUND · UN-HABITAT FOR A BETTER URBAN FUTURE

Climate Change Vulnerability Assessment of Phouvong, Samakkhixay, Sanxay and Xaysetha Districts in Attapeu Province **ATA12**


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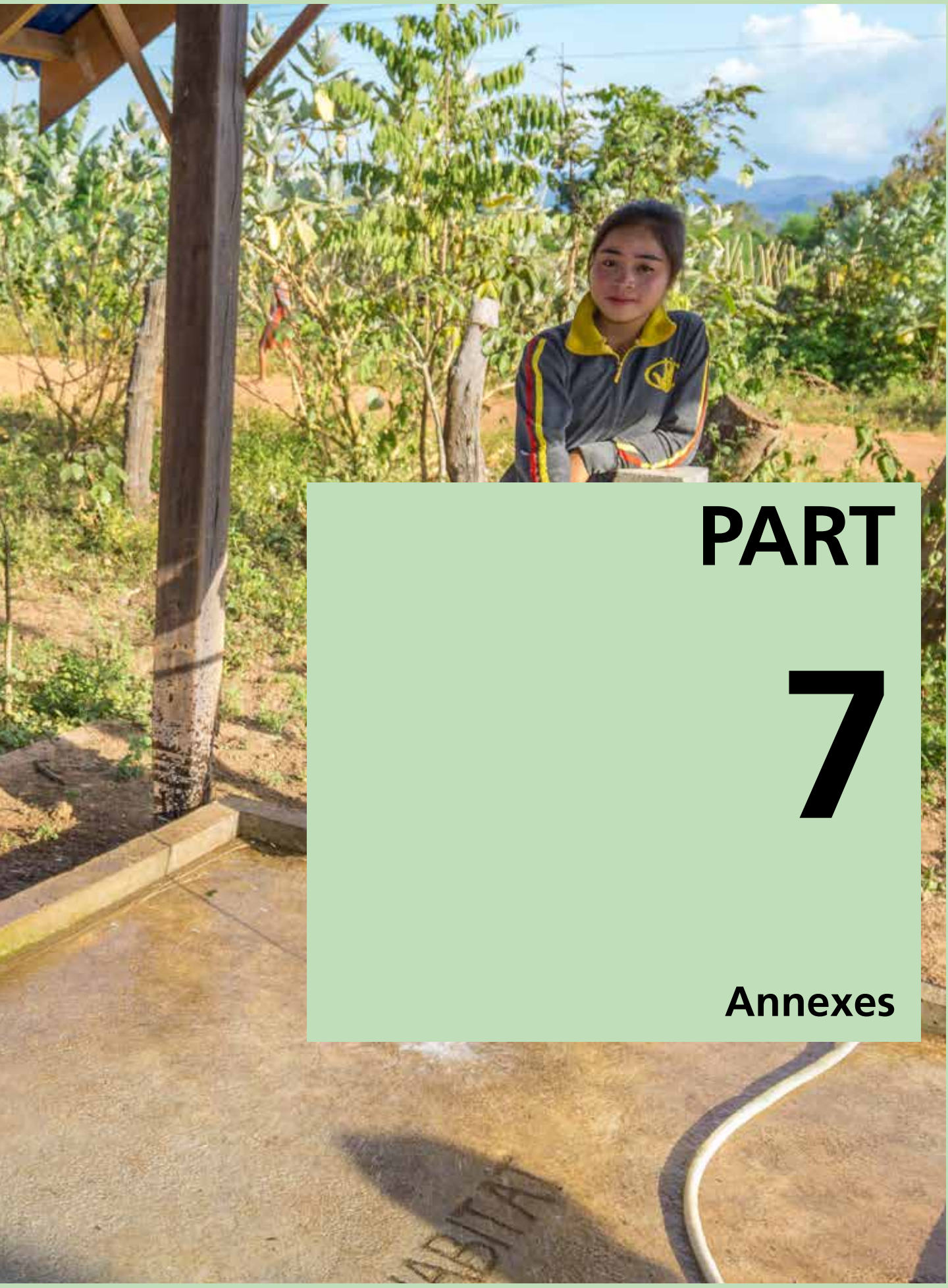


PART 7

Annexes

Annex 1 List of target villages by district

District	Village Code	Village Name	Population
PHOUVONG	1705005	B. Vongsay	755
	1705012	B. Kaouan (Taoom)	295
	1705014	B. Vonglakone	445
	1705020	B. Vongvilaytay	1,427
	1705024	B. Phousay	1,156
	1705026	B. Vungkhan	1,738
	1705027	B. Khamvongsa	1,293
		B. Makkieng	428
	Total	**8 Villages**	**7,573**
SAMAKKHIXAI	1702018	B. Champhao	836
	1702019	B. Kamesung	752
	1702020	B. Somsanook	860
	1702021	B. Sisomphone	1,683
	1702035	B. Sayphosy	552
	1702036	B. Halungyay	827
	1702037	B. Kasom	755
	1702038	B. Salk	1,708
	1702039	B. Haisok	917
	1702043	B. Meouhuomeung	2,480
	Total	**10 Villages**	**11,370**
XAISETHA	1701001	B. saysi	1,477
	1701006	B. Toiy	1,071
	1701007	B. Kangyay	1,678
	1701011	B. Hadsun	5,420
	1701015	B. Somkoth	1,560
	1701016	B. Donesim	661
	1701017	B. Phog	2,293
	1701018	B. Thalan	549
	1701019	B. Hadsaty	746
	1701022	B. Kangsay	1,209
	1701023	B. Sapoungneou	1,310
	1701024	B. Numhieng	466
	1701030	B. Sakare	3,114
	1701036	B. Dakying	928
	1701037	B. Maioudom	2,869
	Total	**15 Villages**	**25,351**

District	Village Code	Village Name	Population
	1704001	B. Jalernsay	705
	1704004	B. Dakkanath	456
	1704005	B. Dakhiat	311
	1704007	B. Hindum	258
	1704010	B. Yiatdak	543
	1704012	B. Dakpork	312
	1704014	B. Nongpha	459
	1704015	B. Vungtatyai	293
	1704016	B. Vungtatnoy	525
	1704018	B. Tadsang	1,016
	1704021	B. Moon	922
	1704023	B. Maythavone	161
	1704024	B. Daksang	316
	1704027	B. Sooksavung	821
	1704029	B. Dakdao	207
	1704030	B. Dakband	109
SANXAI	1704031	B. Vungsay	1,315
	1704032	B. Kongnayai	295
	1704035	B. Donechun	106
	1704038	B. Daklakow	676
	1704039	B. Daklomrg	157
	1704040	B. Dakker	206
	1704046	B. Daknong	366
	1704048	B. Darkpokkao	326
	1704049	B. Dakdor	644
	1704050	B. Dakyok	515
	1704052	B. Daksiet	177
	1704053	B. Daksenm	370
	1704054	B. Daksamore	676
	1704059	B. Mainakok	605
	1704060	B. Tathkoom	451
	1704061	B. Pheerkeo	409
	1704062	B. Phouxai	1,190
	Total	**33 Villages**	**15,898**

Annex 2 Methodology of the Matrix of Functions (MoF)

The Matrix of Function (MoF) is used to strategically categorise the existing human settlements based on the mere availability, or non-availability, of key functions184 and to identify economic development areas ("clusters" of human settlements strategically interconnected) within a given region. It was developed from the Scalogram method (Rondinelli, 1985) and renamed to MoF by Giovanni Spaliviero in regional development projects in West and North Africa in the 1980s (Spaliviero, 2015, Unité de Réalisation des Projets Pilotes, 1992, Unité Technique de Planification, 1986). The purpose is to empirically derive the hierarchy of settlements to ensure guidance of realistic planning and implementation.

The assumption in this proposed assessment method is that those human settlements where fewer functions are present are more sensitive, and their sensitivity would be reduced by providing the services that are largely missing. This method allows visualising the linkages between villages such as the degree of dependency in terms of health or education services.

The analysis is based on the data collected through a simple questionnaire filled by local government or community representatives at the basic administrative unit of reference that identifies a human settlement (villages), to check whether services/functions are available. (i.e. primary school, police station, pharmacy, or lawyer across 10 to 15 functional categories, such as education and health facilities, transport services, law and security, financial services, or private professionals).

The team establishes a list as comprehensive and exhaustive as possible of services and facilities which is further revised by relevant stakeholders and government authorities to ensure complete adaption to the context of the region.

Data collected is then fed into an unordered MoF (spreadsheet), where:

- **1st column**: shows the name/code of selected Villages
- **2nd columns**: shows the "functions"(as many columns as functions are inventoried)
- I**n the table (or matrix) itself**, a black cell indicates the presence of the function (NB: not how many times the function is present, just if it is present or not – this is a normalised method), while a white cell indicates its absence in the Village concerned

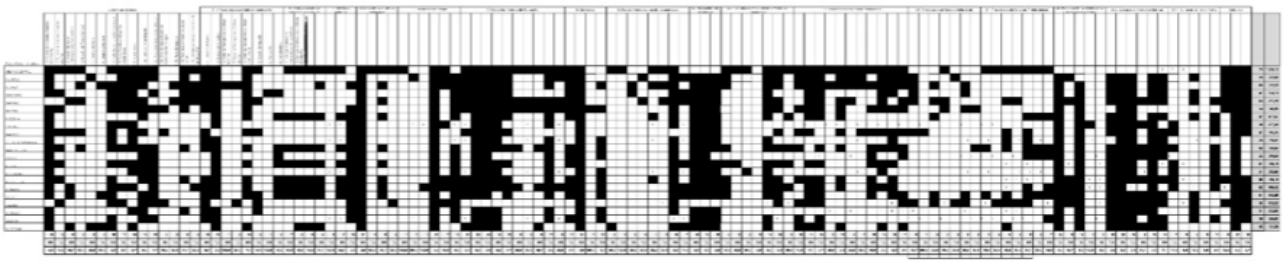


Figure 44 - Matrix of Ordered Functions (MoF) spreadsheet

Then by summing the number of times a function occurs, which is the function frequency, and by convention divides by 100 a function weight is obtained. Hence basic functions which occur often, obtain a low weight and rare central functions obtain a high weight. Therefore, each black square represents a present function and has an associated weight. When the weights of all functions present in each administrative unit are summed, the "centrality score" emerges for each settlement. Then, after sorting by function weight and centrality score the "ordered matrix" is established (see figure 45).

