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USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin

Socio-economics

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USAID MEKONG ARCC CLIMATE CHANGE IMPACT AND ADAPTATION STUDY FOR THE LOWER MEKONG BASIN

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The USAID Mekong ARCC project is a five-year program (2011–2016) funded by the USAID Regional Development Mission for Asia (RDMA) in Bangkok. The larger project focuses on identifying the environmental, economic, and social effects of climate change in the Lower Mekong Basin (LMB), and on assisting highly exposed and vulnerable rural populations in ecologically sensitive areas adapt to climate change impacts on agricultural, fisheries, livestock, ecosystems, and livelihood options.

This phase of the project was led and implemented by ICEM, and focuses specifically on predicting the response of the key livelihood sectors—agriculture, livestock, fisheries, rural infrastructure and health, and natural systems—to the impacts associated with climate change, and offering broad-ranging adaptation strategies to the predicted responses.

This volume is part of the USAID Mekong ARCC study set of reports:

1. USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin: Summary
2. USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin: Main Report
3. USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin on Agriculture
4. USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin on Livestock
5. USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin on Fisheries
6. USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin on Non Timber Forest Products and Crop Wild Relatives
7. USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin on Protected Areas
8. USAID Mekong ARCC Climate Change Impact and Adaptation Study for the Lower Mekong Basin: Socio-economic Assessment

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ABBREVIATIONS

ARCC	Adaptation and Resilience to Climate Change
CAM	Climate Change Adaptation and Mitigation Methodology
LMB	Lower Mekong Basin
NTFP	Non-Timber Forest Product
PPP	Purchasing Power Parity

SUMMARY

The countries of the Lower Mekong Basin (LMB) have seen significant advances in socio-economic development over recent decades. The overall incidence of poverty and food insecurity has declined in response to rising incomes, rural-urban migration, improved health conditions, and the expansion of rural infrastructure. Despite this progress, however, there remain tens of millions of rural poor who are dependent on the LMB's natural resources and, by consequence, are highly exposed to climate change (see Section 2).

A key characteristic of rural livelihoods in the LMB is that households typically pursue a range of activities across different sectors, such as agriculture, fisheries, harvesting of forest products, and livestock rearing. Moreover, even the poorest communities engaged in subsistence agriculture typically pursue some commercial agricultural activities as well. In the context of climate change, this wide range of income sources is both an asset and a weakness. On the one hand, a diversified portfolio may allow a productivity decline in one sector to be compensated in another. On the other hand, households may face concurrent declines in all sectors, many of which are quite marginal in the first place. The LMB is also undergoing a transition from subsistence to commercial farming systems that presents its own mix of risks and opportunities.

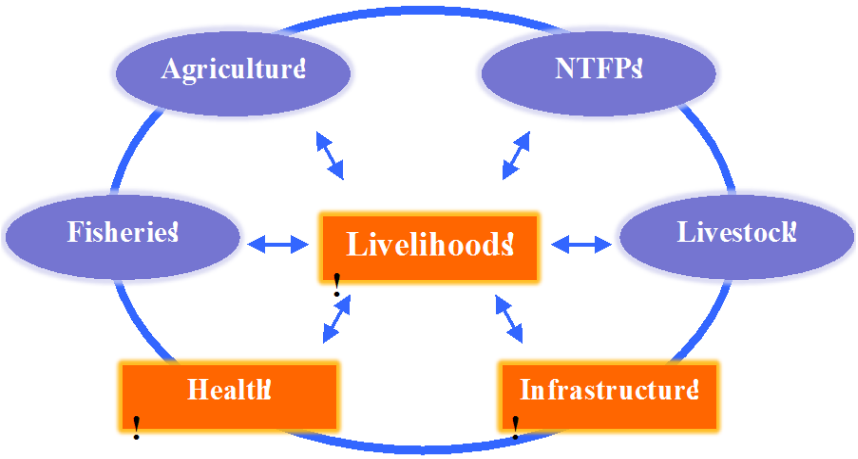

Figure 1: The structure of the livelihood system in a representative rural household in the LMB

This Social and Economic Assessment complements the other sectoral reports in the USAID Mekong ARCC Climate Change Impact and Adaptation Study by assessing the vulnerability to climate change of two critical sectors of household livelihood systems: health and rural infrastructure. Human health is critical to livelihoods because it is the foundation of productivity in all activities. Inadequate health access limits the capacity of individuals to farm, fish, gather NTFPs, or attend to livestock. Moreover, adequate health ensures the nutritional benefits of food consumption are realized and is an important, but often forgotten, component of food security. The inability of one working member of a household to work due to poor health reduces household income and therefore impacts on the income and food security of all members of a household and potentially the broader community.

In this report we consider infrastructure to be the physical, stationary infrastructure that enables rural households and communities to pursue and benefit from livelihood activities. For example: roads and

bridges that facilitate sales and purchases at district markets; covered groundwater bores and health facilities that sustain health; and, housing and other buildings that provide shelter for people and their assets. Damage or lack of access to such infrastructure has long-term impacts on poverty and food security.

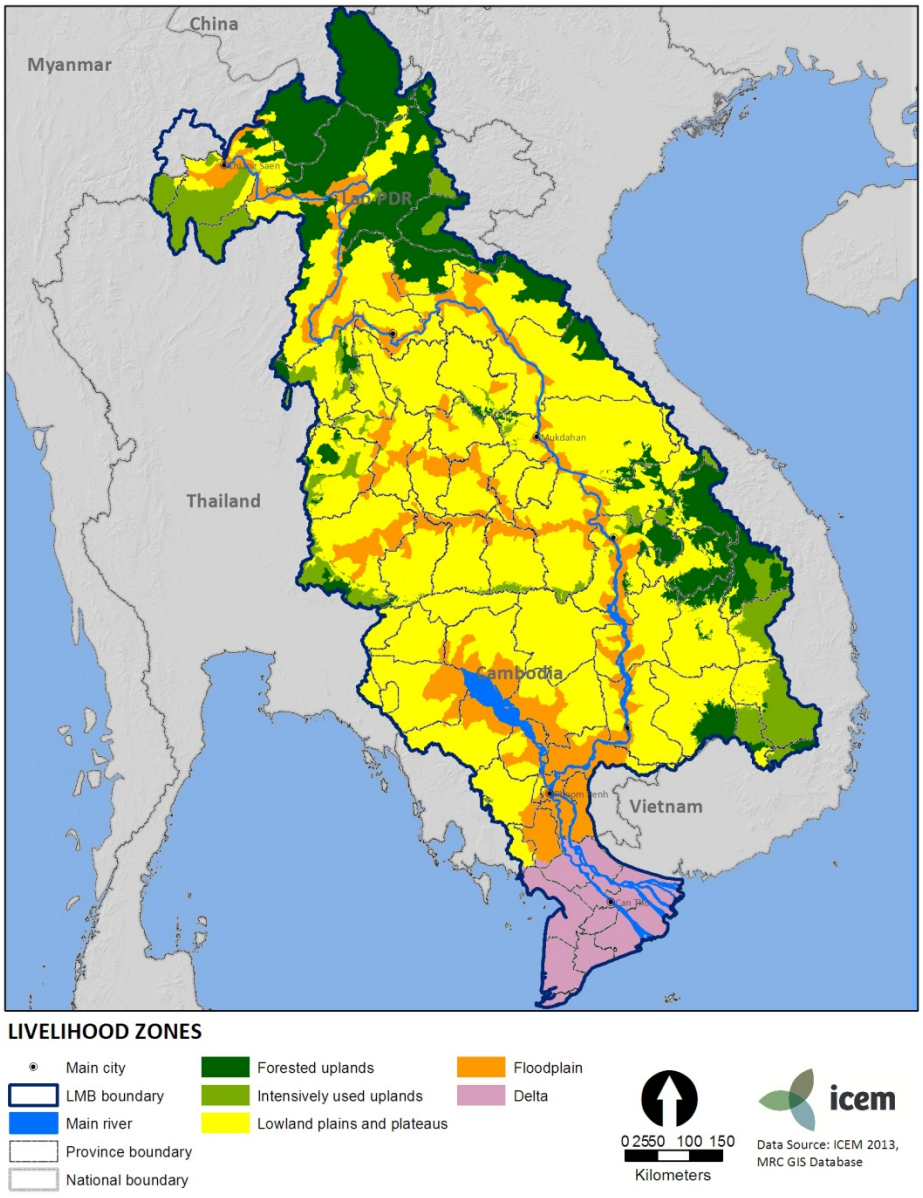

Figure 2: Livelihood zones of the Lower Mekong Basin.

In order to provide an overall picture of climate change vulnerability across the LMB, we divide the basin into five livelihood zones on the basis of their natural and socio-economic features: *Forested uplands*, *Intensively used uplands*, *Lowland plains and plateaus*, *Delta*, and *Floodplain* (see Section 2). Five 'hotspot provinces' highly exposed to climate change were identified through climate modeling for the USAID Mekong ARCC study: Chiang Rai (Thailand), Gia Lai (Vietnam), Khammouan (Lao PDR), Kien Giang (Vietnam), Mondulkiri (Cambodia). In this report we assess the vulnerability of the health and infrastructure sectors of rural communities in the constituent livelihood zones of each province (see Annexes).

Highly vulnerable areas of community health in the LMB are: vector-borne and water–borne disease control, and maternal and child health. The most prominent threats to human health are temperature rise, flooding, flash flooding, and landslides (see Section 3).

Two key areas of the infrastructure sector are identified as highly vulnerable to climate change: roads and water supply infrastructure. The most prominent threats to infrastructure identified across hotspot provinces were flooding, flash flooding, and landslides.

Overall, the neighboring provinces of Mondulkiri and Gia Lai were identified as the most vulnerable provinces. A key projected threat in these provinces is an increase in average maximum temperature of 3°C to 4°C that would generate dangerous heat stress conditions for several months of the year. Another key projected threat for both health and infrastructure is higher rainfall during the rainy season increasing the extent and severity of either flooding or flash flooding and landslides across all of the hotspot provinces.

The vulnerability assessments for health and infrastructure identified a range of trends regarding specific vulnerabilities within particular livelihood zones: flooding in *Floodplain*, *Delta*, and *Lowland plains and plateaus*; flash floods and landslides in *Intensively used uplands* and *Forested uplands*; and, specific to health, temperature rise in *Lowland plains and plateaus*.

Adaptation strategies addressing climate change vulnerabilities need to be formulated in the prevailing development context of the LMB. Section 3 discusses four main factors: hydropower development; land concessions; deforestation, illegal logging, and poaching; and, population growth and migration.

Section 3 presents an overview of key adaptation actions across the LMB and in specific livelihood zones. Annex 3 presents a broader range of strategies, including details of phasing priorities and relevance to other sectors.

In the health sector four focus areas are identified at the basin level:

- Addressing the adaptation deficit in the health sector
- Warning, prevention, and response systems for vector-borne and water-borne disease
- Incorporating climate change into the design, technology, and location of health-related infrastructure
- Protection of ecosystem services that support community health

In the rural infrastructure sector three key areas are identified:

- Implementation of community-based bioengineering projects
- Revision or implementation of design standards for rural infrastructure to incorporate climate change
- Revision of infrastructure planning given threats posed by climate change

Priority adaptation strategies in particular livelihood zones include:

Forested uplands

- Enhance food security and flood protection by strengthening sustainable management of forest resources by developing stronger land tenure systems and enhancing capacity of protected area management
- Improve access to maternal and pediatric healthcare, including child immunization programs and access to trained health professionals for pre- and post-natal care

- Improve road access to remote communities, including extension of the road network, and construction of embankments and bridges

Intensively used uplands

- Reforestation and other locally managed bioengineering initiatives in riparian and sloping areas, especially those linked to strategic rural infrastructure
- Climate-sensitive design, siting and maintenance of major infrastructure in areas highly vulnerable to extreme events

Lowland plains and plateaus

- Improve access to safe water and sanitation, including covered groundwater bores, rainwater tanks, water treatment technology, and covered latrines
- Construction of heat respite community centers for the benefit of vulnerable groups
- Enhance food security and flood protection by strengthening sustainable management of forest and river resources

Floodplain

- Climate change sensitive bridge construction, road elevation and design, and other civil engineering programs to secure road access to flood-prone communities
- Community managed bioengineering programs in riparian areas
- Strengthen institutional capacity for provision of forecasting, early warning systems, and effective response for flooding and water-borne and vector-borne disease

Delta

- Strengthen natural coastal protection from inundation through community-based rehabilitation and protection programs, particularly for mangrove ecosystems
- Improvements to canal networks that are required to cope with more intense flood events, particularly to ensure effective drainage of fields and waterways
- Support the dissemination of household infrastructure that reduces the exposure of communities to water-borne disease during flood events, such as raised rainwater tanks, floating toilets, and solar water filters

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INTRODUCTION

This document is the Socio-Economic Report contributing to the USAID Mekong ARCC Climate Change Impact and Adaptation Study. The analysis in this study focuses on the impact of projected climate change on human health and rural infrastructure. The major outputs of the report are: (1) a detailed assessment of vulnerability to climate change threats in highly exposed provinces, including a scaling up to general findings concerning zones of the basin sharing similar social and environmental characteristics; and (2) the identification of adaptation priorities for these "hotspot provinces" and the broader "livelihood zones".

Section 1 provides an overall description of socio-economic trends in the Lower Mekong Basin (LMB) that focuses on population, poverty, food security, and health and rural infrastructure. Section 2 outlines the concept of 'livelihood zones', or regions of the basin sharing socio-economic and agro-ecological characteristics. This section also describes the methodology of the climate change vulnerability assessment, including the rationale for the focus on health and infrastructure in terms of livelihood systems, as well as the criteria that are used in the assessment. Section 3 presents the results of the vulnerability assessment by specific climate change threats across hotspot provinces and livelihood zones; discusses the broader development context of the LMB that influences adaptation planning; and recommends adaptation priorities in the health and rural infrastructure sectors.

The main body of text is complemented by a series of detailed appendices. Annex 1 provides further detail regarding the aggregation of livelihood zones in Section 2. Annex 2 contains the detailed hotspot province profiles that are the principal input to the vulnerability assessment reported in Section 3, as well as the detailed matrices that comprise the vulnerability assessment. Annex 3 contains supporting material for the adaptation planning in Section 3, including a broader range of adaptation options.

SECTION 1 – BASELINE: DEMOGRAPHICS AND SOCIO-ECONOMIC TRENDS

1 POPULATION

The total population of the Lower Mekong Basin (LMB) countries was estimated to be around 177 million in 2010. That of the LMB alone is estimated to be around 65 million, 80% of which live in rural areas and are predominantly dependent upon agriculture and other forms of natural resource use.[1] Populations in LMB countries have been growing fairly rapidly with overall population growth in the last decade at 1.1%. There is considerable difference between countries. Cambodia and Lao PDR have seen higher population growth rates over the last decade of approximately 1.27% and 1.54% respectively. Thailand and Vietnam on the other hand have seen declines in population growth to 0.9% and 0.11% respectively over the same time period. Differing population growth rates are, by and large, explained by differences in fertility rates.