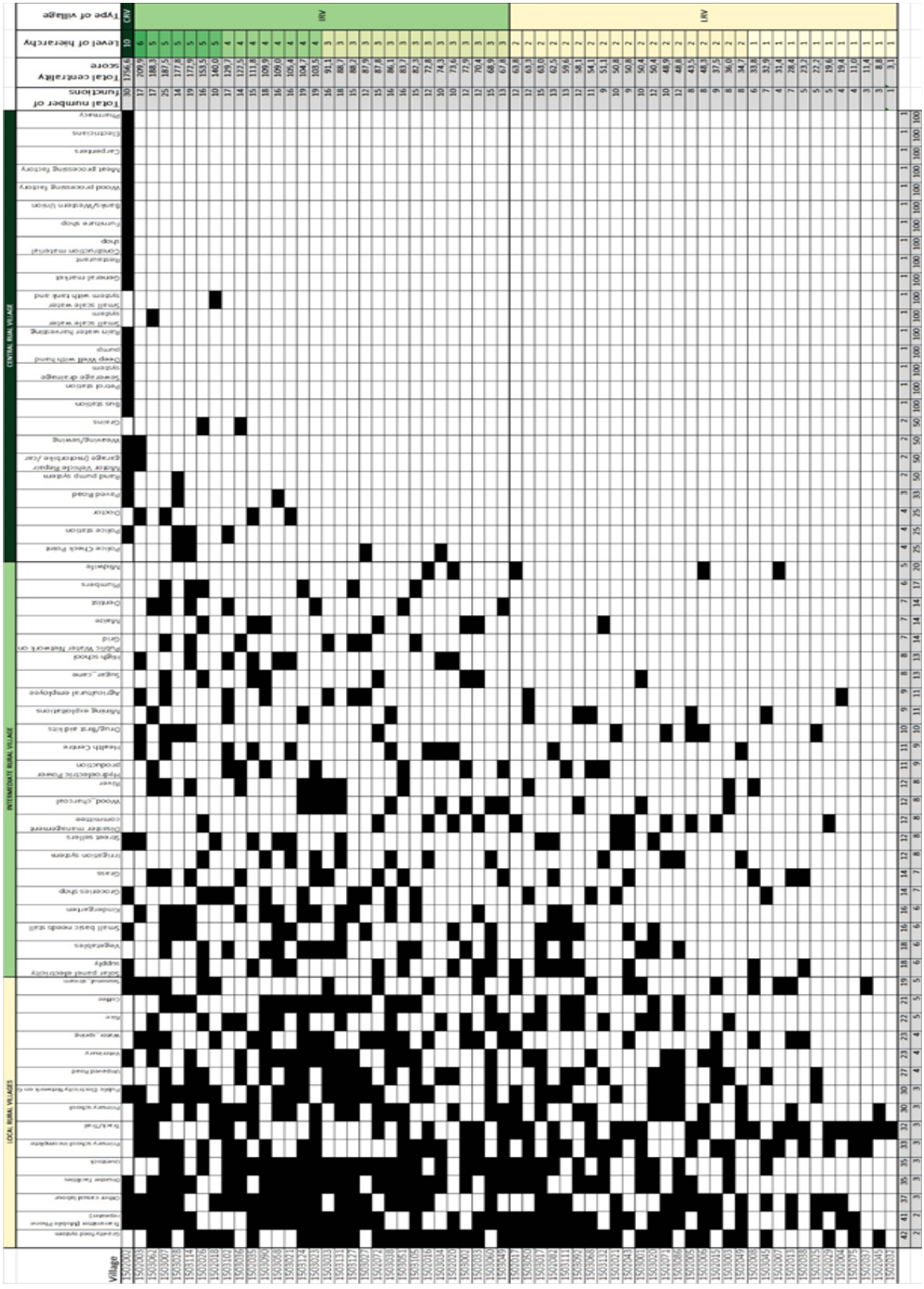
- **Functions** are sorted according to their frequency, basic functions on the left side of the matrix
- **Villages** are sorted according to their centrality score, higher values on the top of the matrix

184 NB: A "function" we define as every service, equipment, activity and facility which has an economic, administrative, social or cultural function in a given human settlement.

Table 10 - List of functions used to build the Matrix of Function

Category	Function
Transportation Infrastructure	Paved road, Gravel road, Trail/Track, Bus transport on daily basis, Bus Station, Bus stop, Petrol Supply Station,
Public Utilities and Facilities	Telecommunication Transmitter (Mobile Phone repeater), Solar panel electricity supply, Public Electricity Network on Grid, Sewerage drainage system, Storm water drainage system
Water supply systems	Gravity feed system, Deep Well with hand pump, Rain water harvesting (on ground/underground), Small scale water system, Small scales water system with tank and well, Rand pump system, Public Water Network on Grid (piped water), Irrigation system
Markets and Commercial Establishments	General market, Livestock market, Small basic needs stall (i.e a stall selling basic items (fruits, veg, soaps, drinks, mobile phone cards), Groceries shop, Supermarket, Restaurant, Hotel, Bicycle Repair garage, Motor Vehicle Repair garage (motorbike /car), Construction material shop, Furniture shop, Banks/Western Union, ATM
Business and industrial activities	Hydroelectric Power production, Mining exploitations, Wood processing factory, Meat processing factory, Feed (e.g. for animals) Processing Factory
Jobs/own account workers	Street sellers, Weaving/sewing, Carpenters, Veterinary, Electricians, Lawyers, Plumbers, Agriculture (small-holder/self-sufficient), Agricultural employee, Employment in industry/manufacturing, Other casual labour
Community Organisations and NGOs	Farmers cooperatives, Non-Profit Associations (NPAs), International/ National Non-Government Organisations (I/NGOs)
Provisioning eco-systems services	Rice, Coffee, Tea, Sugar cane, Maize, Grains, Vegetables, Livestock, Wood for charcoal, Roof/wall material (Grass), River, Seasonal stream, Water spring
Health facilities and services	Health Centre, Drug/first aid kits, Doctor, Midwife, Dentist, Pharmacy
Educational institutions	Vocational training center, High school, Primary school, Primary school but with incomplete classes (i.e. not enough teachers/space), Kindergarten
Public recreational and Cultural Facilities	Monastery, Library, Cultural Centre, Museum, Playground
DRR and Security Services	Disaster management committee, Disaster facilities (i.e. Shelter), Police Check Point, Police station, Fire Station

Figure 45 - Matrix of Ordered Functions (MoF)



The ordered matrix is then interpreted to group basic, intermediate, and central settlements and determine a "set of functions" that should be covered considering the highest presence of a function for each category in the context of the region. Considering local rural villages as the lowest level, an implicit assumption is that in a "regular/standard distribution" any higher hierarchical level should contain the number of functions of the precedent level(s) plus their own specific functions, hence the matrix allows to identifying settlements where functions are "missing" and whether functions of higher levels are present.

Table 11 - Functions that should be covered in each type of village

Functions		Local Rural Village (LRV)	Intermediate Rural Village (IRV)	Central Rural Village (CRV))
INFRASTRUCTURE	Transportation Infrastructure	Track/Trail Unpaved Road		Paved Road Bus station Petrol station
	Public Utilities and Facilities	Mobile Phone repeater Public Electricity Network on Grid	Solar panel electricity supply	Sewerage drainage system
	Water supply systems	Gravity feed system	Irrigation system Public Water Network on Grid	Deep Well with a hand pump Rain water harvesting Small scale water system
SOCIO-ECONOMIC SERVICES	Health facilities and services		Drug/first aid kits Health Centre Dentist Midwife	Doctor Pharmacy
	Educational institutions	Primary school incomplete Primary school	Kindergarten High school	
	DRR and Security Services	Disaster facilities	Disaster management committee	Police Check Point Police station
	Markets and Commercial Establishments		Small basic needs stall Groceries shop	Motor Vehicle Repair garage (motorbike /car General market Restaurant Construction material shop Furniture shop Banks/Western Union
	Business and industrial activities		Hydroelectric Power production Mining exploitations	Wood processing factory Meat processing factory
	Jobs/own account workers	Other casual labour Veterinary	Street sellers Agricultural employee Plumbers	Weaving/sewing Carpenters Electricians
ECO-SYSTEM SERVICES	Provisioning services	Livestock Rice Coffee Seasonal stream Water spring	Vegetables Sugar cane Maize Grass Wood charcoal River	
Total		16	22	21

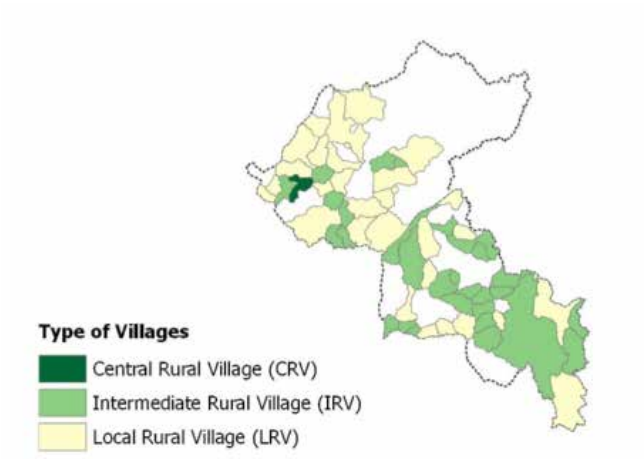


Figure 46 - Spatial distribution of the type of villages

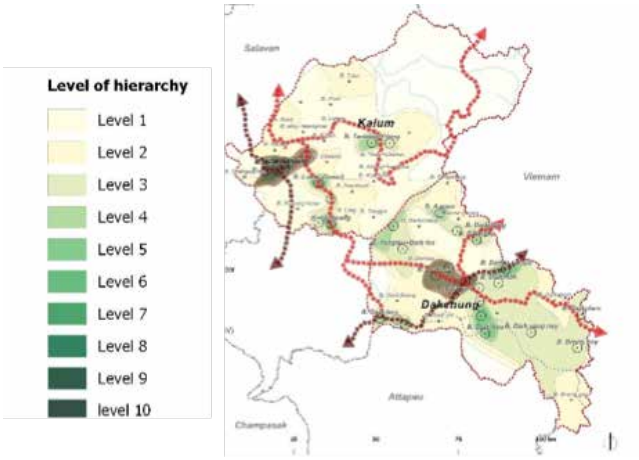


Figure 47 - Territorial linkages and spatial structure

In addition, mapping the different typologies of settlements through geographic information system (GIS) helps visualising how balanced the spatial development of the region is, which, from the perspective of improving the human settlements gives already some clear indications, in terms of prioritisation, for preliminary needed investments in each settlement:

- **Sanxai district concentrates the highest percentage (40%) of selected villages categorised as Local Rural Villages (LRV), considered the lowest level of socio-economic and infrastructure development**

- **Better transportation infrastructure across villages in lowland areas enable better access to socio-economic services than in highland villages.**

The spatial analysis is then complemented with an isopleth map showing the levels of centrality of each settlement. The map can be drawn by hand or mapped in a geographic information system (figure 45). From the isopleth map, the spatial structure emerges. It visualises the "territorial linkages" of each settlement and identifies "clusters" of settlements (or areas of concentration of urban settlements) which are strongly interconnected and work cooperatively in terms of socio-economic activities.

- **The territorial and socio-economic development of the region is mainly centred on the village of Meouhuomeung (Samakkhikay) and the bi-polar set of settlements Saysi (Xaisettha) and Vungkhan (Phouvong), all three strategically Meouhuomeung (Samakkhikay) located at lowland areas and at the cross-junctions of main roads (international/national)**

Under the strategy of socio-economic complementarity, the analysis of the existing and missing functions in the settlements within these "clusters", helps to define priority investments for clustering services and facilities, considering the proposed regional settlement system, the distribution of functions among settlements and the settlement hierarchy

Meouhuomeung (Samakkhikay)

Meouhuomeung (Samakkhikay) provides the highest levels of education facilities and security services and represents the main supply centre of goods and services to the neighbouring rural communities.

Villages	Name	Level	Type of village
	Meouhuomeung (1702043)	9	Central Rural Villages (CRV)
Main infrastructure and public services provided	Infrastructure service	Public Water Network on Grid, Mobile Phone repeater, Public Electricity Network, Deep Well with a hand pump, Irrigation system, Paved Road, Bus stop, Petrol station	
	Socio-economic services	Kindergarten, Primary school, High school, Health Centre, Doctor, Midwife, Pharmacy	
	Eco-system Provisioning services	Livestock, Rice, vegetables, Maize, rivers	
Main sources of income	Other casual labour, Meat processing factory, Plumbers, Construction material shop		
Main recommendations	Enhance road infrastructure and transport services to/from northern areas of the district		

The bi-polar set of settlements Saysi (Xaisettha) and Vungkhan (Phouvong) is strategically located at lowland areas and at the cross-junctions of main roads (international/national)

Saysi (Xaisettha) and Vungkhan (Phouvong), represent the productive area of the region, with Wood Meat processing factories and large-scale rice and maize plantations

Villages	Name	Level	Type of village
	B.Saysi (1701001)	10	Central Rural Villages (CRV)
	B.Vungkhan (1705026)	8	Central Rural Villages (CRV)
Main infrastructure and public services provided	Infrastructure service	Public Electricity Network on Grid, Mobile Phone repeater, Deep Well with a hand pump, Public Water Network on Grid, Paved Road, Petrol station, Irrigation system	
	Socio-economic services	Kindergarten, Primary school, High school, Vocational training center, General market	
	Eco-system Provisioning services	Livestock, Rice, vegetables, Maize, Seasonal stream, River	
Main sources of income	Wood processing factory, Agricultural employee, Employment in industry/ manufacturing, Other casual labour		
Main recommendations	Efforts should be made to create Vocational Training Centres to provide skilled people needed in the agro-industries and enhance agricultural practices at household levels		

Annex 3 Developing the vulnerability index

The vulnerability index was calculated based on the three vulnerability elements; exposure, sensitivity and adaptive capacity, which in this assessment were determined by a total of 40 indicators, categorised into 20 indicator groups. The general structure of the index was based on the calculation of the world risk index[185] and adjusted to fit the context of the vulnerability assessment in Saravan, Sekong, and Attapeu and to utilise the data available.

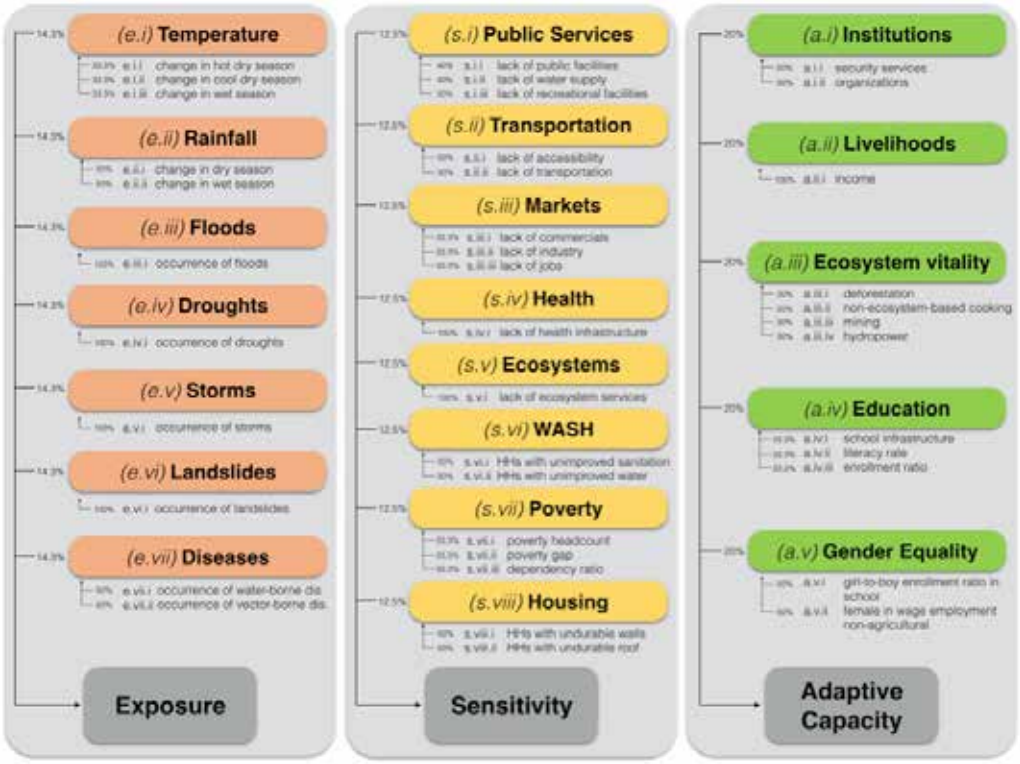


Figure 48 - an overview of vulnerability index indicators, including weight for Exposure calculation

The vulnerability index considers of the exposure to 7 different hazards. These are: (e.i) temperature, (e.ii) rainfall, (e.iii) floods, (e.iv) droughts, (e.v) storms, (e.vi) landslides, and (e.vii) diseases. Based on the results of these indicator groups, the overall exposure was calculated as the mean value of these 7 groups, hence every indicator group has an equal weight of 14.3 per cent to the overall exposure. The indicator groups for exposure are expressed in a value between 0 and 10, where 0 is the lowest exposure and 10 is the highest.

These 7 indicator groups are composed of 11 individual indicators. The indicators are arranged as follows:

- **Temperature**
  - Change in the hot dry season (February to April)
  - Change in the cool dry season (November to January)
  - Change in the wet season (May to October)
- **Rainfall**
  - Perceived change in the dry season (November to April)
  - Perceived change in the rainy season (May to October)
  - Floods – Occurrence of floods
- **Droughts** – Occurrence of droughts
- **Storms** – Occurrence of storms
- **Landslides** – Occurrence of landslides
- **Disease**
  - Occurrence of water-borne disease
  - Occurrence of vector-borne disease

185 http://weltrisikobericht.de/wp-content/uploads/2017/11/Indicators-WorldRiskIndex.pdf.

element	indicator group	group weight for element (%)	indicator	indicator weight in group (%)	data source	N° of options	type of option	options/answers	weighting	possible score (multiple-choice only)	conversion scheme	conversion
Exposure	(e.i) Temperature	14,3%	(e.i.i) perceived change of Temperature_hot dry season	33,3%	survey	7	single choice	significant_increase, some_increase, slight_increase, no_change, slight_decrease, some_decrease, significant_decrease	n/a	n/a	10, 8.4, 6.7, 5, 3.4, 1.7, 0	significant_increase=10, some_increase=8.4, slight_increase=6.7, no_change=5, slight_decrease=3.4, some_decrease=1.7, significant_decrease=0
			(e.i.ii) change of Temperature_cool dry season	33,3%	survey	7	single choice	significant_increase, some_increase, slight_increase, no_change, slight_decrease, some_decrease, significant_decrease	n/a	n/a	10, 8.4, 6.7, 5, 3.4, 1.7, 0	significant_increase=10, some_increase=8.4, slight_increase=6.7, no_change=5, slight_decrease=3.4, some_decrease=1.7, significant_decrease=0
			(e.i.iii) change of Temperature_rain y season	33,3%	survey	7	single choice	significant_increase, some_increase, slight_increase, no_change, slight_decrease, some_decrease, significant_decrease	n/a	n/a	10, 8.4, 6.7, 5, 3.4, 1.7, 0	significant_increase=10, some_increase=8.4, slight_increase=6.7, no_change=5, slight_decrease=3.4, some_decrease=1.7, significant_decrease=0
	(e.ii) Rainfall	14,3%	(e.ii.i) change of Rain_dry season	50,0%	survey	7	single choice	significant_increase, some_increase, slight_increase, no_change, slight_decrease, some_decrease, significant_decrease	n/a	n/a	10, 8.4, 6.7, 5, 3.4, 1.7, 0	significant_increase=0, some_increase=1.7, slight_increase=3.4, no_change=5, slight_decrease=6.7, some_decrease=8.4, significant_decrease=10
			(e.ii.ii) change of Rain_rainy season	50,0%	survey	7	single choice	significant_increase, some_increase, slight_increase, no_change, slight_decrease, some_decrease, significant_decrease	n/a	n/a	10, 8.4, 6.7, 5, 3.4, 1.7, 0	significant_increase=0, some_increase=1.7, slight_increase=3.4, no_change=5, slight_decrease=6.7, some_decrease=8.4, significant_decrease=10
	(e.iii) Floods	14,3%	(e.iii.i) occurrence of Flood	100,0%	survey	5	single choice	more_1_year, 1_year, 1_every_3_5_years, 1_every_10_years, no_floods	n/a	n/a	10, 7.5, 5, 2.5, 0	more_1_year=10, 1_year=7.5, 1_every_3_5_years=5, 1_every_10_years=2.5, no_floods=0
	(e.iv) Droughts	14,3%	(e.iv.i) occurrence of Drought	100,0%	survey	5	single choice	more_1_year, 1_year, 1_every_3_5_years, 1_every_10_years, no_droughts	n/a	n/a	10, 7.5, 5, 2.5, 0	more_1_year=10, 1_year=7.5, 1_every_3_5_years=5, 1_every_10_years=2.5, no_droughts=0
	(e.v) Storms	14,3%	(e.v.i) occurrence of Storms	100,0%	survey	5	single choice	more_1_year, 1_year, 1_every_3_5_years, 1_every_10_years, never	n/a	n/a	10, 7.5, 5, 2.5, 0	more_1_year=10, 1_year=7.5, 1_every_3_5_years=5, 1_every_10_years=2.5, never=0
	(e.vi) Landslides	14,3%	(e.vi.i) occurrence of Landslides	100,0%	survey	2	single choice	yes, no	n/a	n/a	10, 0	yes=10, no=0
	(e.vii) Diseases	14,3%	(e.vii.i) occurrence of Water_disease	50,0%	survey	6	multiple choice	Diarrhea_disease, Skin_disease, Eye_disease, Allergies, Other, No_problems	n/a	5 (highest) to 0 (lowest); intervall: 1	10, 8, 6, 4, 2, 0	score_5=10, score_4=8, score_3=6, score_2=4, score_1=2, score_0=0
			(e.vii.ii) occurrence of Vector_disease	50,0%	survey	5	multiple choice	Malaria, Dengue, Encephalitis, Other, None	n/a	4 (highest) to 0 (lowest); intervall: 1	10, 7.5, 5, 2.5, 0	score_4=10, score_3=7.5, score_2=5,
count	7	100,0%	11	EXPOSURE		0-10	0-lowest, 10-highest					

Figure 49 - an overview of the determination of exposure and its indicators

Where there is more than one indicator per indicator group, the individual indicators contribute equally. For example, the indicator for disease is the average of the two sub-indicators; water-borne disease and vector-borne disease. All 11 indicators were taken from the vulnerability assessment survey and consider a period of the last 30 years for the perceived/reported hazards.