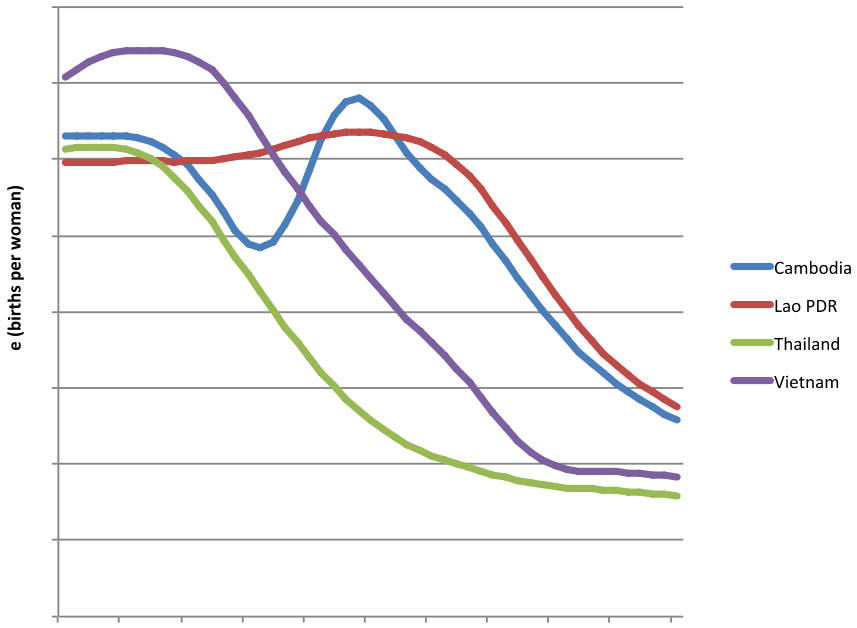

Figure 3: Falling fertility rates in LMB countries 1960 - 2010

Source: World Bank 2013

Thailand's demographic transition began around the mid to late 1960s with rapidly falling fertility rates, Vietnam followed in the early 1970s, Cambodia in the early 1990s and Lao PDR a few years later (Figure 3). This trend data suggests all countries are converging on relatively low fertility rates in the next 30 to 40 years. As a result of these falling fertility rates populations are expected to peak before 2050 after which time they are expected to decline (Figure 4). UN median projections suggest that this population will peak in 2045 with an aggregate regional population of around 15% above current levels, or 206 million (Figure 4).

[1] This is based upon various different data sources, notably Mainuddin (2011) who adopts a figure of approximately 65 million.

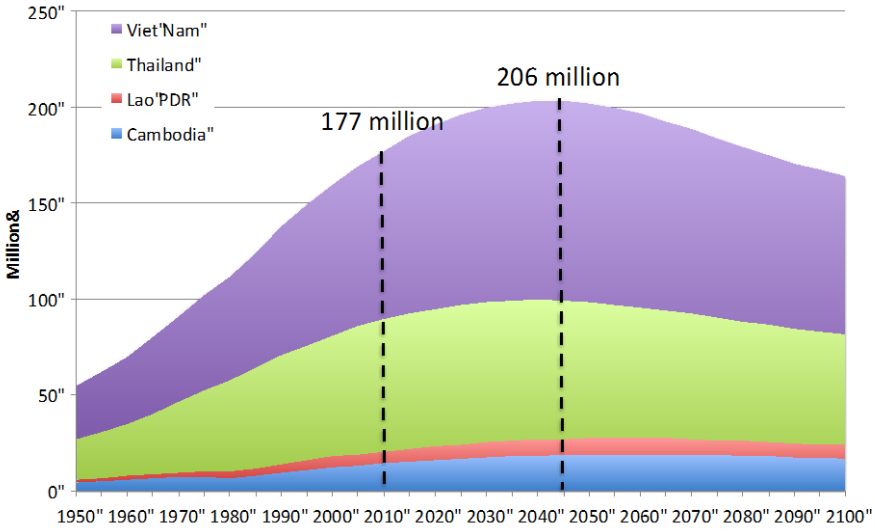

Figure 4: Historical and projected population (median variant) in LMB countries 1950 - 2100

Source: World Bank 2013, UN 2010

Table 1 gives a breakdown of LMB populations by country. Populations in the basin are distributed unevenly (Figure 5), with flood plains and low-lying areas in general having much higher population densities. Whereas remote areas with limited land suitable for agricultural production in the mountainous up-stream areas of the catchment tend to have very low population densities. Using UN population projections weighted for the relative country share of LMB populations and assuming the population distribution will remain approximately the same; by 2050 the basin population is likely to increase to around 76 million.[2]

Table 1: Estimated 2010 LMB population by country

Country	Population within LMB (million)	Proportion of LMB population (%)
Cambodia	12.4	19%
Lao PDR	7.2	11%
Thailand	23.3	36%
Vietnam	21.7	34%
Total	64.6	100%

Source: World Bank 2013, consultants' calculations

[2] Other population projections suggest figures as high as 80 or 90 million, consistent with a population growth rate in the basin of up to 0.8% per year between 2010 and 2050. We feel this is unlikely given i) UN population estimates that suggest a growth rate of 0.3%; ii) declining fertility rates; and, iii) migration from the predominantly rural basin to urban areas such as Ho Chi Minh City and Bangkok, which lie outside the LMB.

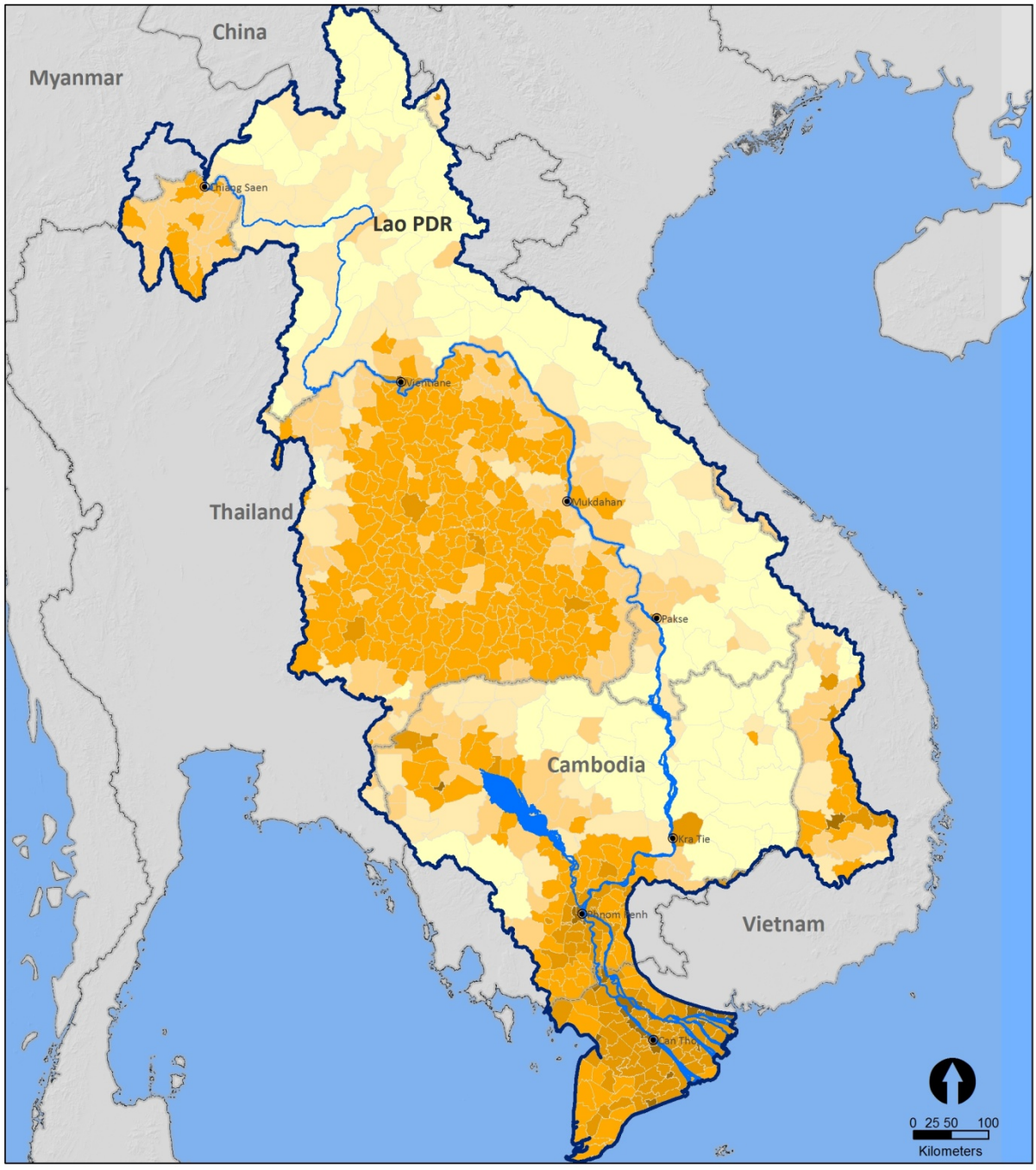

Figure 5: Population density in the LMB

However, population distributions are likely to change, particularly given growing population movements over the last two decades. Migration in the region can be characterized as falling into three types, i) rural – urban migration; ii) transboundary migration; and, iii) rural-rural migration. Each of these migration types is discussed as follows.

Rural – urban migration is probably the most significant population trend in the region. Despite higher fertility rates in rural areas, urban areas and large urban agglomerations in particular[3] show much higher population growth rates. The difference is accounted for by migration into urban areas. Rural – urban migration is part and parcel of the process of economic growth and development.

The decision to migrate is complex, typically characterized by a number of 'push' and 'pull' factors. Push factors include rural poverty, a lack of employment opportunities in rural areas, and the need for cash income. Pull factors include higher perceived cash income levels in urban areas and perceived employment opportunities. Rural-urban migration is also facilitated by improved transportation links between rural areas and existing migrant communities in large urban areas, which can act as a network for would-be migrants in seeking employment and accommodation.

Enumerating migrants to urban areas is problematic. Migration is often temporary and seasonal, with migrants involved in informal casual or short-term contract work in urban areas, returning home to rural areas during times of high labor demand (such as rice planting and harvesting seasons). Nor is the migrant flow one-way, as a good proportion of migrant workers choose to return home to rural areas after a period in urban areas. Finally, population registration systems in some countries mean that migration is frequently underestimated in official figures. For a number of reasons, rural migrants frequently do not register for residency in urban areas.[4] As a consequence, large urban areas are estimated to have much higher populations than those in official estimates, for example Ho Chi Minh City is estimated to have 20-30% more inhabitants than official figures suggest, and a similar situation persists in Bangkok. Based upon limited qualitative work some experts estimate populations in northeastern Thailand could be 20-30% below those in official figures.[5]

As a result of continuing rural-urban migration, population projections extending to 2025 foresee relatively rapid growth in urban populations and declining rural populations before 2020 in all LMB countries except Cambodia, which is likely to see a rising rural population beyond 2025 (Figure 6).

Transboundary migration – Authoritative figures are limited, but indications are that transboundary migration is increasingly common in the region. As with rural – urban migration this is driven by a number of factors, although most importantly a demand for cheap labor in destination countries and lack of economic opportunities in origin countries (ADB 2010). Migration has been facilitated by diaspora in the destination countries, more relaxed migration controls, and better access to transportation links.

[3] Urban agglomerations include areas such as the Bangkok metropolitan area, the Hanoi-Haiphong corridor and the Southeast Economic Zone in Vietnam.

[4] This may be for a number of reasons including the difficulty and cost of the administrative processes involved in registration, the temporary nature of their migration, or indeed the fact that authorities are unwilling to change their registration. There are broader political issues involved in the registration of migrants that may mean authorities are reluctant to properly account for migration.

[5] Blake 2012 (personal correspondence).

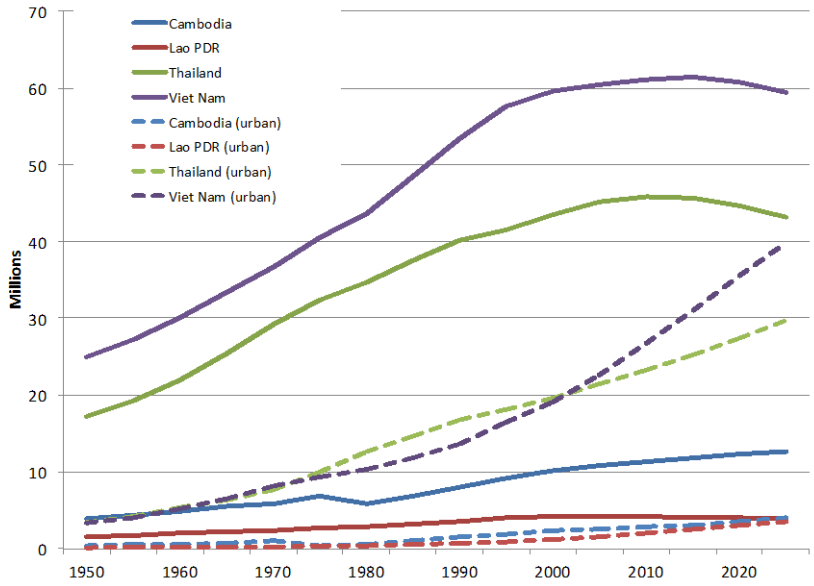

Figure 6: Projected rural and urban populations in LMB countries 1950 – 2025 (median variant)

Source: UN 2011

Thailand and Cambodia account for a large portion of immigrants from the region. In the case of Thailand, most of this migration is from Cambodia, Lao PDR, and Myanmar to work in unskilled employment. In total, migrants are estimated to make up around 4.6% of the workforce in Thailand (Table 2). This is expected to increase as economic growth creates more employment opportunities. In the case of Cambodia, the existence of a large Vietnamese diaspora of approximately 1 million, has acted to effectively facilitate continued migration from southern Vietnam. Between 2005 and 2010, some estimates suggest that migration from Vietnam to Cambodia has been in the hundreds of thousands, although firm figures are difficult to come by (ADB 2010). Semi-skilled Vietnamese construction workers also commonly migrate to Lao PDR and Cambodia for work. While Vietnam is currently a source of migrants, given its rapid demographic transition and expectations of rapid economic growth, the expectation is that it is likely to become an important destination for migrant labor in the future (ADB 2010).

Table 2: International net migration in the LMB (thousands) *Source: ADB 2010*

Country	Net migration flow 2003-2008	Migrant stock 2008
Thailand	**645**	**2,553**
from Myanmar	*592*	*2,072*
from Cambodia	*44*	*248*
from Lao PDR	*9*	*199*
Cambodia	**106**	**1,048**
from Vietnam	*100*	*1,000*
from China	*5*	*25*
Lao PDR	**18**	**118**
from China	*10*	*80*
Vietnam	**8**	**27**
from China	*3*	*14*

Rural-rural migration – Although in terms of scale less significant than other migration flows, rural-rural migration has also been a common response in the region to social and economic change. Current drivers of migration include involuntary resettlement, sedentarization programs, and voluntary migration. Involuntary migration due to large-scale infrastructure development and the granting of land concessions is likely to emerge as increasingly significant with the acceleration of these types of projects in Cambodia and Lao PDR.

Voluntary rural-rural migration is common in some areas. In the recent past some of the largest rural-rural population movements in the basin have been from the impoverished North Central coast of Vietnam to the Central Highlands region. Opportunities for in-migrants stem from low population densities and considerable agricultural potential in terms of various planation and commercial crops, such as coffee and pepper in the Central Highlands. In the case of the latter region, movement was also encouraged by the state through policies such as preferential land grants to migrants. Most of this migration took place during the late 1980s and 1990s. Current trends in rural-rural migration show a similar pattern, driven by poverty and lack of economic opportunity to locations where there is a perceived (relative) abundance of natural resources (such as land, timber, mineral resources, or fisheries). An example would be the migration of landless households from the central Mekong Delta provinces to the more remote areas of Ca Mau and up the Mekong River to Cambodia (Nguyen and Sawdon 2010).

The demographic picture of the LMB is therefore a complex one of both increasing populations and increasing population movement. Key trends reflect the broader socio-economic context, as industrial and service sector growth leads to employment generation in urban areas and increased commercialization of agriculture leads to increased capital intensity and decreased levels of rural employment. For poor and landless households and those without saleable skills in urban areas, the declining land availability and employment in established agricultural areas is an important push factor driving movement to more marginal areas with relatively unconstrained access to natural resources.

Shifting focus to the population trends in the LMB more specifically, while national population trends reflect the situation in the Cambodian and Laotian portions of the basin, the Thai and Vietnamese portions of the basin show population growth trends that are distinct from the rest of the country. In particular, indications are that rural populations are already falling in the Mekong Delta and Isan (the large Northeast region of Thailand); conversely populations in the Central Highlands region of Vietnam have grown rapidly over the last decade.