In some cases, the raw data, especially from the survey, was not expressed as a numerical value, and therefore had to be converted for use in the index. For example, the occurrence of floods, droughts, storms, and landslides was a multiple-choice question in the survey; respondents could choose from five pre-determined answers; more than one event per year, one event per year, one event every 3 to 5 years, one event every 10 years, never. More than one event per year indicates the greatest level of exposure, which means that it was assigned a value of 10. Never indicates the lowest exposure, so a value of 0 was assigned to it. The remaining answers were assigned values with equal distance between them, meaning once per year = 7.5, once every 3-5 years = 5 and once every 10 years = 2.5.

More than one indicator could be chosen for both disease sub-indicators (water and vector-borne) because more than one disease can occur in a given village. The survey respondents could choose up to four vector-borne diseases, or none (a total of five options). Therefore, four diseases in a given village were assigned a value of 10. Three was assigned 7.5, two was assigned 5, one was assigned 2.5 and none was assigned 0.

The same conversion concept was also applied for the other exposure indicators that are characterised by single-choice options.

Sensitivity

Sensitivity is calculated using eight different indicators and 17 sub-indicators, shown below. Each indicator has an equal weight of 12.5 per cent of overall sensitivity. Overall sensitivity (and each individual indicator) were expresses as a value between 0 and 10, with 10 being the highest level of sensitivity.

Of the 17 sub-indicators, 10 were taken from the survey and 7 from the census and/or secondary analysis of census data. The weight of each sub-indicator is shown in parenthesis below. The sub-indicators were also expressed as a value between 0 and 10, where 0 indicates the lowest level of sensitivity and 10 indicates the highest:

- **Public services**
  - Lack of public facilities (40 per cent)
  - Lack of water supply infrastructure (40 per cent)
  - Lack of recreational facilities (20 per cent)
- **Transportation**
  - Lack of accessibility (50 per cent)
  - Transportation infrastructure (50 per cent)
- **Markets**
  - Lack of commercial activity (33 per cent)
  - Lack of industry (33 per cent)
  - Lack of markets (33 per cent)
- **Health**
  - Lack of health infrastructure (100 per cent)
- **Ecosystems**
  - Lack of ecosystems (100 per cent)
- **WASH**
  - Percentage of households with unimproved sanitation (50 per cent)
  - Percentage of households relying on unprotected water (50 per cent)
- **Poverty**
  - Absolute poverty rate (33 per cent)
  - Poverty gap index (33 per cent)
  - Dependency ratio (33 per cent)
- **Housing**
  - Percentage of houses with non-durable roof materials (50 per cent)
  - Percentage of houses with non-durable wall materials (50 per cent)

element	indicator group	group weight for element (%)	indicator	indicator weight in group (%)	data source	N° of options	type of option	options/answers	weighting	possible score (quantity only)	conversion sheme	conversion
	(s.i) Public Service	12,5%	(s.i.i) Lack of Public_facility	40,0%	survey	6	multiple choice	Telecomunications, solar_panel, public_electricity, sewerage_drainage, storm_drainage, none	n/a	5 (lowest) to 0 (highest); intervall: 1	10, 8, 6, 4, 2, 0	score_5=0, score_4=2, score_3=4, score_2=6, score_1=8, score_0=10
			(s.i.ii) Lack of Water_suply	40,0%	survey	9	multiple choice	Gravity, deep_well, rain_harvesting, small_water_system, tank_well, rand_pump, public_network, irrigation, none	n/a	8 (lowest) to 0 (highest); intervall: 1	10, 8.75, 7.5, 6.25, 5, 3.75, 2.5, 1.25, 0	score_8=0, score_7=1.25, score_6=2.5, score_5=3.75, score_4=5, score_3=6.25, score_2=7.5, score_1=8.75, score_0=10
			(s.i.iii) Lack of Recreational facilities	20,0%	survey	6	multiple choice	monastery, library, cultural_centre, museum, playground, none	n/a	5 (lowest) to 0 (highest); intervall: 1	10, 8, 6, 4, 2, 0	score_5=0, score_4=2, score_3=4, score_2=6, score_1=8, score_0=10
	(s.ii) Transportation	12,5%	(s.ii.i) Lack of Accessibility	50%	survey	4	single choice	paved, gravel, unmade, no	n/a		10, 6.7, 3.3, 0	paved=0, gravel=3.3, unmade=6.7, no=10
			(s.ii.ii) Lack of Transportation	50%	survey	5	multiple choice	bus, bus_station, bus_stop, petrol, none	bus=1, bus_station=1, bus_stop=0.5, petrol=1	3.5 (lowest) to 0 (highest); intervall: 0.5	10, 8.58, 7.15, 5.72, 4.29, 2.86, 1.43, 0	score_3.5=0, score_3=1.43, score_2.5=2.86, score_2=4.29, score_1.5=5.72, score_1= 7.15, score_0.5=8.58, score_0=10
	(s.iii) Markets	12,5%	(s.iii.i) Lack of Comercials	33,3%	survey	14	multiple choice	general_market, livestock_market, basic, groceries, supermarket, restaurant, hotel, bicycle_repair, motor_repair, construction_shop, furniture_shop, bank, ATM, none	n/a	13 (lowest) - 1 (highest); intervall: 1	10, 9.24, 8.47, 7.7, 6.93, 6.16, 5.39, 4.62, 3.85, 3.08, 2.31, 1.54, 0.77, 0	score_13=0, score_12=0.77, score_11=1.54, score_10=2.31, score_9=3.08, score_8=3.85, score_7=4.62, score_6=5.39, score_5=6.16, score_4=6.93, score_3=7.7, score_2=8.47, score_1=9.24, score_0=10
			(s.iii.ii) Lack of Industry	33,3%	survey	6	multiple choice	hydroelectric, mining, wood, meat, feed_animals, none	n/a	5 (lowest) to 0 (highest); intervall: 1	10, 8, 6, 4, 2, 0	score_5=0, score_4=2, score_3=4, score_2=6, score_1=8, score_0=10

Figure 50 - an overview of the determination of sensitivity and its indicators (part 1)

As with exposure, values had to be converted to a value between 0-10. For example, poverty headcount was expressed as a value between 0 and 100, so to convert the value to the index it was divided by 10. In the case of the poverty gap, where the values were between 0 and 22, the value was divided by 0.455. Meanwhile, some non-numerical values were converted in the same way as for exposure, outline above, by placing them on a scale with equal spacing. For example, in the case of 'lack of accessibility', a paved road was assigned 0, while gravel was assigned 3.3, unmade 6.7 and no road was 10.

However, in some cases, options are not considered to be of equal value. To address this, the team developed a weighting system to reflect this.

Sensitivity			(s.iii.iii) Lack of Jobs	33,3%	survey	12	multiple choice	street_sellers, weaving_sewing, carpenters, veterinary, electricians, lawyers, plumbers, agriculture_small, agricultural_employee, employment_industry, casual, none	n/a	11 (lowest) to 0 (highest); intervall: 1	10, 9.1, 8.19, 7.28, 6.37, 5.46, 4.55, 3.64, 2.73, 1.82, 0.91, 0	score_11=0, score_10=0.91, score_9=1.82, score_8=2.73, score_7=3.64, score_6=4.55, score_5=5.46, score_4=6.37, score_3=7.28, score_2=8.19, score_1=9.1, score_0=10
	(s.iv) Health	12,5%	(s.iv.i) lack of health_infrastructure	100%	survey	7	multiple choice	health_centre, drug, doctor, midwife, dentist, pharmacy, none	health_centre=1.5, drug=0.5, doctor=2, midwife=1, dentist=1, pharmacy=1	7 (lowest) to 0 (highest); intervall: 0.5	10, 9.23, 8.52, 7.81, 7.1, 6.39, 5.68, 4.97, 4.26, 3.55, 2.84, 2.31, 1.42, 0.71, 0	score_7=0, score_6.5=0.71, score_6=1.42, score_5.5=2.31, score_5=2.84, score_4.5=3.55, score_4=4.26, score_3.5=4.97, score_3=5.68, score_2.5=6.39, score_2=7.1, score_1.5=7.81, score_1=8.52, score_0.5=9.23, score_0=10
	(s.v) Ecosystems	12,5%	(s.v.i) Lack of eco_systems_services	100%	survey	15	multiple choice	rice, coffee, tea, sugar_cane, maize, grains, vegetables, livestock, wood_charcoal, grass, river, seasonal_stream, water_spring, other, none	n/a	14 (lowest) to 0 (highest); intervall: 1	10, 9.23, 8.52, 7.81, 7.1, 6.39, 5.68, 4.97, 4.26, 3.55, 2.84, 2.31, 1.42, 0.71, 0	score_14=0, score_13=0.71, score_12=1.42, score_11=2.31, score_10=2.84, score_9=3.55, score_8=4.26, score_7=4.97, score_6=5.68, score_5=6.39, score_4=7.1, score_3=7.81, score_2=8.52, score_1=9.23, score_0=10
	(s.vi) WASH	12,5%	(s.vi.i) HH (%) with unimproved access to sanitation	50%	census	0-100	single choice	0-100	n/a		%/10	
			(s.vi.i) HH (%) with unimproved drinking water facility	50%	census	0-100	single choice	0-100	n/a		%/10	
	(s.vii) Poverty	12,5%	(s.vii.i) poverty headcount (%)	33,3%	census based poverty map	0-100	single choice	0-100	n/a		%/10	
			(s.vii.ii) poverty gap (%)	33,3%	census based poverty map	0-22	single choice	0-22	n/a		x*0,457	
			(s.vii.iii) dependency ratio (%)	33,3%	census based poverty map	0-100	single choice	0-100	n/a		%/10	
	(s.viii) Housing	12,5%	(s.viii.i) HH (%) with undurable wall material	50%	census	0-100	single choice	0-100	n/a		%/10	
			(s.viii.ii) HH (%) with undurable roof material	50%	census	0-100	single choice	0-100	n/a		%/10	
count	8	100,0%	17	SENSITIVITY		0-10		0-lowest, 10-highest				

Figure 51 - an overview on the determination of sensitivity and its indicators (part 2)

Taking the lack of health infrastructure sub-indicator as an example, a health centre and a doctor have greater influence on reducing sensitivity than a village drug kit, which provides on very basic medicines. Reflecting this, the team determined higher weights for the presence of a doctor (2) and a health centre (1.5) than for a village drug kit (0.5). The options of dentist, midwife or pharmacy were all given a weight of 1. Consequently, if a village would have each of these options, their score for this indicator would be 7 (1.5+2+0.5+1+1+1=7). If it only had a doctor and a midwife, the score would be 3 (2+1=3) and if the village had none of these options, it would be 0.

If a village had all the above health care professionals and facilities, it would be given an indicator of 7. If it had a doctor and a midwife, it would get 3 (2 for doctor + 1 for midwife). Some villages had none of the above, and therefore score 0. As with the other indicators, these were then converted to a value between 0 and 10. So, continuing the above example, the village with all facilities and professionals would be given a value of 10, while the village with a doctor and a midwife only would be given a score of 4.29

Consequently, if a village would have each of these options, their score for this indicator would be 7 (1.5+2+0.5+1+1+1=7). If it only had a doctor and a midwife, the score would be 3 (2+1=3) and if the village had none of these options, it would consequently be 0. The range of this indicator is 7 to 0, however 7 is considered as low lack while 0 expresses a high lack. The interval is 0.5, which means that it is possible to score values with the difference of 0.5 (7, 6.5, 6, 5.5 ...) which finally amounts for 14 scores. Just like the other multiple-choice indicators, these scores are equally transferred to a range of 0 (lowest) to 10 (highest). So taking up the above outlined examples of the scores 7, 3 and 0; these would be transferred to 0, 5.68 and 10. Therefore, having all health facilities in place will result in a minimum lack of health infrastructures, contributing to a low sensitivity, while having none of these options will result in a high lack and thus also contributes to a high sensitivity.

Adaptive Capacity

The adaptive capacity element of the vulnerability index was calculated using 5 different indicator groups, and 12 sub-indicators. The weight of the sub-indicators is shown in parenthesis below:

- **Institutions**
  - Existence of security services (50 per cent)
  - Existence of NGOs/CBOs and other external organisations (50 per cent)
- **Livelihoods**
  - Number of income sources (100 per cent)
- **Ecosystem vitality**
  - Occurrence of deforestation (20 per cent)
  - Use of forest-based cooking fuels (20 per cent)
  - Occurrence of mining (30 per cent)
  - Occurrence of hydropower (30 per cent)
- **Education**
  - Presence of schools (33 per cent)
  - Literacy rate (33 per cent)
  - School enrolment rate (33 per cent)
- **Gender equality**
  - Female to male school enrolment rate (50 per cent)
  - Percentage of female in non-agriculture wage employment (50 per cent)

The overall adaptive capacity was calculated as the mean value of these 5 groups, hence every indicator group was given an equal weight of 20 per cent. Both adaptive capacity and the 5 indicator groups are expressed in a value between 0 and 10, where 0 is the lowest adaptive capacity and 10 respectively the highest.

element	indicator group	group weight for element (%)	indicator	indicator weight in group (%)	data source	N° of options	type of option	options/answers	weighting	possible score (multiple-choice only)	conversion scheme	conversion
Adaptive Capacity	(a.i) Institutions	20%	(a.i.i) Security Services	50%	survey	6	multiple choice	disaster_committee, disaster_facilities, police_check_point, police_station, fire_station, none	n/a	5 (highest) to 0 (lowest); intervall: 1	10, 8, 6, 4, 2, 0	score_5=10, score_4=8, score_3=6, score_2=4, score_1=2, score_0=0
			(a.i.ii) Organizations	50%	survey	4	multiple choice	Cooperatives, NPAS, NGO, none	n/a	3 (highest) to 0 (lowest); intervall: 1	10, 6.7, 3.3, 0	score_3=10, score_2=6.7, score_1=3.3, score_0=0
	(a.ii) Livelihoods	20%	(a.ii.i) income	100%	survey	7	multiple choice	Agriculture, Agricultural_employee, Livestock, Trade, Industry_manufacturing, casual_labour, other	n/a	6 (highest) to 0 (lowest); intervall: 1	10, 8.33, 6.67, 5, 3.33, 1.67, 0	score_6=10, score_5=8.33, score_4=6.67, score_3=5, score_2= 3,33, score_1=1,67, score_0=0
	(a.iii) Ecosystem vitality	20%	(a.iii.i) Deforestation	20%	survey	2	single choice	yes, no	n/a	n/a	10, 0	yes=0, no=10
			(a.iii.ii) non-ecosystem-based cooking	20%	census	0-100	single choice	0-100	n/a	n/a	%/10	
			(a.iii.iii) Mining	30%	survey	2	single choice	yes, no	n/a	n/a	10, 0	yes=0, no=10
			(a.iii.iv) Hydropower	30%	survey	2	single choice	yes, no	n/a	n/a	10, 0	yes=0, no=10
	(a.iv) Education	20%	(a.iv.i) school infrastructure	33,33%	survey	6	multiple choice	vocational, high_school, primary_school, primary_school_incomplete, kindergarten, none	vocational=2, high_school=2, primary_school=1, primary_school_incomplete=0.5, kindergarten=0.5	6 (highest) to 0 (lowest); intervall: 0.5	10, 9.16, 8.33, 7.5, 6.66, 5.83, 5, 4.17, 3.33, 2.5, 1.66, 0.83, 0	score_6=10, score_5.5=9.17, score_5=8.33, score_4.5=7.5, score_4=6.66, score_3.5=5.83, score_3=5, score_2.5=4.17, score_2=3.33, score_1.5=2.5, score_1=1.66, score_0.5=0.83, score_0=0
			(a.iv.ii) literacy rate	33,33%	census	0-100	single choice	0-100	n/a	n/a	%/10	
			(a.iv.iii) enrollment ratio	33,33%	census	0-100	single choice	0-100	n/a	n/a	%/10	
	(a.v) Gender Equality	20%	(a.v.i) girl-to-boy enrolment rate in school	50%	census based poverty map	0-1	single choice	0-1	n/a	n/a	x*10	
			(a.v.ii) female in wage employment non-agriculture	50%	census based poverty map	0-100	single choice	0-100	n/a	n/a	%/10	
count	5	100,0%	12 ADAPTIVE CAP.			0-10	0-lowest, 10-highest					

Figure 52 - an overview of the determination of adaptive capacity and its indicators

Vulnerability

After the calculation of the above outlined elements, the overall vulnerability was calculated for every village. This was done by adding exposure and sensitivity and then subtracting the adaptive capacity. Because each element has a value between 0 and 10, the minimum vulnerability is therefore -10, while the maximum is 20, expressing a very high vulnerability.

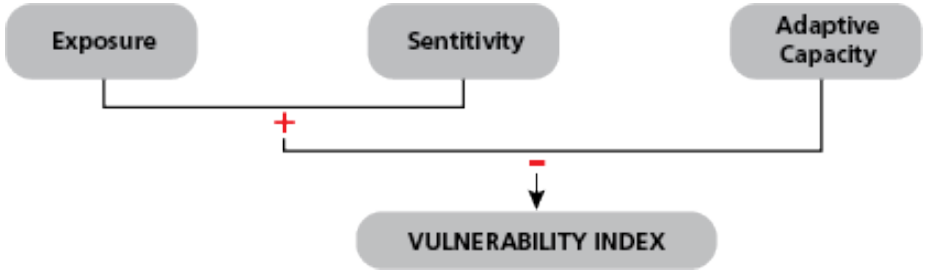


Figure 53 - an overview of vulnerability calculation based on the afore determined elements

Annex 4 Determination of coefficients of change under 'business-as-usual' (BAU) scenario

The coefficients of change are based on the current trends and have been defined to show the worst future scenario in 2050, 'business-as-usual' (BAU), that assumes no adaptation actions are taken. As such, they should be considered as the "estimated reduction" to 2017's baseline given the projected climate changes in temperature and rainfall.

These coefficients are spatially based considering the observed impacts and trends to identify the most vulnerable villages to maintain and support current living standards assessed in 2017.

Agriculture

The predominant crop in Lao PDR is rice, accounting for 71% of all households in 2010[186], being rainfed paddy practices the most common.

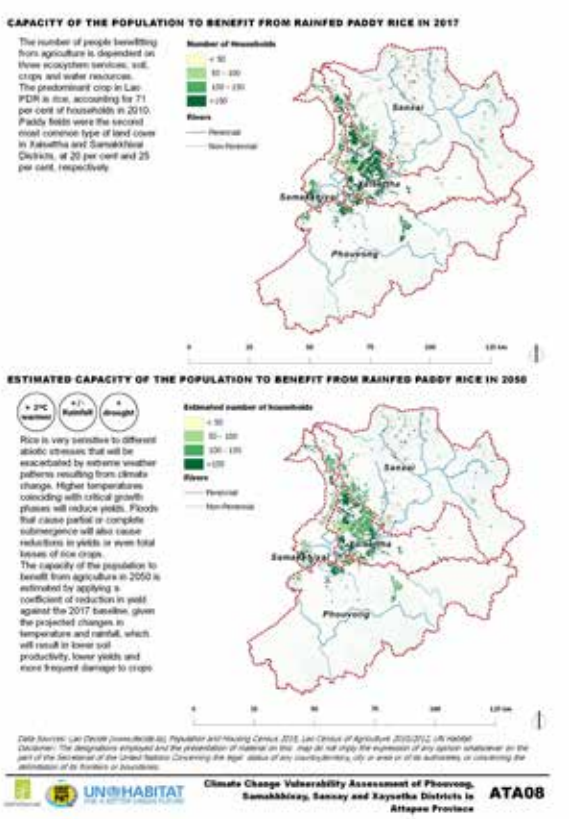
Levels of rice yields depended not only on the climatic conditions but also on field soils and capability of management (crop, irrigation, fertiliser, tillage and harvest)[187].

Changes in temperature and rainfall will also affect the suitability of key crops particularly rainfed rice, coffee, maize, and cassava. Rainfed paddy practices are highly diverse so it is difficult to assess the potential impacts of climate change on rice production. However, model evaluations suggest that while increases in precipitation will increase suitability for rice, changes in the onset of the rainy season may affect the suitability for traditional paddy varieties-at least in localised areas of different livelihood zones

Assumptions

- We assume the percentage of households growing rice is the same percentage of farm households growing rice in 2010/11 (71%) according to the Agriculture Census 2010-2012.

- We assume the percentage of people depending on agriculture is located in villages with paddy fields according to the land cover map of 2010.



186 Lao Agriculture Census 2011-2012.
187 USAID Mekong ARCC.

Coefficient of Climate Change (based on current trends)

The following coefficients are spatially based considering the observed impacts and trends to estimate the worst future scenario to identify the most vulnerable villages to maintain and support current living standards assessed in 2017. Impact on crop yield from climate change is estimated at around 12% for rice crops by 2050

- CCC drought: Rice is highly susceptible to heat stress, particularly during the reproductive and ripening stages[188] in all areas

- CCC temperature: High night temperatures having a greater negative effect on rice yield have been documented, with 1°C above the critical temperature (>24°C) leading to a 10% reduction in both grain yield and biomass [189]

- CCC Inundation recurrence: Unpredictable flood events can lead to complete submergence (often referred to as "flash flooding") causing plant mortality after a few days or partial submergence over longer time spans (often referred to as "stagnant flooding") triggering substantial yield losses[190]

Calculations

(i) HHs depending on agriculture in 2017 = 71% of the total population in each Village (Census 2015).