2 POVERTY

The LMB countries as a whole have seen rapid declines in poverty rates over the last two decades (Figure 7). This is a direct consequence of economic growth. While some reduction in poverty[6] has been associated with employment generation in high value added industrial and service sectors, improved agricultural productivity has played a central role in terms of addressing severe poverty for rural populations. Figure 7 also highlights, despite impressive levels of poverty reduction, the continuing persistence of populations vulnerable to falling back into poverty. For example, almost 70% of the population in Cambodia, almost 80% in Lao PDR, and nearly 60% of the population in Vietnam are at or below the US$2.5/person/day threshold, a level of income that leaves these groups extremely vulnerable to falling back into poverty.

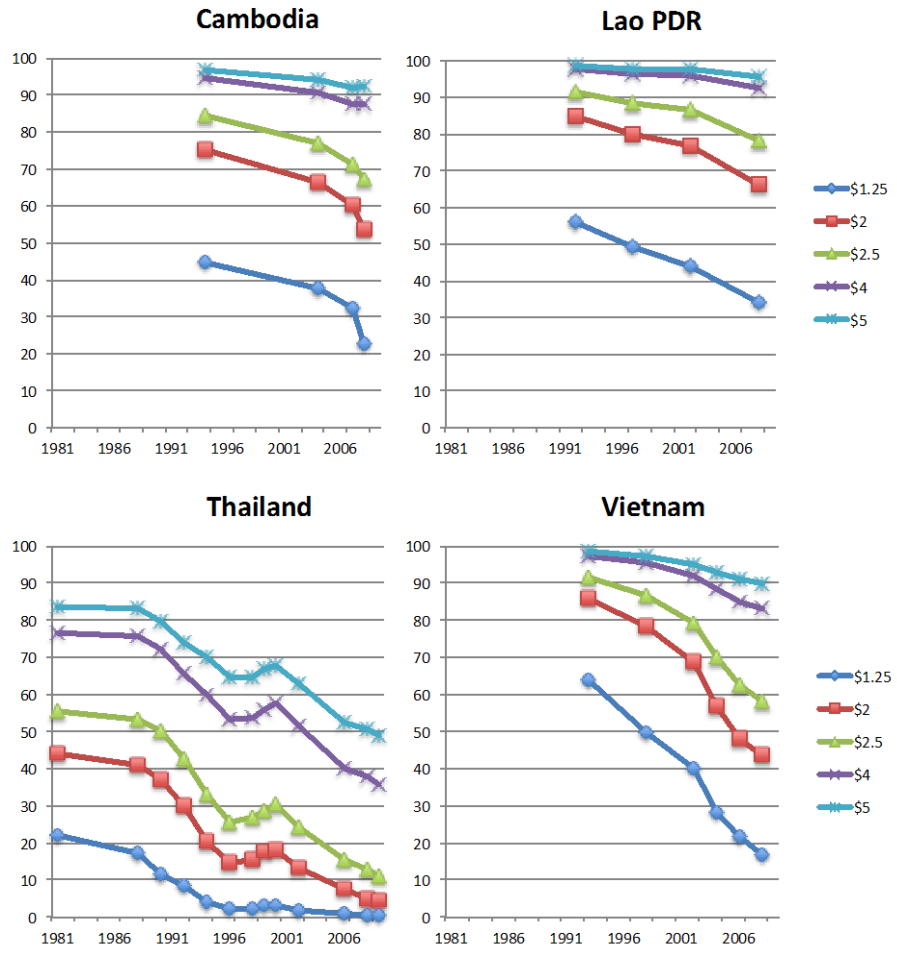

Figure 7: Poverty rates in LMB countries 1981 – 2009

Source: World Bank 2013

[6] Taking the US$ 1.25 at PPP/person/day as the poverty threshold.

Aggregate poverty rates can obscure important differences between levels of poverty in rural and urban areas, and differences between poverty rates between different geographical areas and amongst different social groups. For example, poverty rates in all countries have been consistently lower in urban than rural areas (Figure 8).

Poverty rates also tend to be much higher in remote mountainous areas where livelihoods are at best marginal. Figure 9 shows the relative poverty rate by district in the LMB. This clearly shows the upland, remote and least populous areas as having particularly high incidence of poverty (in Lao PDR and Cambodia around the border of Vietnam, as well as North and Central Lao PDR), whereas lowland and floodplain areas tend to have lower relative poverty rates. By contrast Figure 10 shows relative poverty density. Areas with the highest number of poor tend to be in densely populated urban and lowland areas, although the poverty rate is relatively low in these locations the difference in population density between these areas and sparsely occupied upland areas means the density of poor people in these areas is higher.

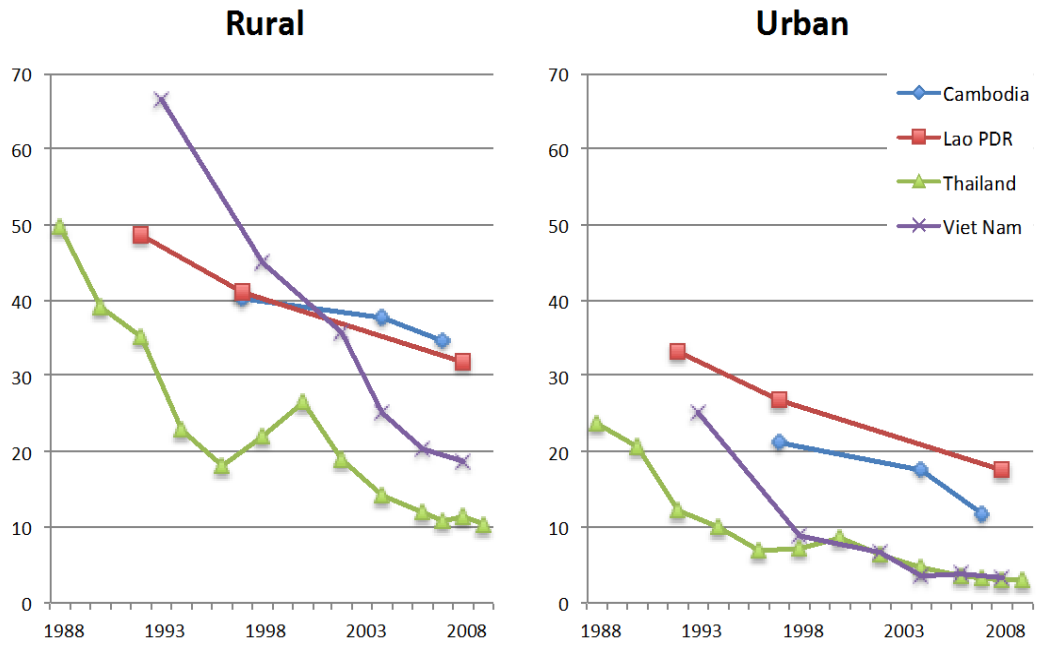

Figure 8: Urban and rural poverty rates in LMB countries 1988 - 2009

Source: World Bank 2013

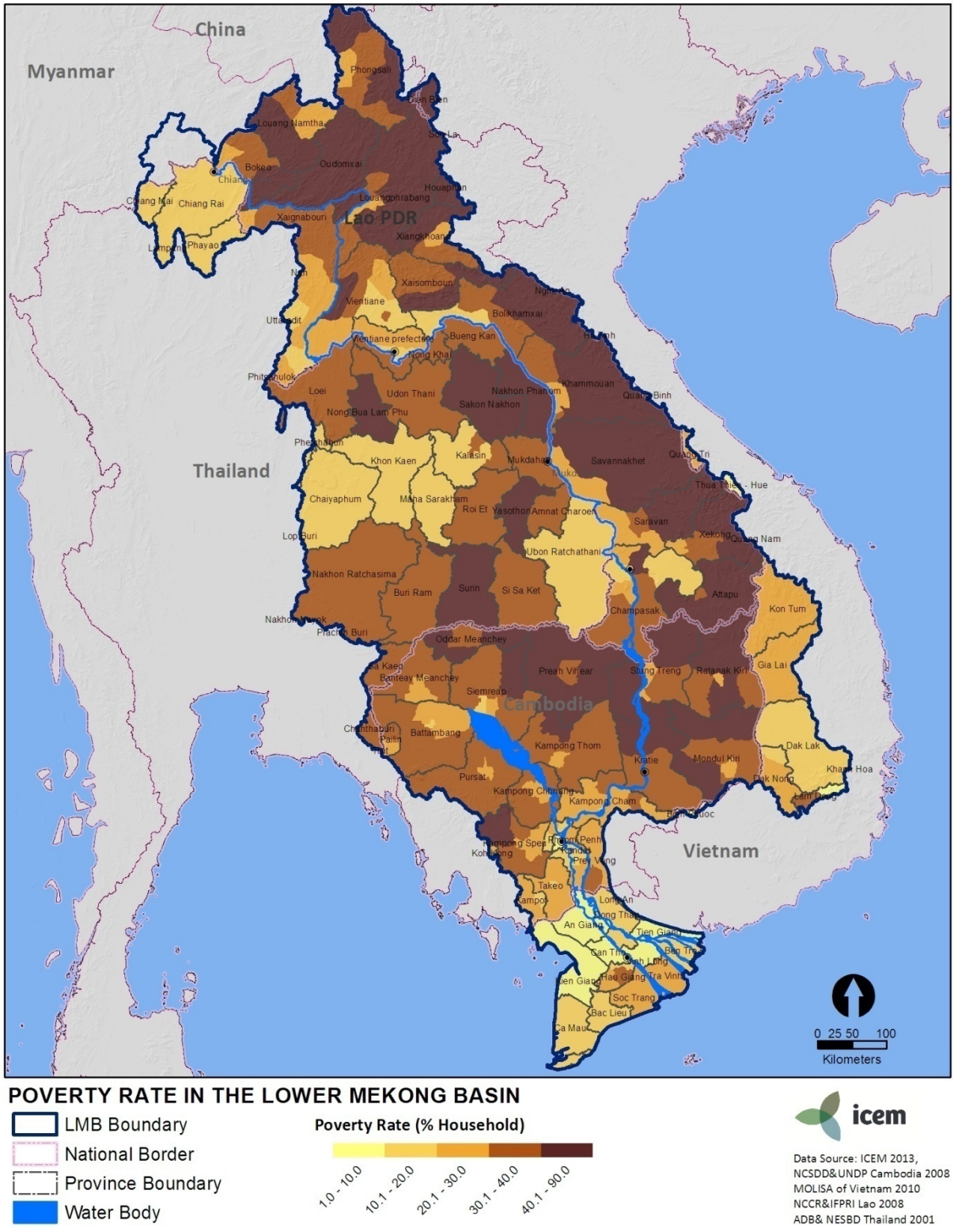

Figure 9: Poverty rates in the LMB

Note: All poverty figures are calculated with respect to national poverty lines. Given higher levels of average income in Thailand, a poverty rate of, say, 40% in a particular Thai district implies a much higher level of community welfare than a district with a 40% poverty rate in Cambodia or Lao PDR.

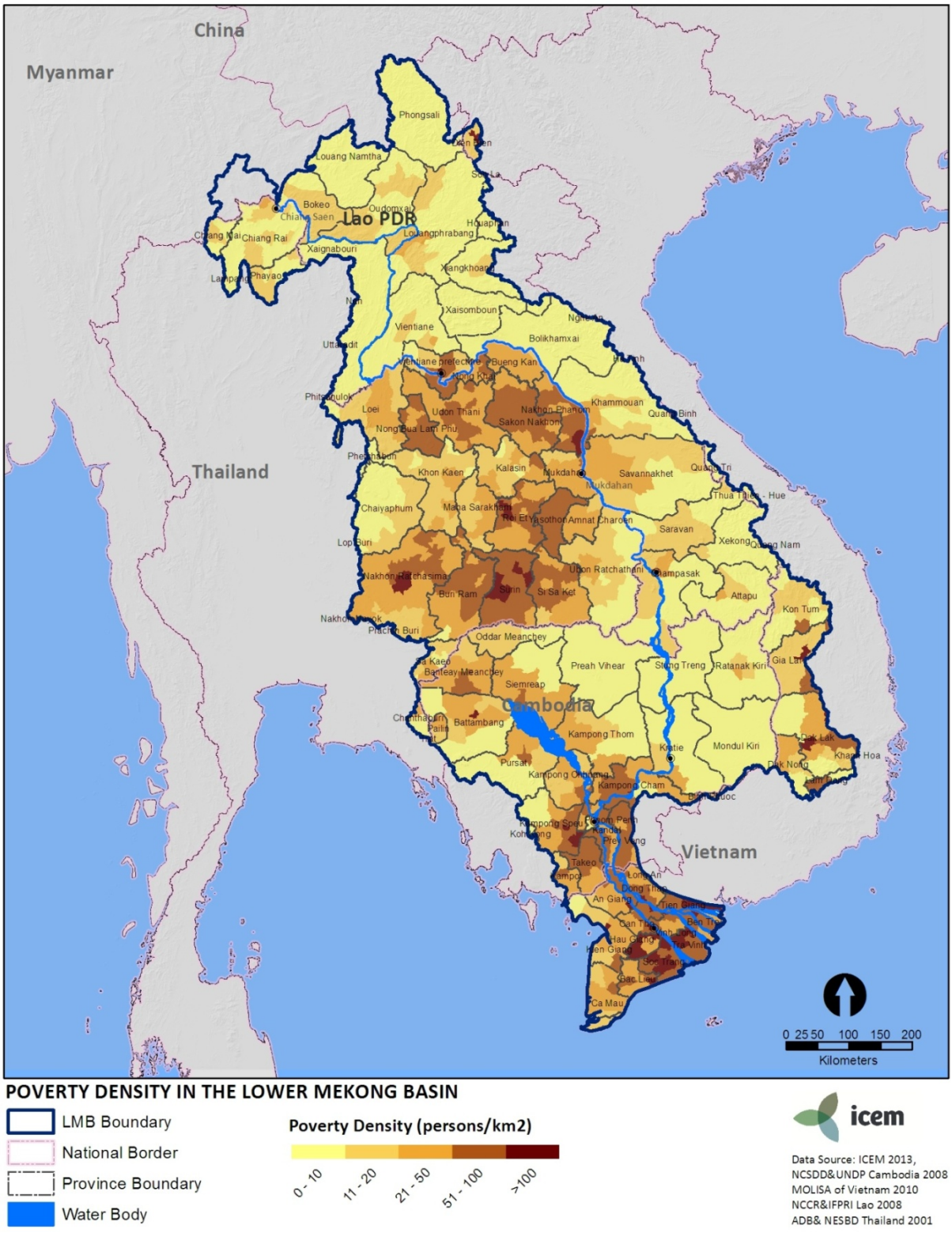

Figure 10: Poverty density in the LMB

Note: All poverty figures are calculated with respect to national poverty lines. Given higher levels of average income in Thailand, a poverty rate of, say, 40% in a particular Thai district implies a much higher level of community welfare than a district with a 40% poverty rate in Cambodia or Lao PDR.

3 FOOD SECURITY

Food security is an important consideration throughout the LMB, particularly in regard to rural populations. Food security is a complex concept encompassing both the nutritional adequacy of food availability and usage over a period of time but also some notion of the risk - or lack of risk - that access to adequate nutrition can be obtained over that period. Therefore, measuring food security and its components can be a challenging undertaking. Nevertheless, widely used composite indicators have been developed; Figure 911 shows a food security index developed by the International Food Policy Research Institute (IFPRI) for 1990 and 2009 for the four LMB countries. At this very general level, the fruits of improved agricultural production and economic development more generally are visible in rapid declines in the Global Hunger Index measure of food security. Despite these considerable improvements, these figures also indicate that food security remains a problem in all four countries of the LMB. Cambodia and Lao PDR continue to have significant issues with an index of around 20. Vietnam does much better with an index of around 10, and Thailand does better still. Nevertheless, and despite a much higher level of development, Thailand continues to have a persistent problem with food security amongst some groups.

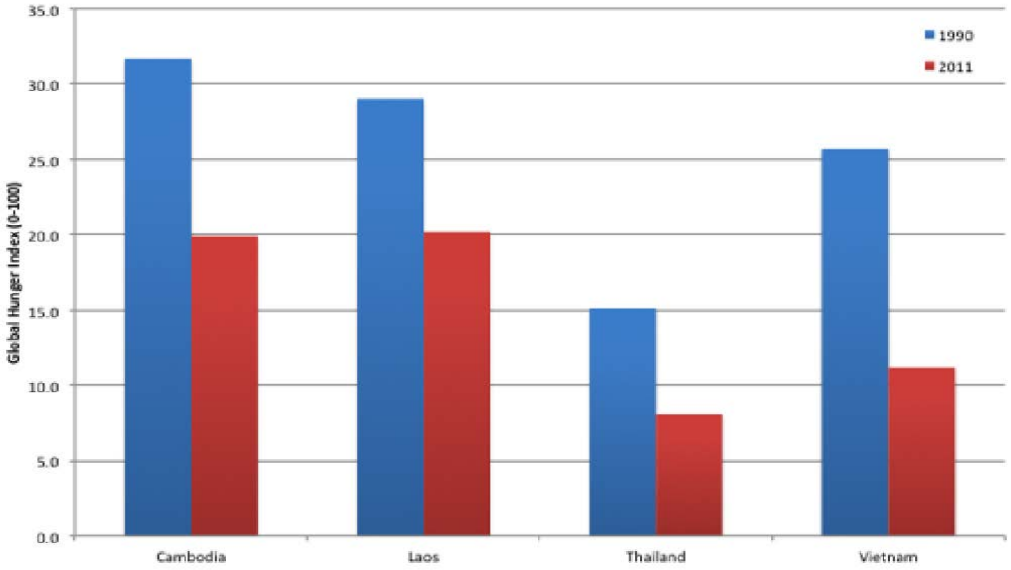

Figure 11: Food security in LMB countries 1990 and 2009

Source: IFPRI 2012

More detailed time series data measures on child malnutrition, another important indicator of food security, also show rapid improvements in the LMB countries (Figure 12). In common with poverty indicators, levels of infant malnutrition have dropped particularly quickly in Vietnam for both measures of malnutrition shown in the figure. Cambodia also saw significant declines up until around 2005, after which time improvements seem to have slowed down. Lao PDR fares worse, with some declines in the late 1990s but with malnutrition indicators remaining relatively constant for the last decade. Thailand has also seen improvement but, as with poverty, the indication is that less tractable problems with chronic food insecurity remain amongst some groups.

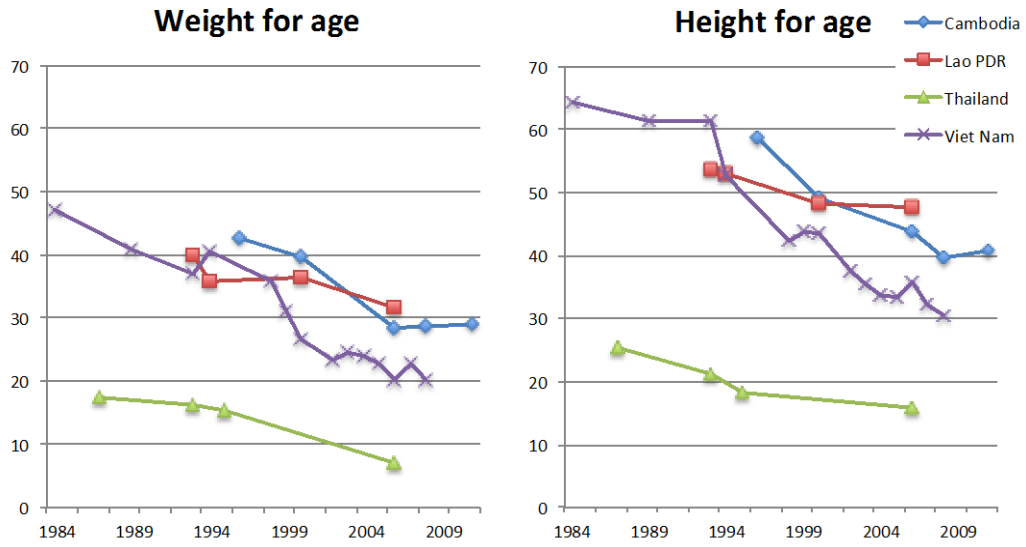

Figure 12: Percent of children <5 years of age displaying malnutrition in LMB countries, 1984 - 2010

Source: World Bank 2013

While indicating the continuing issue of food insecurity in the LMB region, these aggregate trends obscure important differences in terms of the occurrence of food insecurity amongst different groups. Recent survey-based studies on food security in Cambodia (WFP 2008) and Lao PDR (WFP 2007) serve to illustrate the complexities of food security issues in these countries, and across the LMB more generally. Figure 13 shows results from the Cambodia survey. Occupational groups were determined by cluster analysis and are indicated based upon the main household income source. Based upon details of household food consumption in the previous week, a food consumption score was determined indicating the nutritional adequacy of the household diet. The histogram shows how different groupings faired relative to the national average of 53. Groups scoring below the mean can be deemed more vulnerable to food insecurity and those scoring above the mean are less vulnerable. These results illustrate that farmers and wage laborers of various kinds tend to be the most vulnerable to food insecurity. By contrast, salaried households, the self-employed, households involved in animal husbandry and fisheries, and garment factory workers tended to be relatively more food secure. Indications are that this pattern is replicated across the LMB.

In a similar study performed by WFP (2007) in Lao PDR, it was also found that unskilled laborers of various kinds and farmers tended to be the most food insecure. Figure 14 shows the different food sources relied upon by different occupational groups.[7] In particular, it serves to emphasize the importance of marketed food sources for all groups, even those we would commonly regard as subsistence producers. This indicates the importance of markets in achieving a nutritionally balanced food intake, allowing farmers, for example, to sell rice that is excess to requirements to buy meat or fish. Similarly, the importance of subsistence production is emphasized for all groups. Fishing, hunting, and gathering also appeared as important for most groups. As these activities are likely to be important in supplementing the diet with vital fats and proteins their importance in achieving food security is

[7] Occupational groupings were determined by cluster analysis.

probably under-represented in the figure. A final comment about these figures is that they serve to illustrate the prominent importance of natural resources associated with hunting, fishing, and gathering activities for farmers and unskilled laborers - those groups that are likely to be at greater risk of food insecurity.

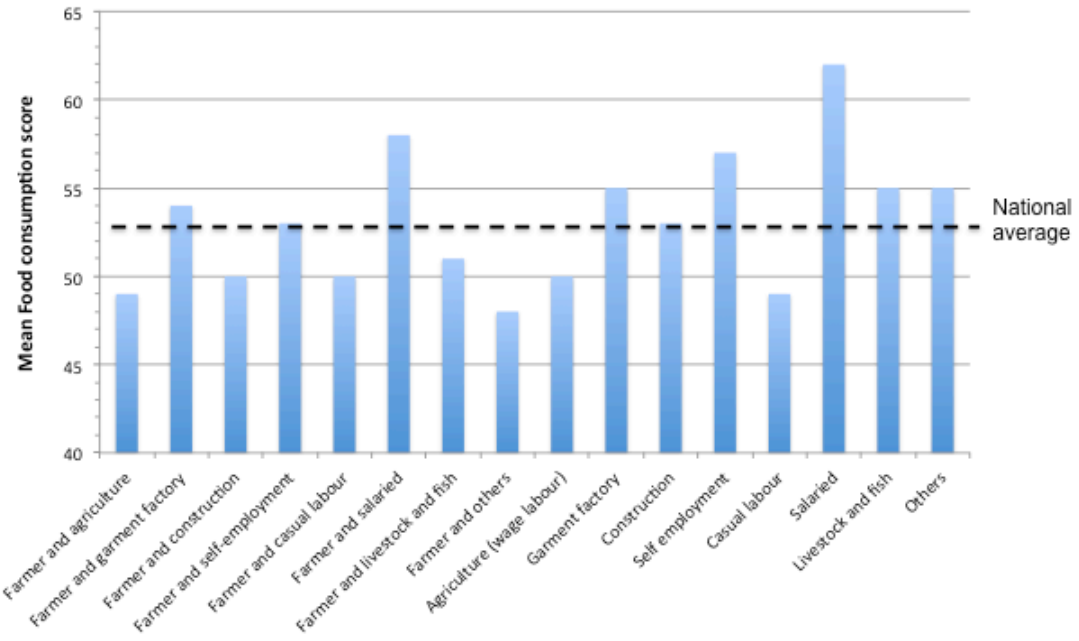

Figure 13: Food security by occupation (Cambodia 2008)

Source: WFP 2008

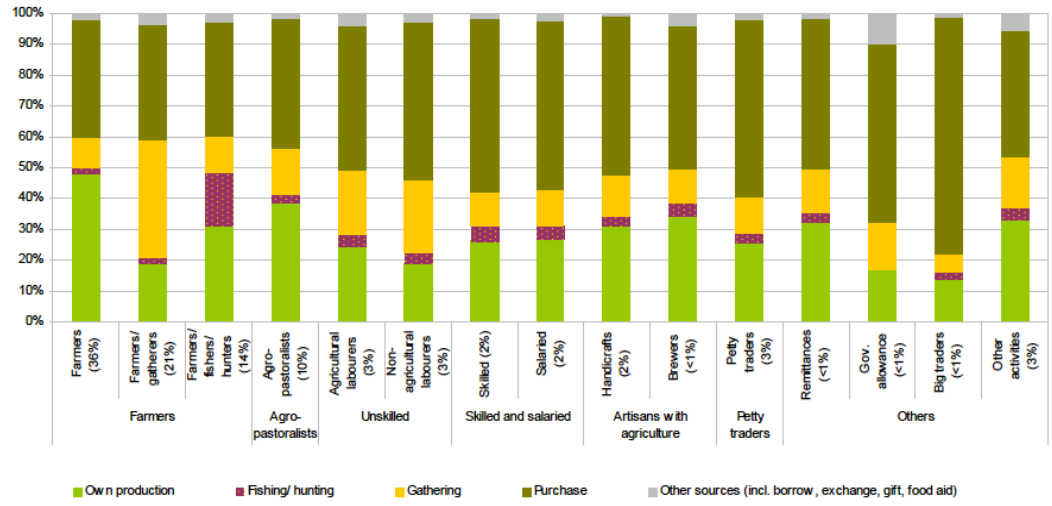

Figure 14: Food source by occupation (Lao PDR 2007)

Source: WFP 2007

A final important point relating to food security in the LMB is the importance of capture fisheries (MRC 2010, Orr et al. 2012). Fisheries are a key source of protein and fats in the diets of many of the LMB's population. Figure 15 illustrates the importance of fish consumption relative to other sources of protein in Cambodia, with fish comprising at least 75% of protein intake in every province. Although amongst LMB countries capture fisheries are most important in Cambodia, they compose an extremely important part of the diet across the basin and particularly in riverine areas.

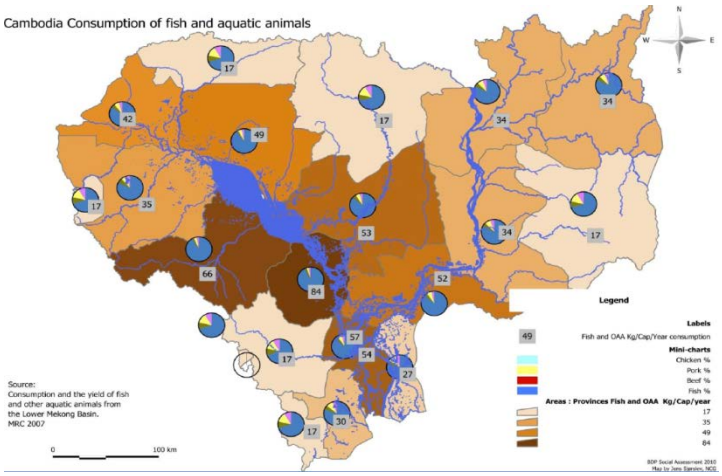

Figure 15: Consumption of fish and aquatic animals in Cambodia

Source: MRC 2010

4 HEALTH AND RURAL INFRASTRUCTURE IN THE LMB

Health and infrastructure conditions are closely related. Firstly, health indicators tend to be correlated with infrastructure indicators as poor health and poor infrastructure both stem from more fundamental causal factors such as geographical location and poverty rates. Secondly, health outcomes are frequently dependent upon access to infrastructure. Access to a potable water supply and environmental sanitation infrastructure are related closely to the incidence of enteric diseases, protein malnutrition in infants, and infant mortality. Adequate transportation infrastructure and the provision of physical health amenities, such as clinics, are closely related to the proportion of women with access to adequate pre-natal and post-natal care and as a consequence, the maternal death rate. Therefore, while considerations of health and infrastructure are distinct, it is important to bear in mind the connections between them.

4.1 HEALTH

As with other indicators, and notwithstanding remarkable overall progress, it is important to realize that aggregate national figures obscure important discrepancies. Nevertheless, it is instructive to examine key aggregate health indicators, which are illustrative of health trends and conditions in the LMB. The general trend of declining poverty levels in the LMB has been both driven by, and contributed to improving health conditions. MRC (2010) shows that progress towards the health-related Millennium Development Goals (MDGs)[8] is either "on track" or "possible to achieve" in the LMB countries.

Figure 16 shows trends in life expectancy at birth over the past half-century. All four countries have seen dramatic improvements since the 1960s. The effects of widespread regional conflict are clearly visible in the life expectancy trends of Cambodia and Vietnam in particular and to a lesser extent Lao PDR. Progress made by Vietnam is particularly impressive, which has moved from a level comparable to Cambodia and Lao PDR in the 1960s to overtake Thailand by the mid-2000s.

Lao PDR and Cambodia continue to lag well behind Thailand and Vietnam, and this is reflected in other health indicators. For example, in Cambodia and Lao PDR the proportion of deaths attributable to mainly communicable diseases, maternal, prenatal, and nutritional conditions (i.e., largely preventable diseases affecting mothers and infants disproportionately associated with poor environmental sanitation and limited access to basic healthcare) remains at 47% and 41% of deaths respectively in 2008. In Thailand and Vietnam the proportion of deaths attributable to these causes was 17% and 16%

[8] The health-related MDGs include: "Halve the proportion of people who suffer from hunger", "Reduce by two-thirds, between 1990 and 2015, the maternal mortality ratio", "Reduce by two-thirds, between 1990 and 2015, the under-five mortality ratio", "Achieve, by 2015, universal access to reproductive health", "Have halted by 2015 and begun to reverse the spread of HIV/AIDS", "Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it", "Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases".

respectively. By contrast, non-communicable diseases, such as cancer, cardiovascular disease and other conditions associated with old age, were much higher in Thailand and Vietnam.

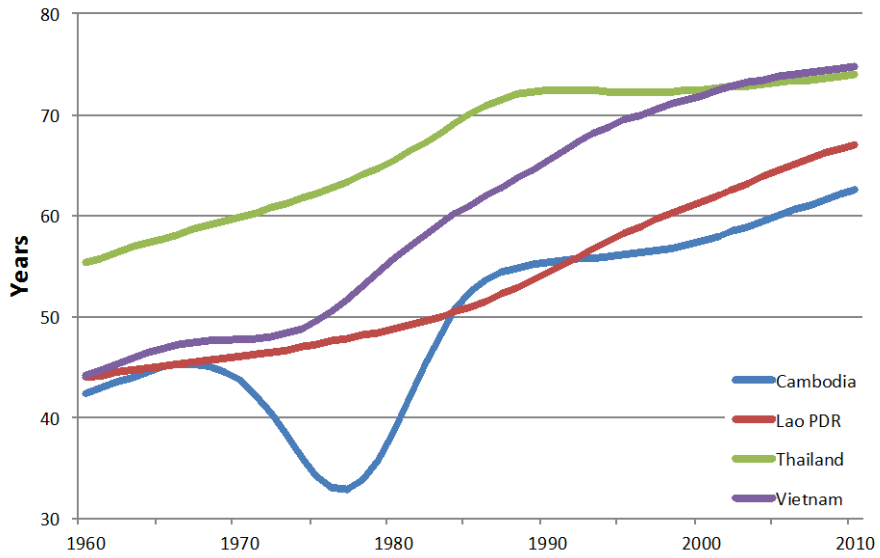

Figure 16: Life expectancy at birth in LMB countries 1960 - 2011

Source: World Bank 2013

Figure 17 emphasizes the rapid improvement of health indicators in general and also the persistent difference in health performance between Cambodia and Lao PDR on one hand and Thailand and Vietnam on the other.