(ii) HHs depending on agriculture in 2050 = (i)*0.12 (CC Increase temperature and less rainfall 12%) in all areas + (i)*0.05 (CC Inundation recurrence in lowland plains areas 5%)

District	VCODE	Land type	Area paddy rice	(i) HHs 2017	CCC temp/ rainfall	CCC inundation	(ii) HHs 2050
Xaisettha	1701001	lowland	11,57	209	0,12	0,05	245
	1701006	lowland	58,76	152	0,12	0,05	178
	1701007	lowland	13,86	239	0,12	0,05	279
	1701011	plateau	15,85	770	0,12		954
	1701015	lowland	4,17	222	0,12	0,05	259
	1701016	lowland	8,99	94	0,12	0,05	110
	1701017	lowland	8,11	326	0,12	0,05	381
	1701018	lowland	18,58	78	0,12	0,05	91
	1701019	lowland	4,72	106	0,12	0,05	124
	1701022	lowland	10,76	172	0,12	0,05	201
	1701023	lowland	15,39	186	0,12	0,05	217
	1701024	lowland	5,45	66	0,12	0,05	77
	1701030	lowland	41,69	442	0,12	0,05	517
	1701036	plateau	3,36	132	0,12		164
	1701037	lowland	5,07	408	0,12	0,05	476
Samakkhixai	1702018	lowland	3,43	119	0,12	0,05	139
	1702019	lowland	2,86	106	0,12	0,05	125
	1702020	lowland	4,34	122	0,12	0,05	143
	1702021	lowland	10,32	239	0,12	0,05	280
	1702035	lowland	6,63	78	0,12	0,05	91

188 Mohanty S, Wassmann R, Nelson A, Moya P, and Jagadish SVK. 2013. Rice and climate change: significance for food security and vulnerability. IRRI Discussion Paper Series No. 49. Los Baños (Philippines): International Rice Research Institute, p.14.

189 Ibid, p.27.

190 Ibid.

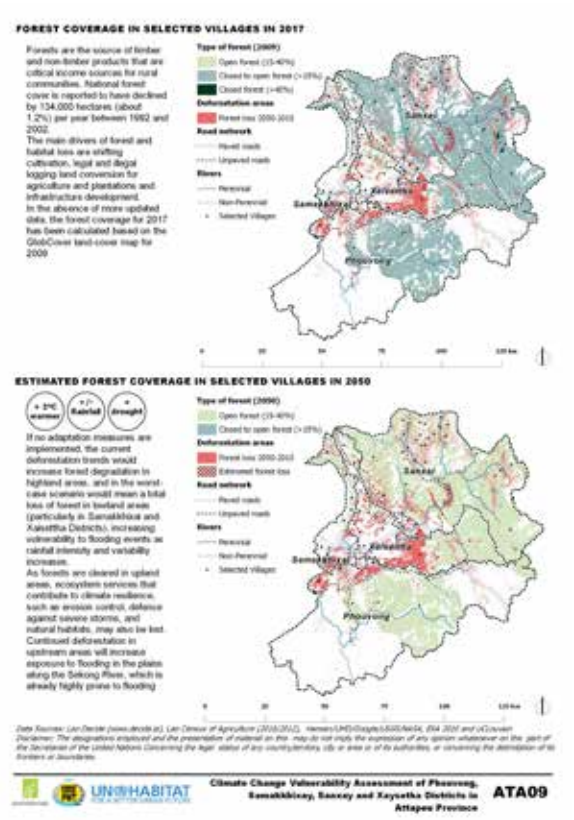
	1702036	lowland	6,32	117	0,12	0,05	137
	1702037	lowland	3,10	107	0,12	0,05	125
	1702038	lowland	4,50	243	0,12	0,05	284
	1702039	lowland	1,63	130	0,12	0,05	152
	1702043	lowland	6,56	352	0,12	0,05	412
Sanxai	1704001	upland	0,00	100	0,12		124
	1704004	upland	1,90	65	0,12		80
	1704005	lowland	6,01	44	0,12	0,05	51
	1704007	upland	6,71	37	0,12		46
	1704010	upland	2,06	77	0,12		96
	1704012	upland	1,44	44	0,12		55
	1704014	upland	0,44	65	0,12		81
	1704015	upland	0,60	42	0,12		52
	1704016	upland	0,84	75	0,12		92
	1704018	lowland	19,00	144	0,12	0,05	168
	1704021	upland	21,67	131	0,12		162
	1704023	upland	0,54	23	0,12		28
	1704024	upland	0,89	45	0,12		55
	1704027	upland	5,53	116	0,12		144
	1704029	upland	0,04	29	0,12		36
	1704030	upland	0,96	16	0,12		19
	1704031	upland	3,72	187	0,12		231
	1704032	upland	1,03	42	0,12		52
	1704035	upland	1,35	15	0,12		18
	1704038	upland	1,65	96	0,12		119
	1704039	upland	0,21	22	0,12		27
	1704040	upland	0,70	29	0,12		36
	1704046	upland	4,09	52	0,12		64
	1704049	upland	2,33	92	0,12		114
	1704050	upland	0,70	73	0,12		91
	1704052	upland	0,15	25	0,12		31
	1704053	upland	0,40	53	0,12		65
	1704054	upland	1,54	96	0,12		119
	1704059	lowland	1,52	86	0,12	0,05	100
	1704060	lowland	2,64	64	0,12	0,05	75
	1704061	lowland	3,61	58	0,12	0,05	68
	1704062	lowland	0,40	169	0,12	0,05	198
Phouvong	1705005	lowland	8,51	107	0,12	0,05	125
	1705012	plateau	0,09	42	0,12		52
	1705014	lowland	0,69	63	0,12	0,05	74
	1705020	lowland	3,25	202	0,12	0,05	237
	1705024	lowland	4,28	29	0,12	0,05	34
	1705026	lowland	15,79	247	0,12	0,05	289
	1705027	lowland	24,08	184	0,12	0,05	215

Deforestation trends by 2050

National forests cover has declined dramatically between 1992 and 2002, at an average rate of 134,000 hectares per year (equivalent to 1.2 -1.3%).

This decade also saw widespread deterioration in forest quality, with dense forest declining from 29% to 8.2% from 1992 to 2002, and open forest increasing from 16% to 24.5%. The UN REDD program estimates that, if the current reduction rate continues, the forest area will decrease to 7.4 million ha (31.3% of the total land) by 2020.

The quality of forest coverage in 2050, if no adaptive measure is considered, assumes the quality of the forest in 2009 will worsen, given the observed deforestation trends.



Assumptions

It is assumed that human activities such as wood harvesting, shifting cultivation, legal and illegal logging, conversion to agriculture and forest plantations and infrastructure development will continue leading to:

- "Closed forest" areas in 2009[191] (2017) will be "closed to open forest" areas in 2050.
- "Closed to open forest" areas in 2009 (2017) will be "open forest areas" in 2050.
- "Open forest" areas in 2009 (2017) will disappear by 2050.

Calculations

District	VCODE	Type of Forest 2017	Estimated type of forest 2050	Area (Ha)
Xaysettha	1701001	Closed forest (>40%)	Closed to open forest (>15%)	56,00
	1701001	Closed to open forest (>15%)	Open forest (15-40%)	107,00
	1701001	Open forest (15-40%)	No forest	259,00
	1701006	Closed forest (>40%)	Closed to open forest (>15%)	215,00
	1701006	Closed to open forest (>15%)	Open forest (15-40%)	226,00
	1701006	Open forest (15-40%)	No forest	1.105,00
	1701007	Closed forest (>40%)	Closed to open forest (>15%)	129,00
	1701007	Closed to open forest (>15%)	Open forest (15-40%)	397,00
	1701007	Open forest (15-40%)	No forest	142,00
	1701011	Closed forest (>40%)	Closed to open forest (>15%)	51,00
	1701011	Closed to open forest (>15%)	Open forest (15-40%)	7.631,00
	1701011	Open forest (15-40%)	No forest	2.369,00
	1701015	Closed to open forest (>15%)	Open forest (15-40%)	1,00
	1701015	Open forest (15-40%)	No forest	7,00

191 In the absence of more updated data the forest coverage for 2017 has been calculated from Glove cover map from 2009.

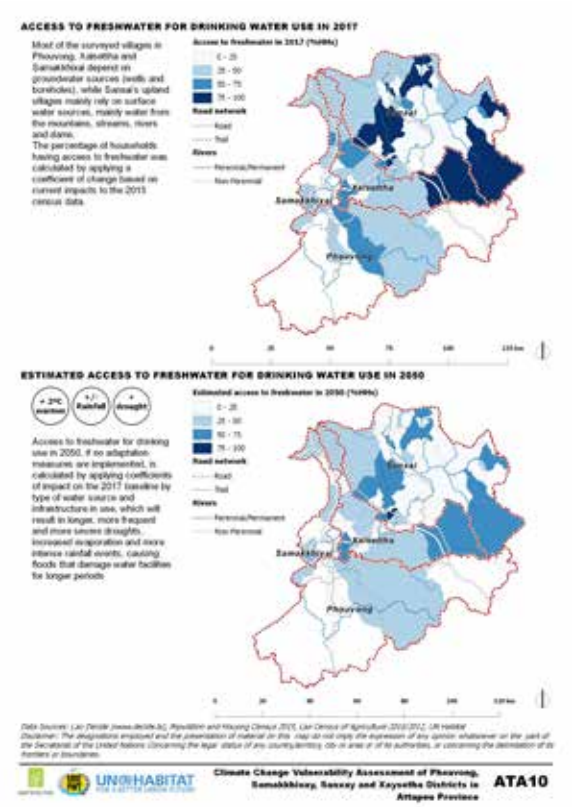
	1701016	Closed forest (>40%)	Closed to open forest (>15%)	8,00
	1701016	Closed to open forest (>15%)	Open forest (15-40%)	312,00
	1701016	Open forest (15-40%)	No forest	85,00
	1701017	Closed to open forest (>15%)	Open forest (15-40%)	86,00
	1701017	Open forest (15-40%)	No forest	16,00
	1701018	Closed forest (>40%)	Closed to open forest (>15%)	13,00
	1701018	Closed to open forest (>15%)	Open forest (15-40%)	23,00
	1701018	Open forest (15-40%)	No forest	45,00
	1701019	Closed forest (>40%)	Closed to open forest (>15%)	0,00
	1701019	Closed to open forest (>15%)	Open forest (15-40%)	159,00
	1701019	Open forest (15-40%)	No forest	56,00
	1701022	Closed forest (>40%)	Closed to open forest (>15%)	1,00
	1701022	Closed to open forest (>15%)	Open forest (15-40%)	391,00
	1701022	Open forest (15-40%)	No forest	205,00
	1701023	Closed forest (>40%)	Closed to open forest (>15%)	8,00
	1701023	Closed to open forest (>15%)	Open forest (15-40%)	2.051,00
	1701023	Open forest (15-40%)	No forest	586,00
	1701024	Closed forest (>40%)	Closed to open forest (>15%)	61,00
	1701024	Closed to open forest (>15%)	Open forest (15-40%)	1.916,00
	1701024	Open forest (15-40%)	No forest	532,00
	1701030	Closed forest (>40%)	Closed to open forest (>15%)	122,00
	1701030	Closed to open forest (>15%)	Open forest (15-40%)	1.327,00
	1701030	Open forest (15-40%)	No forest	2.169,00
	1701036	Closed forest (>40%)	Closed to open forest (>15%)	22,00
	1701036	Closed to open forest (>15%)	Open forest (15-40%)	34.332,00
	1701036	Open forest (15-40%)	No forest	70,00
	1701037	Closed to open forest (>15%)	Open forest (15-40%)	434,00
	1701037	Open forest (15-40%)	No forest	452,00
Smakkhixay	1702018	Closed to open forest (>15%)	Open forest (15-40%)	378,00
	1702019	Closed to open forest (>15%)	Open forest (15-40%)	266,00
	1702019	Open forest (15-40%)	No forest	17,00
	1702020	Closed to open forest (>15%)	Open forest (15-40%)	155,00
	1702020	Open forest (15-40%)	No forest	166,00
	1702021	Closed forest (>40%)	Closed to open forest (>15%)	9,00
	1702021	Closed to open forest (>15%)	Open forest (15-40%)	441,00
	1702021	Open forest (15-40%)	No forest	272,00
	1702035	Closed forest (>40%)	Closed to open forest (>15%)	6,00
	1702035	Closed to open forest (>15%)	Open forest (15-40%)	449,00
	1702036	Closed forest (>40%)	Closed to open forest (>15%)	9,00
	1702036	Closed to open forest (>15%)	Open forest (15-40%)	433,00
	1702036	Open forest (15-40%)	No forest	15,00
	1702037	Closed forest (>40%)	Closed to open forest (>15%)	38,00
	1702037	Closed to open forest (>15%)	Open forest (15-40%)	691,00
	1702038	Closed forest (>40%)	Closed to open forest (>15%)	32,00
	1702038	Closed to open forest (>15%)	Open forest (15-40%)	2.495,00
	1702038	Open forest (15-40%)	No forest	13,00

	1702039	Closed to open forest (>15%)	Open forest (15-40%)	136,00
	1702043	Closed forest (>40%)	Closed to open forest (>15%)	457,00
	1702043	Closed to open forest (>15%)	Open forest (15-40%)	3.505,00
	1702043	Open forest (15-40%)	No forest	989,00
	1702018	Closed to open forest (>15%)	Open forest (15-40%)	378,00
	1702019	Closed to open forest (>15%)	Open forest (15-40%)	266,00
	1702019	Open forest (15-40%)	No forest	17,00
Sanxai	1704001	Closed forest (>40%)	Closed to open forest (>15%)	9,00
	1704001	Closed to open forest (>15%)	Open forest (15-40%)	2.397,00
	1704004	Closed to open forest (>15%)	Open forest (15-40%)	807,00
	1704005	Closed to open forest (>15%)	Open forest (15-40%)	362,00
	1704005	Open forest (15-40%)	No forest	27,00
	1704007	Closed forest (>40%)	Closed to open forest (>15%)	518,00
	1704007	Closed to open forest (>15%)	Open forest (15-40%)	47.568,00
	1704007	Open forest (15-40%)	No forest	58,00
	1704010	Closed forest (>40%)	Closed to open forest (>15%)	373,00
	1704010	Closed to open forest (>15%)	Open forest (15-40%)	30.858,00
	1704010	Open forest (15-40%)	No forest	62,00
	1704012	Closed forest (>40%)	Closed to open forest (>15%)	134,00
	1704012	Closed to open forest (>15%)	Open forest (15-40%)	5.591,00
	1704014	Closed forest (>40%)	Closed to open forest (>15%)	87,00
	1704014	Closed to open forest (>15%)	Open forest (15-40%)	989,00
	1704015	Closed forest (>40%)	Closed to open forest (>15%)	485,00
	1704015	Closed to open forest (>15%)	Open forest (15-40%)	4.660,00
	1704016	Closed forest (>40%)	Closed to open forest (>15%)	73,00
	1704016	Closed to open forest (>15%)	Open forest (15-40%)	3.771,00
	1704018	Closed to open forest (>15%)	Open forest (15-40%)	3.538,00
	1704018	Open forest (15-40%)	No forest	1.643,00
	1704021	Closed forest (>40%)	Closed to open forest (>15%)	156,00
	1704021	Closed to open forest (>15%)	Open forest (15-40%)	25.128,00
	1704021	Open forest (15-40%)	No forest	1.248,00
	1704023	Closed to open forest (>15%)	Open forest (15-40%)	1.528,00
	1704024	Closed to open forest (>15%)	Open forest (15-40%)	1.078,00
	1704027	Closed forest (>40%)	Closed to open forest (>15%)	170,00
	1704027	Closed to open forest (>15%)	Open forest (15-40%)	16.377,00
	1704029	Closed to open forest (>15%)	Open forest (15-40%)	173,00
	1704030	Closed to open forest (>15%)	Open forest (15-40%)	1.344,00
	1704031	Closed forest (>40%)	Closed to open forest (>15%)	160,00
	1704031	Closed to open forest (>15%)	Open forest (15-40%)	11.273,00
	1704031	Open forest (15-40%)	No forest	22,00
	1704032	Closed to open forest (>15%)	Open forest (15-40%)	715,00
	1704035	Closed to open forest (>15%)	Open forest (15-40%)	2.265,00
	1704038	Closed to open forest (>15%)	Open forest (15-40%)	638,00
	1704038	Open forest (15-40%)	No forest	124,00
	1704039	Closed to open forest (>15%)	Open forest (15-40%)	268,00
	1704039	Open forest (15-40%)	No forest	0,00

	1704040	Closed to open forest (>15%)	Open forest (15-40%)	664,00
	1704046	Closed forest (>40%)	Closed to open forest (>15%)	39,00
	1704046	Closed to open forest (>15%)	Open forest (15-40%)	5.699,00
	1704048	Closed to open forest (>15%)	Open forest (15-40%)	717,00
	1704049	Closed forest (>40%)	Closed to open forest (>15%)	15,00
	1704049	Closed to open forest (>15%)	Open forest (15-40%)	732,00
	1704049	Open forest (15-40%)	No forest	40,00
	1704050	Closed to open forest (>15%)	Open forest (15-40%)	657,00
	1704052	Closed to open forest (>15%)	Open forest (15-40%)	192,00
	1704052	Open forest (15-40%)	No forest	21,00
	1704053	Closed to open forest (>15%)	Open forest (15-40%)	414,00
	1704053	Open forest (15-40%)	No forest	12,00
	1704054	Closed to open forest (>15%)	Open forest (15-40%)	2.503,00
	1704059	Closed forest (>40%)	Closed to open forest (>15%)	38,00
	1704059	Closed to open forest (>15%)	Open forest (15-40%)	281,00
	1704059	Open forest (15-40%)	No forest	707,00
	1704060	Closed forest (>40%)	Closed to open forest (>15%)	6,00
	1704060	Closed to open forest (>15%)	Open forest (15-40%)	615,00
	1704060	Open forest (15-40%)	No forest	388,00
	1704061	Closed to open forest (>15%)	Open forest (15-40%)	20,00
	1704061	Open forest (15-40%)	No forest	54,00
	1704062	Closed to open forest (>15%)	Open forest (15-40%)	126,00
Phouvong	1705005	Closed to open forest (>15%)	Open forest (15-40%)	507,00
	1705005	Open forest (15-40%)	No forest	601,00
	1705012	Closed forest (>40%)	Closed to open forest (>15%)	6,00
	1705012	Closed to open forest (>15%)	Open forest (15-40%)	5.740,00
	1705012	Open forest (15-40%)	No forest	18,00
	1705014	Closed to open forest (>15%)	Open forest (15-40%)	62,00
	1705020	Closed to open forest (>15%)	Open forest (15-40%)	7.464,00
	1705020	Open forest (15-40%)	No forest	14,00
	1705024	Closed to open forest (>15%)	Open forest (15-40%)	74,00
	1705024	Open forest (15-40%)	No forest	406,00
	1705026	Closed forest (>40%)	Closed to open forest (>15%)	73,00
	1705026	Closed to open forest (>15%)	Open forest (15-40%)	17.192,00
	1705026	Open forest (15-40%)	No forest	583,00
	1705027	Closed forest (>40%)	Closed to open forest (>15%)	348,00
	1705027	Closed to open forest (>15%)	Open forest (15-40%)	59.881,00
	1705027	Open forest (15-40%)	No forest	1.103,00

Access to freshwater sources by 2050

The projected changes in precipitation patterns and an increase in mean temperature can easily lead to higher rates of evaporation and longer months of drought. Moreover, in the midterm groundwater sources will also be affected as aquifers will take longer to recharge leading to the need for further investments on infrastructure's improvement (tanks capacity, boreholes depth, etc.). In addition, stronger storms and unusually heavy rainfall will inevitably damage water infrastructure



Assumptions

It is assumed, that under a BAU scenario, communities' freshwater sources and current water supply and systems are highly exposed to climate change. The projected climate changes in temperatures and rainfall will lead to more frequent drought periods and more damaging storms.

- The observed drought, storms and floods impacts will worsen in all surveyed communities

- No adaptive measure is considered

Calculations

(i) Percentage of Households having access to freshwater sources in 2015 = percentage of households in each village having access to freshwater according to Census 2015

(ii) Coefficient impacts observed storms = is applied to selected villages where impacts where reported by type of water system used: being a) 0.9 piped water; b) 0.8 protected well/borehole; c) 0.7 unprotected borehole; d) 0.6 river/stream/dam; e) 0.5 mountain water. f) 0.4 Rain water; g) 0.9 Bottled/Canned : h) 0.80 Tank

(iii) Coefficient impacts observed drought = is applied to selected villages where impacts where reported by type of water system used: being a) 0.66 piped water; b) 0.66 protected well/borehole; c) 0.66 unprotected borehole; d) 0.33 river/stream/dam; e) 0.33 mountain water. f) 0.33 Rain water; g) 0.9 Bottled/Canned : h) 0.66 Tank

(iv) Coefficient impacts observed floods = is applied to selected villages where impacts where reported by type of water system used: being a) 0.9 piped water; b) 0.66 protected well/borehole; c) 0.33 unprotected borehole; d) 0.33 river/stream/dam; e) 0.9 mountain water. f) 0.9 Rain water; g) 1 Bottled/Canned : h) 0.9 Tank

(v) Percentage of the Households having access to freshwater sources in 2017 = (i)*(ii)*(iii)*(iv)

(vi) Climate change Coefficient = is applied to all selected villages due to the projected climate changes on stronger storms and unusually heavy rainfall by type of water system used: being 0.9 piped water; 0.8 protected well/borehole; 0.7 unprotected borehole; 0.6 river/stream/dam; 0.7 mountain water. 0.5 Rain water; 0.9 Bottled/Canned

(vii) Percentage of the Households having access to freshwater sources in 2050 = (v)*(vi)