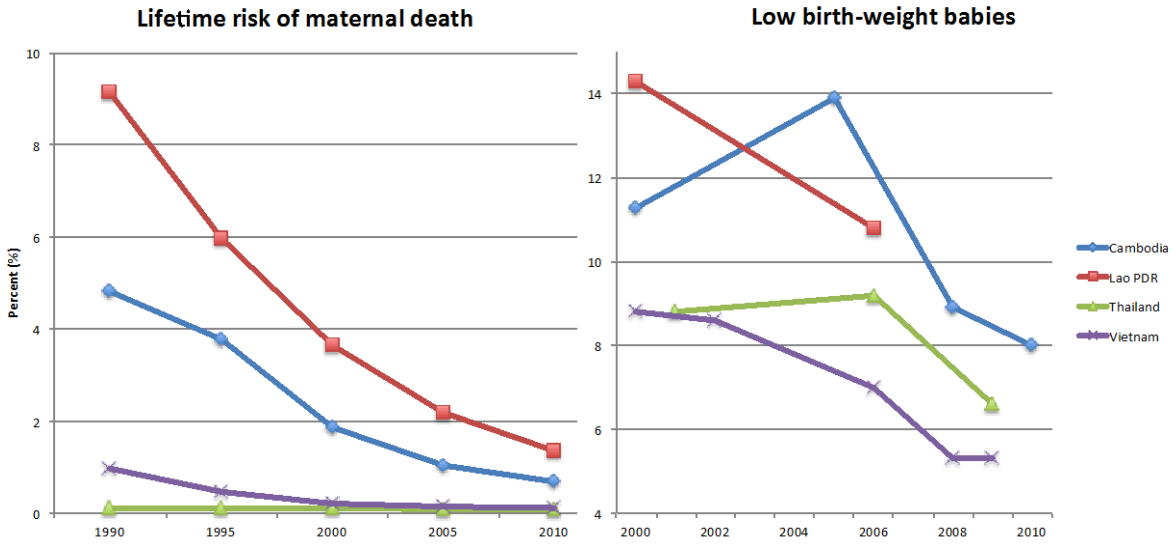

Figure 17: Lifetime risk of maternal mortality and low birth-weight in LMB countries 1990 - 2010

Source: World Bank 2013

Declining child mortality rates also reflect the overall progress that has been made in the health sector (Figure 18). However, the profiles of particular provinces in this report show that some regions still experience very high rates. A recent survey across half the districts of Khammouan Province in Lao PDR

found that, on average, mothers had lost at least one child before the age of 5; certain districts of Mondulkiri Province in Cambodia reported under five mortality rates of 20% in 2011 (see Annexes).

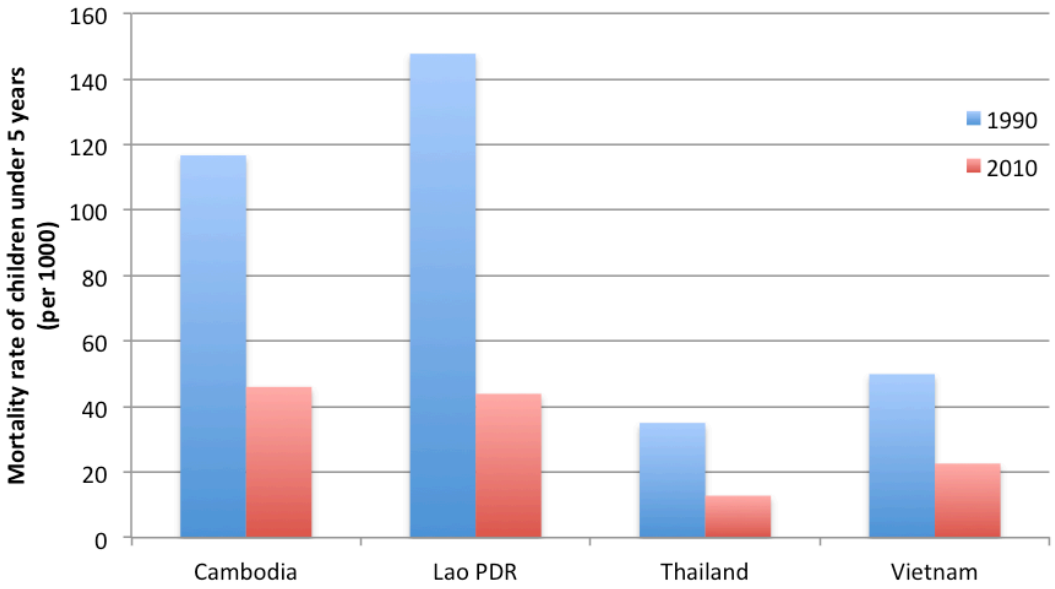

Figure 18: Mortality rates of children under 5 in the LMB, 1990 and 2010

Source: World Bank 2013

In terms of the level of health access (i.e., hospitals, beds, physicians) the situation is better in Thailand and, to a lesser extent, Vietnam as compared to Cambodia and Lao PDR. Once again, however, health coverage is not uniform across these countries, with access to health services much better in urban and lowland areas. Ethnic minority groups in remote upland areas in particular tend to have much poorer access to health services.

4.2 RURAL INFRASTRUCTURE

Similar to the health sector, the level and quality of infrastructure across the region varies greatly between and within countries of the LMB. For example, the relatively advanced transport infrastructure of the Isan region in Thailand is in stark contrast to the unpaved and sparse road network in upland areas of Lao PDR and Cambodia, reflected in the national statistics given in Figure 19. Similarly, the figures on the number of phone lines per 100 people gives some indication of the penetration of modern telecommunications technology – although this comes with the important caveat that mobile phones obviate the necessity for fixed line communications technology visible in recent declines in traditional fixed lines in Thailand and Vietnam. Nevertheless, similar trends to those visible in health are clear. Thailand has a significantly higher level of infrastructure development, Vietnam has been going through a rapid transition since the mid-1990s, and Cambodia and Lao PDR lag behind, with obvious changes in indicators only emerging in recent years.

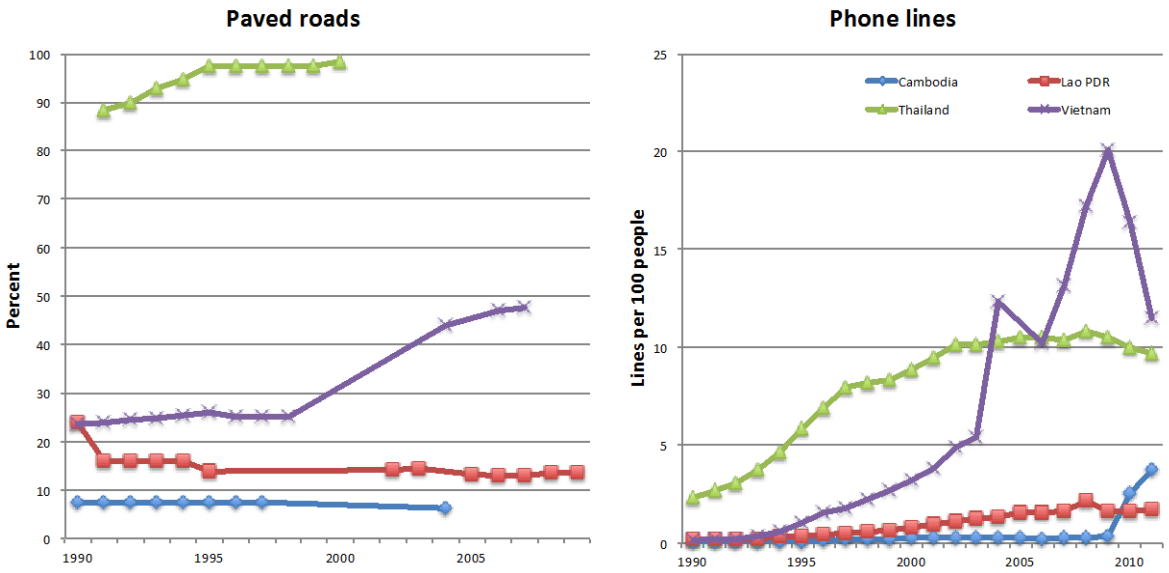

Figure 19: Proportion of roads paved and phone lines per 100 people 1990 - 2010

Source: World Bank 2013

The variation in access to infrastructure is illustrated well by the rural-urban disparity in World Health Organization assessments of access to safe drinking water and improved sanitation facilities (Table 3). It should be noted that measuring aggregate health conditions tends to obscure the real situation on the ground: the indicators "access to an improved water source" and "access to an improved sanitation facility" greatly over-estimate household access to safe drinking water (Bain et al. 2012, Onda et al. 2012). This bias means that the situation in rural areas is actually much worse than the data suggests.

Country	Access to an improved water source		Access to improved sanitation facilities	
	1994	2010	1994	2010
Cambodia	32%	64%	9%	31%
Urban	48%	87%	36%	73%
Rural	29%	58%	5%	20%
Lao PDR	39%	67%	16%	63%
Urban	75%	77%	58%	89%
Rural	32%	62%	8%	50%
Thailand	88%	96%	88%	96%
Urban	96%	97%	94%	95%
Rural	85%	95%	85%	96%
Vietnam	65%	95%	44%	76%
Urban	90%	99%	69%	94%
Rural	65%	95%	37%	68%

Table 3: Access to improved water source and improved sanitation facilities in the LMB

Source: World Bank 2013

The extent of irrigation infrastructure varies greatly between the LMB countries. Table 4 shows that Thailand and Vietnam have extensive irrigation coverage, whereas Cambodia and Lao PDR do not. The presence of irrigation infrastructure is generally a major determinant of agricultural productivity, allowing multiple and more abundant crops over the course of a year than if water delivery relies solely on rainfall. This is particularly important in terms of dry season crops. However, irrigation infrastructure is expensive to build and requires extensive maintenance; it is understandable therefore that extensive irrigation is both an indicator and driver of higher income and food security.

Country	Total area of irrigated land (1000 ha)	Total area of agricultural land (1000 ha)	Agricultural land under irrigation (%)
Cambodia	354	5655	6.3
Lao PDR	31	2378	13
Thailand	6415	21060	30.5
Vietnam	4600	10768	42.7

Table 4: Total area of irrigated land and percentage of total agricultural land in the LMB

Source: World Bank 2013

In terms of electricity access (see Table 5), it is notable that Lao PDR has a relatively high level of access for its income level; in fact, more recent estimates indicate that 80.3% of households are electrified as of 2012 (LIRE 2013). A key causal factor explaining Cambodia's low electrification rate is some of the highest electricity prices globally, as well as the related issue of low levels of government investment. By contrast, electrification in Thailand and Vietnam is almost universal, largely as a result of dedicated government programs. More broadly, the overall level of poverty in a particular location in the LMB is concomitant with and indicative of the overall level and quality of rural infrastructure (i.e., comprising road networks, bridges, irrigation, water supply, household dwellings, municipal buildings, etc.). Remote

rural locations with poor communities are generally observed to be the areas with the lowest levels of infrastructure.

Country	Electrification rate	Population without access to electricity (millions)
Cambodia	24%	11.3
Lao PDR	55%	2.6
Thailand	99.3%	0.5
Vietnam	97.6%	2.1

Table 5: Electrification rates of LMB countries, 2009

Source: IEA (2013). Note that more recent data indicates a much higher electrification rate for Lao PDR of approximately 80% (see LIRE 2013).

5 TRANSFORMATION OF LMB FARMING SYSTEMS

The LMB's farming systems are being transformed by a shift away from labor-intensive, subsistence-based agriculture (MRC 2010, Johnston et al. 2009). That shift has significant socio-economic implications, particularly for the vulnerability of rural communities to climate change.

5.1 COMMERCIAL AND SUBSISTENCE AGRICULTURE

Figure 20 summarizes the major characteristics of LMB commercial and subsistence agriculture. A third category (not shown) is also common in the basin: smallholder commercial agriculture, which represents a mixture between the two main types, but farming still occurs on a relatively small-scale and with some subsistence activities.

In the LMB there are examples of both full-scale commercial agriculture (e.g., large plantations of non-food crops such as rubber, cassava, and coffee) and the purest forms of subsistence agriculture (e.g., shifting cultivation). Most rural households and communities lie somewhere in between. The diversified nature of rural farming systems means that even the remotest subsistence-based communities have opportunities or need to conduct commercial activities at least some of the time. Whether commercial or subsistence-based, all farming systems and sectors have one thing in common: their productivity is dependent on healthy, functioning natural ecosystems.

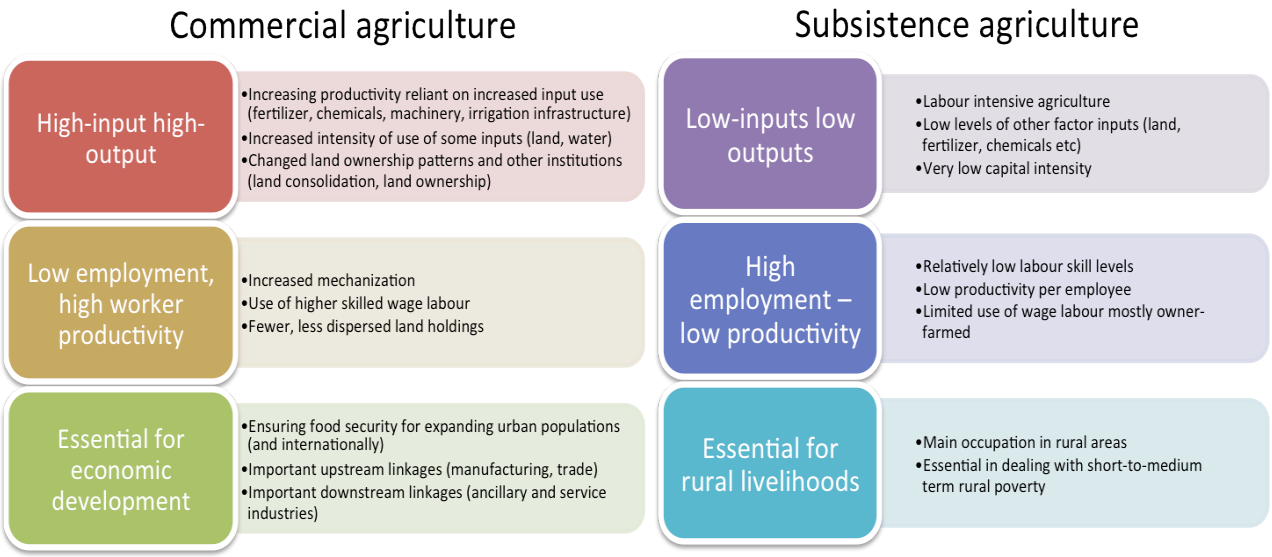

Figure 20: Characteristics of commercial and subsistence agriculture

5.2 AGRICULTURAL PRODUCTION IN THE LMB

Three main trends point to the rise of commercialization in the region: (i) agricultural exports have risen rapidly, (ii) harvested areas of most key commodity crops have also risen rapidly, and (iii) upward, though not necessarily uniform, trends in yield have occurred in all major commodities.

Across LMB countries three broad phases of agricultural commercialization can be observed: a large, relatively advanced agricultural sector in Thailand; a smaller, but established and growing commercial sector in Vietnam; and, the relatively recent emergence of commodity production in Cambodia and Lao PDR. The rate of development is not uniform within countries: subsistence and smallholder communities occur throughout Thailand and advanced commercial farming operations exist in Lao PDR.

In Thailand and Vietnam, the emergence of commercial agriculture has followed from capitalist-oriented policy reform and broader economic development. In Lao PDR and Cambodia, commercialization is largely driven by government policies that focus on attracting private, often foreign, investment in economic land concessions (Johnston et al. 2009).[9]

The upward trajectory of regional population, urbanization, and income growth is also driving rising food demand. Moreover, the diets of a wealthier population are shifting towards the consumption of more resource-intensive meat and dairy products. These shifts will provide demand for further productivity improvements and further commercialization. Other external factors (e.g., China's demand for agricultural imports and the evolution of global commodity prices) will also drive this shift in the future.

5.3 SOCIO-ECONOMIC IMPLICATIONS OF COMMERCIAL AGRICULTURE

Over the long term, the LMB agricultural transition has strong positive implications for the alleviation of poverty and the provision of food security. For LMB countries rising agricultural productivity is a major engine of economic development (Timmer 2000). A stable food supply, foreign exchange earnings, higher savings, greater demand for industrial sector goods, as well as the shift of labor to industry; these are all critical elements of the broad economic development which is an integral part of poverty reduction.

Yet, in the short to medium term, the commercialization of agriculture poses significant threats to the security of the rural poor (Pingali 1997). Three main factors determine the welfare implications of the transition (after Pingali 1995):

i) Availability of alternative livelihoods and labor mobility – Affected communities need to either engage in commercial agriculture themselves or find wage employment elsewhere. The first choice presupposes adequate access to the requisite skills and investment capital; the second is contingent on adequate employment opportunities and, once again, necessary education and skills to obtain that employment.

ii) Land tenure – Land is often the only asset subsistence communities possess. Commercialization generally involves a process of land consolidation and transfer of tenure to commercial enterprises. The

[9] This is exemplified by the Lao PDR government's estimate of the area of agricultural land concessions (excluding contract farming): 5.5%, or 1.1 million hectares which is more than the total land area growing rice and officially recognized as probably being an under-estimate (Schönweger et al. 2012).

capacity to effectively sell tenure rights or be otherwise compensated is therefore critical to welfare outcomes.

iii) Food security and relative prices – In terms of net food security, the benefits of commercialization are contingent on the extent to which households are able to earn a higher level of cash income relative to the market price of food.

In certain cases, the transition to commercial agriculture is failing to enhance livelihoods of the poor. For example, a survey of villages adjacent to agricultural land concessions in Northeast Cambodia (Prachvuty 2011) found that: (a) only 16% of families received compensation for loss of land, and most of those felt that compensation was inadequate; (b) only 30% of remaining families had since taken employment with the concession company; and, (c) 92% of families believed they were worse off. Their reduced well-being was due to loss of shifting agricultural land and other farmland, loss of forest lands where they previously collected Non-Timber Forest Products (NTFPs), and land degradation from forest loss.

A transition from subsistence to, for example, contract-based farming has reportedly improved welfare elsewhere in the LMB (Setboonsarng et al. 2011. Yet, in most areas of Cambodia, Lao PDR, and Vietnam, many factors are making the transition disadvantageous to the rural poor. Absence of strong land tenure is one. Another is the lack of skills to adapt; this is particularly prominent among ethnic minorities living in remote areas with poor access to state services.

Price risks are a particular challenge for three reasons: (i) low income households are more vulnerable to price rises. This is of particular concern with increasing real food prices and food price volatility (see Figure 21); (ii) smallholder commercial farmers may be exposed to the significant swings in international commodity markets for their produce (also Figure 19); and (iii) input prices, such as fertilizer costs, may also be subject to volatility.

Another critical issue is environmental sustainability. Central aspects of the shift to commercial agriculture are the increased application of fertilizers and pesticides, large irrigation diversions, more intensive cultivation of land, and clearance of forestlands. Natural resources are the foundation of rural welfare. The degradation of water supplies, soil erosion, and loss of access to NTFPs all have direct and immediate welfare impacts. Recent history highlights numerous cases in the LMB where the transition to commercialization has represented a worsening or the onset of environmental problems that are affecting the poor disproportionally (e.g., Johnston 2009).

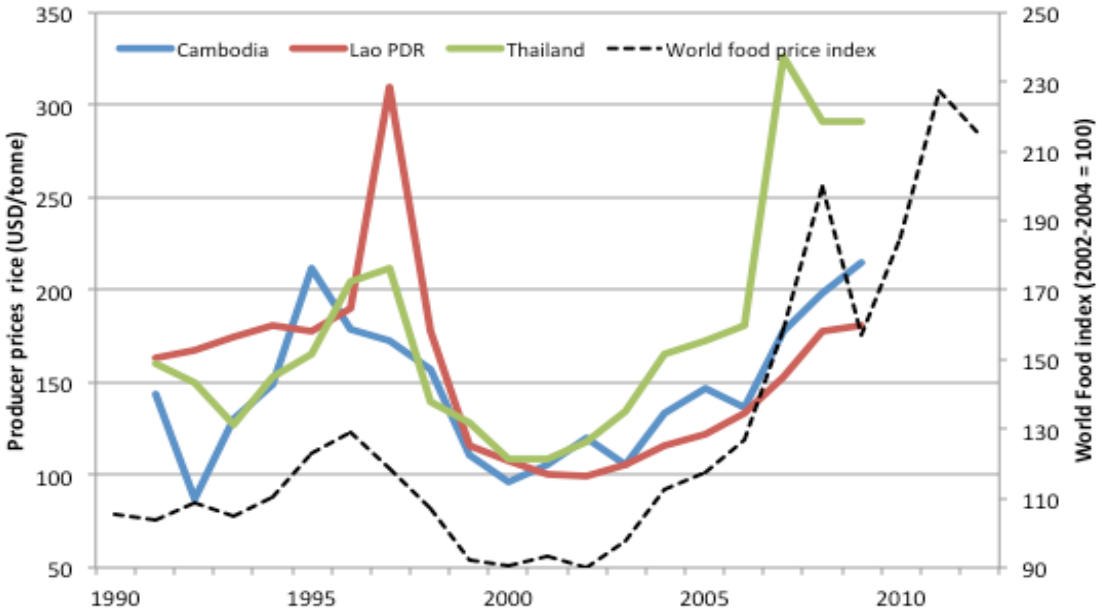

Figure 21: Food price fluctuations

Source: FAOSTAT (2012)

There are also immediate opportunities from the transition. Rising labor productivity could and should raise incomes and living standards for at least some groups during the early stages of the transition. The creation of input supply chains and extension services, such as credit facilities should benefit smallholder commercial farmers. Similarly, the creation of stronger, non-local food trade provides insulation from localized natural disasters or adverse crop conditions.

The agricultural transition exacerbates the risks posed by climate change for vulnerable groups, particularly in the case of extreme events. Although climate change is a long-term process of incremental change in regular climate patterns, the LMB is projected to experience increased magnitude and frequency of extreme events such as floods and drought which can occur at any time.

Where commercialization increases access to markets, education, health services, and overall community welfare, then that would build resilience to climate change in local communities. For the individual household, the balance of risks and opportunities would be highly context specific. Yet, the negative implications of agricultural transition tend to increase the vulnerability of the rural poor to extreme events.

SECTION 2 – METHODOLOGY

I LIVELIHOOD ZONES

In order to assess the climate change vulnerability of socio-economic systems across the LMB, the 12 ecozones set out in ICEM (2013a) are grouped into 4 livelihood zones: *"Forested uplands"*, "*Intensively used uplands*", "*Lowlands plains and plateaus*", *"Floodplain"*, and "*Delta"* (see Figure 22). This geo-spatial characterization is not intended to precisely reflect community activities at particular locations in the LMB. However, the zones do provide an overview of common livelihood strategies for communities residing in similar ecozones and, by consequence, within similar livelihood systems. This approach is adapted from Johnston et al. (2009) and the description below draws on the latter study. Details of the livelihood zone groupings by their constituent ecozones can be found in Annex 1 and a summary of their characteristics can be found in Table 6.

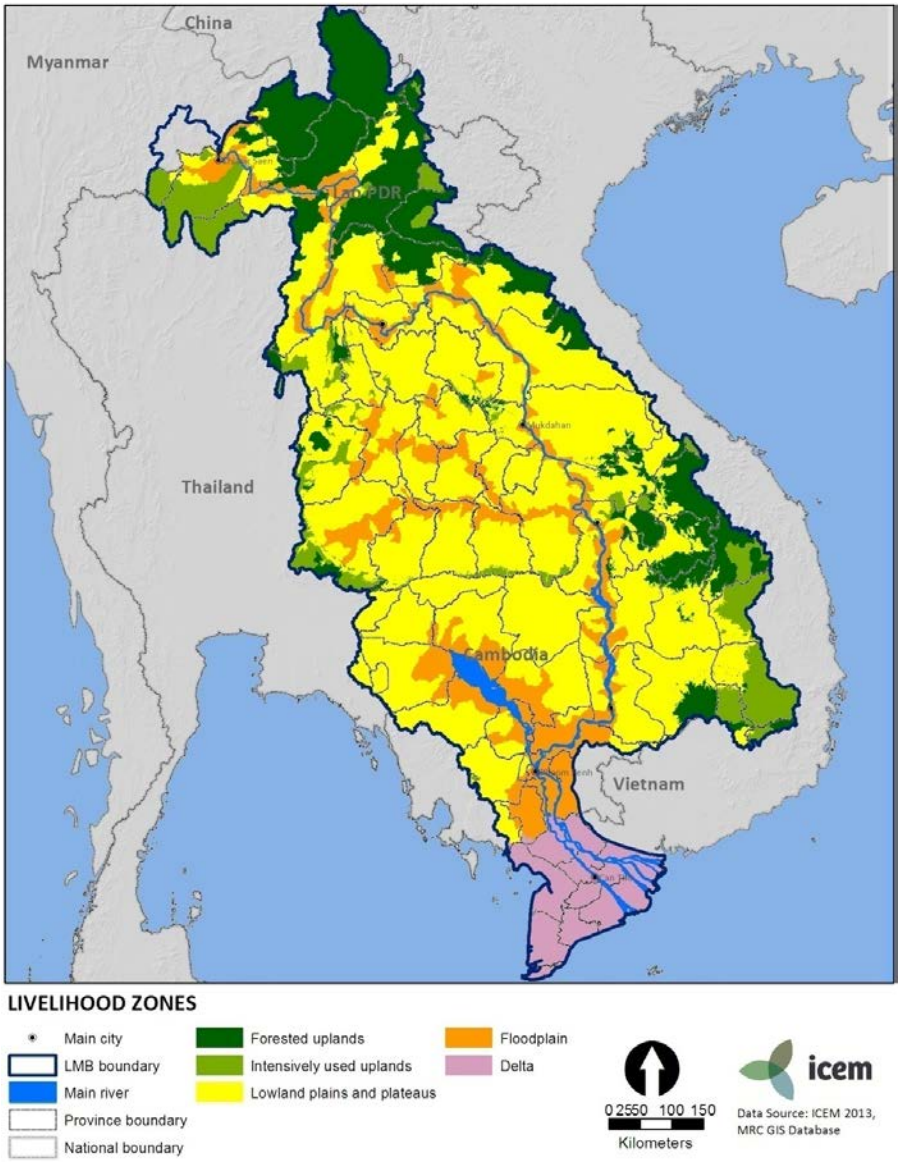

Figure 22: Livelihood zones of the Lower Mekong Basin

1.1 SUMMARY DESCRIPTION OF LIVELIHOOD ZONES

Livelihood zone	*Forested uplands*	*Intensively used uplands*	*Lowland plains and plateaus*	*Floodplain*	*Delta*
Area (% of LMB)	17%	7%	55%	15%	6%
Population (% of LMB)	3%	9%	40%	20%	29%
Population Density (/km²)	16	114	71	130	506
Poverty rate (% of population)	39%	21%	30%	24%	12%
Main regions in each zone	N and SE Lao PDR, E Cambodia, Thai-Myanmar border	Vietnam Central Highlands, N Thailand	Central Lao PDR, E, N and W Cambodia, NE Thailand	Tonle Sap, SE Cambodia, Mekong River Floodplain, E Thailand	Mekong Delta
Main characteristics	Low population density, high poverty, poor health access and food security. Ethnic minority communities. Shifting cultivation. Low rates of electrification and other infrastructure. High level of subsistence agriculture. Diversity of livelihood activities. Exposed to flash floods and landslides. NTFPs a critical source of food and livelihoods. Upland rice instead of paddy rice.	Moderate to high population density. Intensive commercial agriculture. High rates of land degradation due to land-clearing on sloping land. Low rates of poverty among commercial farmers. High rates of poverty among minority groups living on more remote and marginal land. Exposed to flash floods and landslides.	Poverty varies from high (Cambodia) to low (Thailand) across countries. Rain-fed agriculture. High food insecurity in some areas. Distance to markets may limit commercial opportunities. Poor soil fertility and low land productivity. Exposed to floods and droughts.	Relatively low food insecurity and poverty. Fishing a prominent subsistence and commercial activity. Exposed to seasonal floods. Close proximity to markets and strong access to healthcare and other infrastructure. High to medium population density.	Highly intensive commercial agriculture, but declining agricultural productivity. Relatively low levels of poverty and food insecurity, but present in some areas. Population density very high. Access to markets and services is high. Coastal fishing and aquaculture are prominent livelihood activities.

Table 6: Summary description of livelihood zones

Note: Data includes both rural and urban populations. See Figure 9 for data sources. Areas include water-bodies. The above adapts a similar exercise in Johnson et al. (2009).

1.1.1 FORESTED UPLANDS

Upland areas in the LMB typically comprise sloping hills or mountains adjacent to highly productive valleys. Following Johnston et al. (2009), we distinguish between *Forested uplands* and *Intensively used uplands* in our analysis. *Forested uplands* areas exhibit low population density (<50 persons/km^2) and substantial remaining forest cover. Communities in this zone predominately pursue subsistence-based livelihoods. *Intensively used uplands* consist of higher density areas (>50 persons/km^2) with substantial tracts of land cleared for commercial agriculture. The boundaries between the two areas are shifting over time and the distinction above does not precisely delineate the two zones at the regional level.

Forested uplands are characterized by: low population density, limited land suitable for paddy rice (due to steep slopes), and a relatively high proportion of the population consisting of poor ethnic minorities. These areas are concentrated in the north and south east of Lao PDR, the east of Cambodia, parts of Vietnam's central highlands, and the Thai-Myanmar border region. Communities in this zone typically pursue subsistence-based shifting cultivation and livestock rearing, with limited commercial cropping. The poverty rate is the highest across livelihood zones in the LMB. Lack of access to public infrastructure (including health centers, roads, electricity, etc.) and markets is a common problem in these areas. Very poor health conditions and low literacy are also common features. Non-timber forest products (NTFPs) are important sources of food (particularly in times of food insecurity) and income. A major characteristic of livelihood systems in the LMB is the diversity of activities that households employ; this trait is most evident in *Forested uplands* and, in many cases, reflects the more marginal status of household food security.

Although these areas are labeled *Forested uplands*, their natural state is under threat of (or has already been subjected to) degradation. Deforestation and the encroachment of plantation or commercial cropping is changing the landscape and, importantly, reducing the access of rural communities to ecosystem services. These changes, as well as the shortening of fallow periods for shifting cultivation (due to increased demand for food), are major drivers of land degradation. Key crops in this zone include: upland rice, other cereals, vegetables, and other subsistence-based crops. Although commercial fishing is limited across most of this zone, many households fish in upland streams on a subsistence basis.

1.1.2 INTENSIVELY USED UPLANDS

Intensively used uplands encompass high elevation areas of greater population density. This zone makes up the majority of Vietnam's central highlands region, parts of northern Thailand and some small areas in Cambodia and Lao PDR. Farming in these areas focuses on commercial cropping of coffee, irrigated rice (predominantly in valleys), pepper, rubber, and other crops. Given the high value and commercial orientation of these crops (and also that most of this zone can be found within Thailand and Vietnam), the average level of income and the quality of infrastructure are generally higher than in *Forested uplands*. This is also broadly the case across a range of important variables, such as access to markets, access to health, and education facilities; there may however be highly vulnerable groups in certain areas classified as *Intensively used uplands*.