DISTRICT	VCODE	CENSUS 2050								(iii)	(v)
		a	b	c	d	e	f	g	h		
Xaisetha	1701001	7	26	4	0	4	0	59	0	68.41	58.78
	1701006	0	38	24	0	0	0	38	0	47.76	38.89
	1701007	0	62	15	23	0	0	0	0	25.30	18.68
	1701011	18	68	3	10	3	0	0	0	42.17	33.42
	1701015	0	26	10	0	0	0	61	0	60.11	49.64
	1701016	7	0	64	0	0	29	0	0	17.01	11.18
	1701017	0	47	38	0	0	2	13	0	68.47	52.64
	1701018	0	28	11	44	0	0	17	0	27.78	19.91
	1701019	0	38	48	7	3	0	3	0	24.33	17.96
	1701022	0	79	13	8	0	0	0	0	30.04	23.15
	1701023	0	51	15	0	34	0	0	0	35.57	26.71
	1701024	0	50	0	50	0	0	0	0	49.50	34.65
	1701030	14	29	45	9	0	0	3	0	63.98	48.32
	1701036	0	5	5	14	71	0	5	0	100.00	70.00
	1701037	2	42	4	5	46	0	2	0	35.85	26.67
Samakkhixai	1702018	8	38	54	0	0	0	0	0	25.72	19.39
	1702019	7	71	21	0	0	0	0	0	31.98	25.12
	1702020	0	88	6	0	0	0	6	0	36.41	29.13
	1702021	0	42	18	9	0	0	30	0	42.70	33.90
	1702035	0	92	8	0	0	0	0	0	33.34	26.42
	1702036	0	67	7	0	0	0	27	0	45.85	37.60
	1702037	0	54	8	0	0	0	38	0	51.09	42.44
	1702038	0	3	35	0	35	0	26	0	32.71	24.69
	1702039	0	6	0	0	78	0	17	0	26.99	19.94
	1702043	17	58	4	8	0	0	13	0	40.54	32.77
Sanxai	1704001	0	0	0	50	50	0	0	0	18.15	11.80
	1704004	0	0	0	0	100	0	0	0	33.00	23.10
	1704005	0	59	7	0	15	0	19	0	100.00	79.63
	1704007	0	0	0	100	0	0	0	0	10.89	6.53
	1704010	0	0	44	56	0	0	0	0	100.00	64.44
	1704012	0	0	0	100	0	0	0	0	100.00	60.00
	1704014	0	0	0	38	63	0	0	0	53.75	35.61
	1704015	0	0	0	0	100	0	0	0	100.00	70.00
	1704016	0	0	0	0	100	0	0	0	16.50	11.55
	1704018	0	47	6	41	6	0	0	0	100.00	70.59
	1704021	7	60	27	7	0	0	0	0	49.28	37.78
	1704023	0	0	0	0	100	0	0	0	100.00	70.00
	1704024	0	0	0	100	0	0	0	0	19.80	11.88
	1704027	0	0	0	0	100	0	0	0	33.00	23.10
	1704029	0	0	0	0	100	0	0	0	100.00	70.00
	1704030	0	0	0	0	100	0	0	0	100.00	70.00
	1704031	8	23	8	46	0	0	15	0	100.00	72.31
	1704032	0	0	33	67	0	0	0	0	63.33	40.11

	1704035	0	0	0	0	100	0	0	0	100.00	70.00
	1704038	0	0	0	56	44	0	0	0	100.00	64.44
	1704039	0	0	0	0	100	0	0	0	100.00	70.00
	1704040	0	0	0	0	100	0	0	0	100.00	70.00
	1704046	0	0	0	100	0	0	0	0	33.00	19.80
	1704048	0	0	0	0	100	0	0	0	100.00	70.00
	1704049	0	0	0	0	100	0	0	0	33.00	23.10
	1704050	0	38	0	0	63	0	0	0	45.38	33.46
	1704052	0	0	0	33	67	0	0	0	33.00	22.00
	1704053	0	0	0	0	100	0	0	0	16.50	11.55
	1704054	0	0	33	44	22	0	0	0	27.87	18.27
	1704059	0	83	0	17	0	0	0	0	30.13	23.10
	1704060	11	56	0	33	0	0	0	0	44.93	33.45
	1704061	0	40	50	0	0	0	10	0	68.40	51.98
	1704062	6	47	12	29	6	0	0	0	100.00	72.94
Phouvong	1705005	6	35	35	18	0	0	6	0	33.77	25.03
	1705012	0	0	0	0	100	0	0	0	14.85	10.40
	1705014	0	36	0	64	0	0	0	0	22.77	15.32
	1705020	0	36	43	7	0	0	14	0	31.02	23.48
	1705024	0	83	17	0	0	0	0	0	31.58	24.74
	1705026	3	65	9	0	0	0	24	0	59.05	48.28
	1705027	0	63	4	22	0	0	11	0	40.65	31.02

Water sources and systems: a) piped water; b) protected well/borehole; c) unprotected borehole; d) river/stream/dam; e) mountain water. f) Rain water; g) Bottled/Canned; h) Tank

Access to transportation services by 2050

In Kaleum and Dakcheung districts' highland areas, mobility seems to be the main constraint for the socio-economic and livelihood development of rural communities. Currently, the rural transport network mainly relies on a network of secondary and tertiary unpaved roads/trails, which make these rural communities highly vulnerable to strong storms and unusually heavy rainfall. These mobility constraints already jeopardise rural livelihoods but will worsen in emergency situations following the projected extreme weather events.

Most of the selected villages in Kaleum are accessible only by trails/tracks (around 70%) while in Dakcheung accessibility is mainly by unpaved gravel roads (67%). While only 3% in Kaleum and and 6% Dakcheung, have access to paved roads.

Communities report important storm and flood's impacts on infrastructure. Indeed, 81% and 50% of the selected villages pointed damages in the community's infrastructures due to storms and floods, respectively.

Assumptions

It is assumed, that under a BAU scenario, the current rural road networks is a critical infrastructure highly exposed to climate change. The projected climate changes in temperatures and rainfall will lead to frequent landslides, flash floods and hillslope isolate mountain villages from markets, medical facilities, schools, and other core community services.

- The observed landslides and floods impacts will worsen in landslide susceptibility and flood prone areas defined by the National Risk Profile of Lao PDR
- No adaptive measure is considered

Calculations

(i) Population in 2017= total population in each village accruing to Census 2015

(ii) Coefficient of impacts perceived 2017 = is defined by combining the type of transport infrastructure and services available in each village with the hazards and impacts reported, being 0.5 high, 0.75 medium and 0.9 low

(iii) Percentage of the population having access to transportation network in 2017 = [(i)*(ii)]/(i)*100
Coefficient of landslides risk= is applied to landslide's susceptibility areas defined by the National Risk Profile of Lao PDR, being 0.5 high, 0.75 medium and 0.9 low.(iv) Coefficient of flood risk= is applied to flood prone areas defined by the National Risk Profile of Lao PDR, being 0.5 high and 0.9 low

(v) Coefficient of storms = is applied to all villages due to the projected climate changes on stronger storms and unusually heavy rainfall, being 0.5 high and 0.9 low

(vi) Percentage of the population having access to transportation network in 2050 = [(iv)*(v)*(vi)*(i)]/(i)*100

DISTRICT	VCODE	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
Xaysettha	1701001	1477	75	0.75	0.50	0.90	0.75	25
	1701006	1071	50	0.75	0.50	0.90	0.75	17
	1701007	1678	75	0.75	0.50	0.90	0.75	25
	1701011	5420	75	0.75	0.50	0.90	0.75	25
	1701015	1560	75	0.75	0.50	0.90	0.75	25
	1701016	661	75	0.75	0.50	0.90	0.75	25
	1701017	2293	75	0.75	0.50	0.90	0.75	25
	1701018	549	75	0.75	0.50	0.90	0.75	25
	1701019	746	75	0.75	0.50	0.90	0.75	25
	1701022	1209	75	0.75	0.50	0.90	0.75	25
	1701023	1310	75	0.90	0.50	0.90	0.90	30
	1701024	466	75	0.75	0.50	0.90	0.75	25
	1701030	3114	75	0.75	0.50	0.90	0.75	25
	1701036	928	90	0.50	0.90	0.90	0.50	36
	1701037	2869	75	0.75	0.50	0.90	0.75	25
Smakkhixay	1702018	836	90	0.75	0.90	0.90	90	55
	1702019	752	50	0.75	0.50	0.90	50	17
	1702020	860	50	0.75	0.50	0.90	50	17
	1702021	1683	75	0.75	0.50	0.90	75	25

	1702035	552	90	0.75	0.50	0.90	90	30
	1702036	827	75	0.75	0.50	0.90	75	25
	1702037	755	75	0.75	0.50	0.90	75	25
	1702038	1708	75	0.90	0.50	0.90	75	30
	1702039	917	75	0.75	0.50	0.90	75	25
Sanxai	1704001	705	90	0.50	0.90	0.90	0.50	36
	1704004	456	75	0.75	0.90	0.90	0.75	46
	1704005	311	90	0.50	0.90	0.90	0.50	36
	1704007	258	75	0.50	0.90	0.90	0.50	30
	1704010	543	90	0.50	0.90	0.90	0.50	36
	1704012	312	90	0.75	0.90	0.90	0.75	55
	1704014	459	90	0.75	0.90	0.90	0.75	55
	1704015	293	90	0.75	0.90	0.90	0.75	55
	1704016	525	90	0.75	0.90	0.90	0.75	55
	1704018	1016	90	0.75	0.90	0.90	0.75	55
	1704021	922	90	0.50	0.90	0.90	0.50	36
	1704023	161	90	0.75	0.90	0.90	0.75	55
	1704024	316	90	0.75	0.90	0.90	0.75	55
	1704027	821	75	0.50	0.90	0.90	0.50	30
	1704029	207	90	0.75	0.90	0.90	0.75	55
	1704030	109	90	0.75	0.90	0.90	0.75	55
	1704031	1315	90	0.50	0.90	0.90	0.50	36
	1704032	295	90	0.75	0.90	0.90	0.75	55
	1704035	106	90	0.90	0.90	0.90	0.90	66
	1704038	676	90	0.90	0.90	0.90	0.90	66
	1704039	157	90	0.75	0.90	0.90	0.75	55
	1704040	206	90	0.90	0.90	0.90	0.90	66
	1704046	366	90	0.90	0.90	0.90	0.90	66
	1704048	326	90	0.75	0.90	0.90	0.75	55
	1704049	644	90	0.75	0.90	0.90	0.75	55
	1704050	515	90	0.75	0.90	0.90	0.75	55
	1704052	177	90	0.90	0.90	0.90	0.90	66
	1704053	370	90	0.75	0.90	0.90	0.75	55
	1704054	676	75	0.90	0.90	0.90	0.90	55
	1704059	605	90	0.75	0.90	0.90	0.75	55
	1704060	451	50	0.50	0.90	0.90	0.50	20
	1704061	409	90	0.75	0.90	0.90	0.75	55
	1704062	1190	90	0.75	0.90	0.90	0.75	55
Phouvong	1705005	755	75	0.75	0.90	0.90	75	46
	1705012	295	75	0.75	0.90	0.90	75	46
	1705014	445	75	0.75	0.90	0.90	75	46
	1705020	1427	75	0.75	0.90	0.90	75	46
	1705024	203	75	0.75	0.90	0.90	75	46
	1705026	1738	50	0.75	0.90	0.90	50	30

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