The intensive nature of farming on often unsuitable land in this zone is driving widespread erosion and reducing soil fertility; the consequent risk of flooding and landslides on sloping land is a major hazard. Although farmers can earn high profits from commercial crops, the intensive nature of their farming and the high cost of inputs leave farmers highly exposed in the event of crop failure or unfavorable price shifts in the market.

1.1.3 LOWLAND PLAINS AND PLATEAUS

This zone covers the largest proportion of the LMB. Aside from Northeast Cambodia, these areas are extensively cleared of forest cover. Agriculture is primarily rainfed and the most significant crop is rice. Other important crops are maize, sugarcane, cassava, and soybean. Large-scale plantations of industrial crops (such as rubber, eucalyptus trees, and cassava) are becoming more common in the region; many of these plantations arise from foreign direct investment.

Poverty is significant in *Lowland plains and plateaus*, but varies greatly between the intensively irrigated areas of NE Thailand and plains of Mondulkiri in Cambodia. By and large, these areas have better infrastructure and access to services than more remote *Forested uplands* areas, but less than the *Floodplain* zone. Similarly, population density outside of urban areas is also higher than *Forested uplands* (except for northeastern areas of Cambodia) and lower than the *Floodplain* zone. The greater distance to commercial centers (compared to the *Floodplain* zone) means that wage income is less important and subsistence systems remain significant in the many remote regions of the *Lowland plains and plateaus* zone.

Communities in the *Lowland plains and plateaus* zone often live in riparian areas. This means that they are more exposed to flooding than their counterparts in upland areas; it also means that fishing takes greater prominence in livelihood strategies, including commercial fishing amongst a small proportion of households. The dominant form of fishing is capture fisheries. Irrigation in this zone is limited in Cambodia, extensive in Thailand, and moderate but growing in Lao PDR. Except for areas around major rivers, the quality of soil in *Lowland plains and plateaus* is often poor quality and, therefore, generates low agricultural yields for many crops.

1.1.4 FLOODPLAIN

The *Floodplain* zone consists of areas immediately adjacent to the Tonle Sap, areas to the east and south of the Tonle Sap where the hydrological interaction between the lake and the Mekong River causes major annual floods, and riparian areas of the Mekong mainstream and some major tributaries. In these areas, flooding is a seasonal event that is a critical factor in the high productivity of agriculture and fisheries in the zone. This productivity is reflected in the high population density of the basin's *Floodplain*s and the relatively high level of income and food security compared to the *Forested uplands* and *Lowland plains and plateaus* zones. This higher population density also means that households in this region have better access to markets, health centers, education, and infrastructure. The downside of these higher concentrations is that the ecosystems of some areas of *Floodplain* zones, particularly the Tonle Sap, are at risk of degradation from, for example, forest clearing and other factors associated with high population density.

Subsistence fishing is a critical source of food security, even if fishing is not a household's principal activity. Commercial fishing (including aquaculture) as a primary or secondary activity is common amongst many households. Irrigation is relatively under-developed around the Tonle Sap, where wet rice and recession rice are dominant. Rice, as with most other area of the LMB, is the dominant crop.

1.1.5 DELTA

The *Delta* zone consists of three eco-zones within the Mekong Delta. These areas are the most intensively farmed in the region and rice yields are generally much higher as a result. More than half of Vietnam's rice production originates in the *Delta* and this area has been almost completely converted from marshes/wetlands to a system of dykes and man-made waterways supporting paddy rice. Importantly, the sustainability of land use in these areas is under question – declining soil fertility, water pollution, and other environmental factors threaten future production. Poverty and food insecurity rates

are low by regional standards and population density and access to infrastructure and markets are relatively high. Despite this relative wealth, it is important to note that the intensive, high-input nature of farming means that households are exposed to adverse shocks that affect income. So instead of there being a large number of households in a *state* of poverty, a large number are at *risk* of being forced below the poverty line when they lose revenue because of, say, extreme weather events or instances of pests and diseases.

Coastal *Delta* regions are influenced by ocean hydrology, and livelihoods are heavily dependent on offshore fisheries, saline and brackish water aquaculture, and use of estuarine resources (e.g., clams and shrimp). Wet rice in these areas is vulnerable to saline intrusion and, by and large, rice production is more marginal and involves greater risk than in other parts of the LMB. Mangroves are an important source of NTFPs, particularly for firewood.

2 VULNERABILITY ASSESSMENT METHODOLOGY

This sub-section provides information regarding the socio-economic climate change vulnerability assessment in this study. Details regarding the methodology used in the vulnerability assessment, the "Climate Change Adaptation and Mitigation" or "CAM" methodology, are available in ICEM (2011). In the following section we present: (i) details of the hotspot provinces identified by the USAID Mekong ARCC climate modeling, (ii) an overview of the socio-economic analysis in the context of the overall study, (iii) the rationale for the topics covered in the vulnerability assessment (Health and Infrastructure), (iv) the criteria used in the assessment, and (v) a list of the climate change threats which are covered.

2.1 HOTSPOT PROVINCES

On the basis of output from climate change modeling of the LMB, a number of hotspot provinces were selected by the USAID Mekong ARCC project for in-depth analysis: Chiang Rai (Thailand), Gia Lai (Vietnam), Khammouan (Lao PDR), Kien Giang (Vietnam), and Mondulkiri (Cambodia). These provinces were selected on the basis of their coverage of ecozones, in addition to the expert opinion of the sectoral teams regarding the importance of particular provinces for key species of fish, agricultural products, NTFPs, and livestock. The previous section of this report outlined the aggregation of ecozones into livelihood zones and Table 7 illustrates the breakdown of the hotspot provinces into their constituent livelihood zones.

Livelihood zone	Mondulkiri	Gia Lai	Khammouan	Chiang Rai	Kien Giang
Forested uplands	23%	-	17%	-	-
Intensively used uplands	-	32%		62%	-
Lowland plains and plateaus	77%	68%	78%	21%	-
Floodplain	-	-	5%	17%	-
Delta	-	-	-	-	100%

Table 7: Distribution of livelihood zones across hotspot provinces

2.2 SOCIO-ECONOMIC ANALYSIS

The USAID Mekong ARCC project is comprised of five sectoral teams addressing different systems: agriculture, fisheries, NTFPs, livestock, and social and economic systems. The interaction of these various systems within a representative rural household in the LMB is depicted in Figure 23.

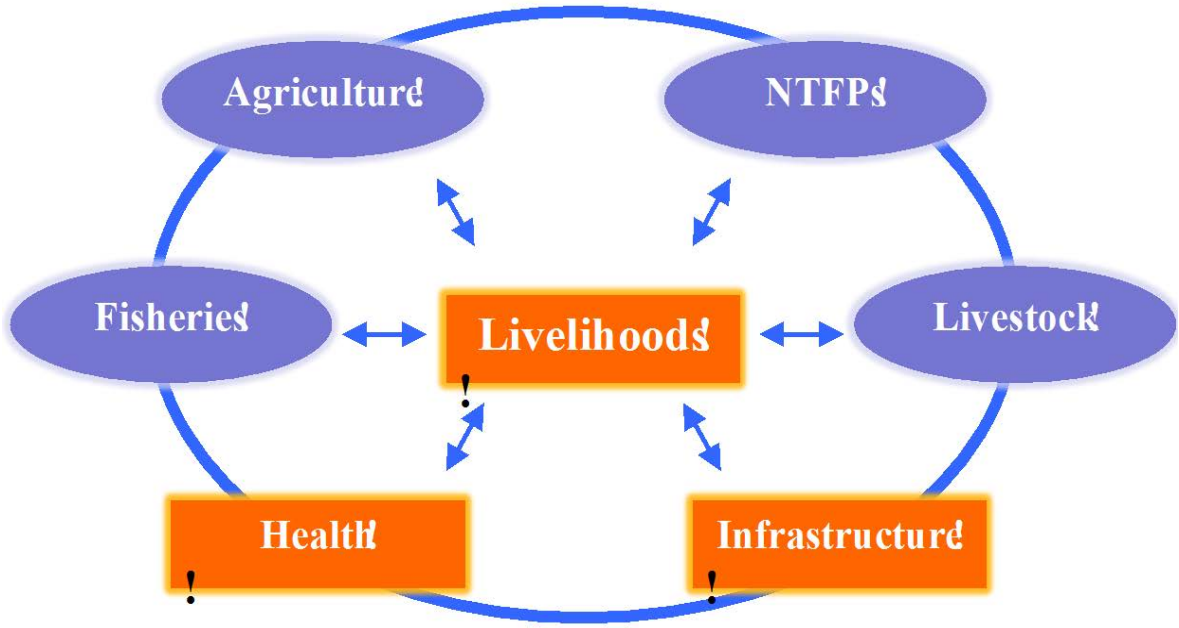

Figure 23: The structure of the livelihood system in a representative rural household in the LMB

This "livelihood system" is the foundation of the socio-economic analysis in this project. Consider a climate change impact on the agriculture or livestock sector. Beyond the direct, immediate impact on livelihoods, there are indirect factors to consider over the longer term. For example, lower rice yields and stunted pig growth may: (i) lower incomes, reduce food security, and, hence, lower household health, (ii) increase dependence on fisheries and NTFPs for food and thereby encourage unsustainable exploitation, or (iii) decrease the level of household and community income available to spend on infrastructure improvements or repairs.

One of the tasks in the USAID Mekong ARCC project is to aggregate these indirect impacts on livelihood systems and consider the various inter-linkages between sectors. This is not, however, a task which is documented in the current report. Rather, the focus here is to consider the direct impacts of climate change on the components of livelihood systems that are not captured by the climate change vulnerability assessments performed by the other sectoral teams. Two critical sectors remain outstanding: health and infrastructure.

2.3 HEALTH

Human health is critical to livelihoods because it is the foundation of productivity in all activities. Inadequate health access limits the capacity of individuals to farm, fish, gather NTFPs, or attend to livestock. Moreover, adequate health ensures the nutritional benefits of food consumption are realized and is an important, but often forgotten, component of food security. The inability of one working member of a household to work due to poor health reduces household income and therefore impacts the income and food security of all members of a household and, potentially, the broader community.

In analyzing health, this study draws from four classes of climate change impacts (WHO/WMO 2012 and McMichael et al. 2006): (i) infections, including malaria, diarrhea, meningitis, and dengue fever; (ii) emergencies, including floods and cyclones, drought, and airborne dispersion of hazardous materials; (iii) emerging environmental challenges, including heat stress, UV radiation, pollens, and air pollution; and (iv) indirect impacts on crop yields and relocations due to flooding and drought.

Much research is required into how human health is likely to be affected in particular areas of the LMB. Given the lack of detailed scientific knowledge the study draws on international experience and literature to identify a number of key health issues most likely to arise in the basin (WHO/WMO 2012, McMichael et al. 2006, MRC 2010, and World Bank 2011a, 2011b, and 2011c). Those issues are:

- **Heat stress:** The impacts on human health of exposure to high temperatures. Impacts include: exhaustion, fainting, strokes, as well exacerbation of existing conditions. Sherwood et al. (2010) identify prolonged exposure to 35°C as a key threshold for heat stress.

- **Water-borne disease:** Diseases that are caused by microorganisms and other contaminants found in drinking water and other water that humans use. Diarrheal diseases are the most common water-borne diseases and a major cause of illness and death in the LMB at present. There is a clear existing link between flooding and water-borne disease. Climate change driven increases in precipitation and flooding will disrupt the functioning and safety of water sources (e.g., water bores becoming contaminated with surface floodwaters). Moreover, poor water availability in such instances increases the risk of oral-fecal contamination.

- **Vector-borne disease:** Diseases such as malaria and dengue fever (both of which are present in the LMB) that are spread by mosquitoes, ticks, and other disease vectors. It is widely acknowledged that higher levels of precipitation and temperature influence the distribution of vector-borne disease by improving the breeding habitat of disease vectors.

- **Injury, death, or other health issues caused by extreme weather or other events related to climate change:** Violent events such as landslides and floods have the potential to cause serious injury or death. Moreover, the persistence of, for example, flooding restricts access to forest resources that support food security and human health. Forced relocation of rural communities to areas of higher population density increases the risk of disease transmission.

2.4 INFRASTRUCTURE

In this study, infrastructure is the physical, stationary infrastructure that enables rural households and communities to pursue and benefit from livelihood activities. For example: roads and bridges that facilitate sales and purchases at district markets; covered groundwater bores and health facilities that sustain health; and housing and other buildings that provide shelter for people and their assets. Damage or lack of access to such infrastructure can have long-term impacts on poverty and food security.

Past experience in the LMB demonstrates how extensive and serious extreme climate events can be for local infrastructure, damaging and destroying facilities essential for local economies and livelihoods. Projected increased intensity and frequency of extreme events should be taken into account in the planning, maintenance, and adjustment of those strategic assets. This study considered the following rural infrastructure:

- **Roads**
- **Bridges**
- **Water supply infrastructure**
- **Housing, grain storage, and other household buildings**

- **Health centers and other municipal or communal buildings, such as marketplaces**

2.5 ASSESSMENT CRITERIA

Key ingredients of the CAM vulnerability assessment method are the criteria used to assess the exposure, sensitivity, and adaptive capacity of systems and assets to climate change.[10]

Exposure is defined as *the degree of climate stress on a particular asset or system component; it is influenced by long-term changes in climate conditions, and by changes in climate variability, including the magnitude and frequency of extreme events.*
Sensitivity is the *degree to which a system will be affected by or is responsive to climate change exposure.*
Adaptive capacity is *understood in terms of the ability to prepare for a future threat and in the process increase resilience and the ability to recover from the impact.*

The criteria used to determine these components of vulnerability and their definitions are displayed in Table 8.

Exposure	Sensitivity	Adaptive capacity
Location of people/assets in relation to the threat **Severity** of threat **Duration** of threat	**Poverty** – poverty rate of the population based upon the national poverty line. Measured by an income-based or expenditure-based poverty line depending on country. **Food insecurity** – availability of an adequate quantity and quality of food. Indicated by child malnutrition rates. **Human health** – overall level of morbidity and early mortality in the community. Indicated by infant mortality rates and life expectancy. **Strength of key infrastructure** – the capacity of infrastructure, such as roads and bridges, to withstand weather-related stress. Measured by the quality of building materials and design, where information is available. **Demographic composition** – communities with a high number of children or elderly who are not engaged in productive activities or are vulnerable to disease are deemed to be more sensitive. This may be indicated by the dependency ratio. Another component is the ethnicity of a community or household; minorities often have less access to social services.	**Assets** – household assets such as land/housing, livestock, other usufruct rights (such as irrigation canals), and other capital assets (e.g., boats, machinery). **Education/skills** – literacy rates and educational attendance. Also informed by qualitative measures of the quality of education programs. **Physical infrastructure** – access to key infrastructure and amenities, such as roads, safe drinking water and sanitation supply, and electricity. **Access to markets** – Distance and access to transport to markets throughout the year. Percentage of households with access to credit.

Table 8: CAM vulnerability criteria for health and infrastructure

[10] See ICEM (2011) for contextual information regarding the following definitions.

In addition to the severity and duration of a particular climate change threat, the location of people and their assets is a contributing factor to exposure. For example, communities living in a floodplain are more exposed to large-scale floods than those living in sloping upland areas that may be more threatened by flash floods.

The five sensitivity criteria are all directly related to the degree to which human health is affected by a climate-related event, such as disease outbreaks due to changed climate conditions. For example, the accessibility of roads during a multi-day flood event will critically determine the loss of food and clean water access. Demographic composition is also important: a higher proportion of vulnerable groups within a household or community, such as the sick, the elderly, and the poor, will amplify negative impacts. For infrastructure, the strength of key infrastructure is clearly the most relevant criteria. However, the level of poverty, human health, and food insecurity are also indicative of the resources and supportive infrastructure available to communities.

The adaptive capacity of households and communities is a function of: the assets available (i.e., land, machinery, livestock, natural resources, etc.) that can be used or sold to respond to an adverse shock; education attainment and skills, which can be deployed to adapt new techniques or behaviors in a changing environment; the availability of physical infrastructure to facilitate livelihood security (i.e., bridges and roads); and access to markets, both in a physical sense (i.e., distance and transport to markets to sell and purchase goods and services) and a financial sense (i.e., credit markets to finance investment).

Table 9 below provides summary information regarding these criteria across the five hotspot provinces. Note that assessments of criteria across these provinces are made in relative terms. Detailed information regarding these criteria can be viewed in the provincial profiles located in the Annexes.

Criteria	Mondulkiri	Gia Lai	Khammouan	Chiang Rai	Kien Giang
Poverty	Very High	Moderate	Very High	Low	Low
Food security	Low	Moderate	Low	High	High
Demographic composition	53% of population is Phnong ethnic minority; 51% of population <17 years	Ethnic minorities comprise 44% of population	Low population density: 19 persons/km^2; Dependency ratio 84%	High population density province-wide; 20% of population is ethnic minorities	Dependency ratio 43%; 73% of population is in rural areas
Strength of key infrastructure	Low	Moderate	Low	High	Moderate
Human health	Very Low	Moderate	Very Low	High	Moderate
Assets	Low	Moderate	Low	High	High
Education/ skills	Low	Moderate	Low	High	Moderate
Physical infrastructure	Low	Moderate	Low	High	High
Access to markets	Low	High	Moderate	High	High

Table 9: Profile summaries for hotspot provinces

See Annexes for detailed information regarding these criteria in each province. Note that all assessments of indicators are made relative to other hotspot provinces and in terms of the contribution of those criteria to climate change sensitivity and adaptive capacity. Five categories are used: Very Low, Low, Moderate, High, and Very High. In all cases except "Poverty" a rating of "High" implies lower climate change vulnerability. Further note that all of the broad assessments in the table relate to aggregate conditions across the province and do not account for, in the case of Chiang Rai and Gia Lai, a minority of the population who face different circumstances.

2.6 CLIMATE CHANGE THREATS

The final methodological issue to be presented here is the range of climate change threats that are considered in this study. Projections of these threats were generated by climate change modeling detailed in ICEM (2013b).

The social and economic assessment did not consider the full range of threats covered by other sectors. In particular, water availability was not considered. Despite the potential importance of soil water availability for the functioning of groundwater wells, there was insufficient information available to determine the impact of changed soil water availability on groundwater hydrology. An additional threat was considered: landslides. This inclusion is due to the importance of these events to the integrity of infrastructure in sloping areas, as well as their devastating impacts on health and infrastructure. The range of considered climate threats and the manner in which they are interpreted can be found below.

- **Temperature:** Change in the maximum, minimum, or daily average temperature across months and seasons.
- **Precipitation:** Shifts in the average monthly rainfall across months and seasons.
- **Drought:** The period when precipitation is less than half of potential evapotranspiration. See ICEM (2013b) for further details.
- **Floods:** Slow to medium onset floods with a duration of multiple days. Floods are a natural and regular occurrence in *Floodplain* and other flat riparian areas of the LMB and this threat is generally interpreted in this report as flooding which has greater height, duration, or extent than standard seasonal events.
- **Flash floods:** Sudden floods with a duration of hours. Flash floods already occur in sloping areas of the LMB, although their frequency has increased in recent years due to human influences such as deforestation.
- **Landslides:** Sudden movement of earth and rocks on sloping ground. Similar to flash floods, their frequency has increased in recent years due to human-induced erosion.

The threats addressed in the vulnerability assessment of the *Delta* zone are extended to include sea level rise, storms, and salinity. Landslides are not considered a relevant threat in this zone. A brief description of the additional threats can be found below.

- **Sea level rise:** Direct threats to infrastructure from sea level rise, as well as indirect threats to health such as the impact of forced relocation.
- **Salinity:** The impact of saline intrusion associated with storm surges and/or the combination of storm surges and freshwater flooding in estuarine areas.

SECTION 3 – VULNERABILITY ASSESSMENT AND ADAPTATION OPTIONS

1 CLIMATE CHANGE VULNERABILITY ASSESSMENT

This section presents a summary of the vulnerability assessments for Health and Infrastructure conducted in this study. The results are presented in terms of livelihood zones within each of the provinces studied. The detailed CAM assessment matrices generating these vulnerability assessments can be viewed in the Annexes.

1.1 HEALTH

The key areas of community health identified as highly vulnerable to climate change are: vector-borne and water–borne disease control, and maternal and child health. In terms of specific climate change threats, the most prominent across hotspot provinces were temperature rise, flooding, flash flooding, and landslides. The hotspot provinces with greatest overall vulnerability in the health sector are Mondulkiri and Gia Lai.

1.1.1 VECTOR-BORNE AND WATER-BORNE DISEASE

Climate change is projected to cause a marked increase in the incidence and extent of flooding in many parts of the LMB. Floods and their associated extreme rainfall events create the conditions for the spread of water-borne and vector-borne disease, such as: waterlogged or flooded areas, restricted access to freshwater and food, inundation of unsafe sanitation facilities, and isolation from health services. Notwithstanding advances in health coverage over recent years (e.g., improved immunization coverage), such diseases remain prominent development issues in the basin that cause death, incapacitation, and have long-lasting impacts on poverty and food security. And they are not restricted to the poorest areas of the basin: outbreaks of water-borne disease were widespread during recent floods in Thailand and Vietnam. Subjecting today's socio-economic conditions to future climate projections would see an increase in the incidence and extent of water- and vector-borne diseases. A principal reason communities are exposed to these problems is their habitation of fertile riparian areas; this pattern is fundamental to rural livelihoods and will persist into the future. *Floodplain*, *Delta*, and *Lowland plains and plateaus* zones of the LMB are considered to have the highest vulnerability to this particular impact.

1.1.2 MATERNAL AND CHILD HEALTH

Maternal and child health are major contemporary issues in remote parts of the LMB that will deteriorate further under projected climate change. These issues are particularly prominent in Cambodia and Lao PDR and/or amongst ethnic minority groups with weaker access to social services. For example, certain villages of Khammouan (Lao PDR) report an average mortality rate of one child per mother; in Mondulkiri Province (Cambodia) maternal mortality in 2011 was reported to be 7.2% within 1 month of birth. A major cause of such statistics is the lack of access to skilled health attendants in remote areas. Whereas water- and vector-borne disease are mostly associated with flooding, maternal and child health are exposed to a wider range of other climate change impacts, such as heat stress, greater incidence of droughts, death or injury associated with landslides and flash floods, as well as

flooding. The combination of these many impacts with the greater susceptibility of maternal and child health to adverse shifts in food security, as well as the poor state of current conditions in many rural areas, renders this health issue a key component of climate change vulnerability for the basin as a whole. Despite this broad significance, remote areas of the LMB, particularly the *Forested uplands* zone, are considered to be most vulnerable for this issue.

1.1.3 OVERVIEW OF THREATS AND IMPACTS BY PROVINCE AND LIVELIHOOD ZONE – HEALTH

The most prominent climate threats to human health identified across hotspot provinces were temperature rise, flooding, flash flooding, and landslides. Overall, the neighboring provinces of Mondulkiri and Gia Lai were identified as the most vulnerable provinces. A key projected threat in these provinces is an increase in average maximum temperature of 3°C to 4°C that would generate dangerous heat stress conditions for several months of the year. Another key projected threat is higher rainfall during the rainy season increasing the extent and severity of flooding, flash flooding and landslides across all the hotspot provinces.

The vulnerability assessments for health identified certain high to very high vulnerabilities within particular livelihood zones: temperature rise in *Lowland plains and plateaus*; flooding in *Floodplain*, *Delta*, and *Lowland plains and plateaus*; flash floods and landslides in *Intensively used uplands* and *Forested uplands* (*Table 10*).

Province/ Livelihood Zone	Temperature	Precipitation	Drought	Flooding	Flash floods	Landslides
Chiang Rai						
Intensively used uplands	Medium	Medium	NA	Medium	High	High
Lowland plains and plateaus	High	Medium	NA	High	Medium	Medium
Floodplain	High	Medium	NA	Very High	Medium	Low
Gia Lai						
Intensively used uplands	Very High	Medium	NA	Medium	Very High	Very High
Lowland plains and plateaus	High	Medium	NA	Medium	Medium	Medium
Khammouan						
Forested uplands	Medium	Low	NA	Medium	Very High	Very High
Lowland plains and plateaus	Medium	Low	NA	Very High	High	High
Floodplain	Medium	Low	NA	Very High	Medium	Medium
Kien Giang						
Delta	High	Low	NA	Very High	NA	NA
Mondulkiri						
Forested uplands	Very High	Medium	High	Medium	High	High
Lowland plains and plateaus	Very High	Medium	Very High	Very High	Medium	Medium

Table 10: Vulnerability assessments for health by threat, province, and livelihood zone

See Annexes for the detailed CAM assessment matrices generating this summary. NA indicates that the threat is considered to be not applicable due to the lack of a projected threat or the specific conditions within a province.

1.2 INFRASTRUCTURE

Two key areas of the infrastructure sector are identified as highly vulnerable to climate change: roads and water supply infrastructure. The most prominent climate threats across hotspot provinces are flooding, flash flooding, and landslides.

1.2.1 ROADS

Road networks are a critical form of infrastructure that is highly exposed to climate change in both upland and lowland areas of the LMB. Two main factors affect road exposure to climate change impacts: (i) the quality of road construction, and (ii) the location of roads. In upland areas of the LMB (particularly *Forested uplands*) much of the road network is unsealed and structurally unstable. This creates susceptibility to degradation by flash floods. The location of many roads on sloping land increases exposure to landslides as well as flash flood events. The issue of exposure in sloping areas is particularly

serious in *Intensively used upland* areas where deforestation has caused erosion and slope instability. In *Floodplain*, *Delta,* and *Lowland plains and plateaus* areas the proximity of roads to rivers and lakes creates exposure to flood events. In addition, the lack of strong embankments and unsealed road surfaces in remote and/or poor areas, such as areas of Mondulkiri and Khammouan, heighten the impacts when flooding occurs. Similar to the discussion for the health sector, we know from past experience that much of the LMB's road network is exposed to the current manifestation of extreme events. Therefore, the future amplification of extreme events will magnify the instances of: road degradation by flood waters, road inaccessibility due to water coverage, and road destruction by landslides and flash floods. Loss of road access reduces or prevents access to markets and external health facilities; such limitations are significant for rural livelihoods during normal periods, but they are even more important in emergency situations following extreme weather events.

1.2.2 WATER SUPPLY INFRASTRUCTURE

The impact of climate change on irrigation and drinking water infrastructure has the capacity to drive communities back into prolonged poverty and food insecurity. Water supply infrastructure is susceptible to a range of extreme weather threats: degradation and, in the case of groundwater wells, contamination by prolonged flooding; destruction by sudden violent events such as landslides; and inundation by sea level rise storm surges. Similar to above, we are discussing an amplification of historical events and associated damages that already impact the LMB's stock of rural infrastructure. Irrigation dams and canals, groundwater bores, water pump equipment, and the like are expensive to purchase, maintain, and repair. Damage to such infrastructure therefore has prolonged and far-reaching impacts, particularly as it undermines what may have previously been high levels of productivity and thereby threatening reversion back into poverty for relatively prosperous communities with improved access to water supply infrastructure. Notably, groundwater is a major source of drinking water across the region and the lack of access to these supplies during flood events has serious ramifications for the spread of water-borne disease. In upland areas (*Forested uplands* and *Intensively used uplands* zones), water supply infrastructure is most exposed to violent events such as flash floods and landslides. In low altitude areas (*Floodplain*, *Lowland plains and plateaus*, and *Delta* zones), the key issue is flooding (or in coastal areas freshwater flooding combined with seawater inundation) that causes direct physical damage, prevents access, or, in the case of uncovered groundwater wells, contamination after floodwaters have receded.

1.2.3 OVERVIEW OF THREATS AND IMPACTS BY PROVINCE AND LIVELIHOOD ZONE – INFRASTRUCTURE

The most prominent threats to infrastructure identified across hotspot provinces were flooding, flash flooding, and landslides. The distribution of overall climate change threat to infrastructure by province largely depends on livelihood zone composition. As indicated above, flash floods and landslides were identified as key issues in upland areas, with flooding the major threat in lowland areas.

Aside from roads and water supply infrastructure a range of other significant infrastructure were identified as vulnerable to climate change, such as: damage to household buildings, e.g., grain storage; lack of access or damage to health facilities, markets, and other communal infrastructure; and, damage or destruction of bridges and river landing sites for boats.

Province/ Livelihood Zone	Temperature	Precipitation	Drought	Flooding	Flash floods	Landslides
Chiang Rai						
Intensively used uplands	NA	Medium	NA	Medium	High	High
Lowland plains and plateaus	NA	Low	NA	High	Medium	Medium
Floodplain	NA	Low	NA	Very High	Medium	Low
Gia Lai						
Intensively used uplands	NA	Medium	NA	Medium	Very High	Very High
Lowland plains and plateaus	NA	Low	NA	High	High	High
Khammouan						
Forested uplands	NA	Medium	NA	Medium	Very High	Very High
Lowland plains and plateaus	NA	Medium	NA	Very High	Medium	High
Floodplain	NA	Medium	NA	Very High	Medium	Medium
Kien Giang						
Delta	Medium	NA	NA	Very High	NA	NA
Mondulkiri						
Forested uplands	NA	Medium	NA	Medium	High	Very High
Lowland plains and plateaus	NA	Medium	NA	Very High	Medium	Medium

Table 11: Vulnerability assessments for infrastructure by threat, province, and livelihood zone

See Annexes for the detailed CAM assessment matrices generating this summary. NA indicates that the threat is considered to be not applicable due to the lack of a projected threat or the specific conditions within a province.

1.2.4 ADDITIONAL KIEN GIANG/DELTA CLIMATE CHANGE THREATS

Sea level rise (in terms of storm surges) is found to be a significant threat to the coastal infrastructure of Kien Giang, particularly roads and buildings. Saline intrusion is not identified as a significant threat because increased flooding is projected to reduce the level of future salinity in inland areas.

Sector	Sea level rise	Salinity
Health	Medium	NA
Infrastructure	High	NA

Table 12: Summary of vulnerability assessments for additional threats to health and infrastructure in Delta zone

See Annexes for the detailed CAM assessment matrices generating this summary. NA indicates that the threat is considered to be not applicable due to the lack of a projected threat or the specific conditions within a province.

2 ADDITIONAL EFFECTS OF OTHER DEVELOPMENTS ON CLIMATE CHANGE VULNERABILITY AND ADAPTATION PLANNING

The LMB region is experiencing rapid economic growth, beginning first with Thailand, followed by Vietnam during the 2000s, and more recently Lao PDR and Cambodia. Economic expansion at current rates of 6%-10% per year will generate a larger pool of financial resources to dedicate to adaptation over coming decades. With regard to rural health and infrastructure, the focus of the socio-economic portion of this report, this economic growth will finance beneficial public and private sector spending, such as: (i) investment in critical social services, such as health services, education, and access to safe drinking water and sanitation; (ii) extension and strengthening of rural infrastructure networks, particularly roads; and (iii) expansion of access to rural credit. Such investments will undoubtedly reduce the vulnerability of rural communities to climate change broadly, as well as in the health and infrastructure sectors. Moreover, broader development of markets will also strengthen these two important sectors, e.g., greater employment opportunities and access to markets driving higher income, along with access to infrastructure associated with major development projects (such as dam access roads).

An efficient and sufficient response to climate change does however require more than just extra financial capital, the physical capital it purchases, and greater economic activity. Governments must also consider the future state of the natural capital (e.g., forests, wetlands, and land) that is deteriorating under the LMB's current development trajectory. Climate change could degrade this natural capital even further in many areas. The stronger the base state of natural resources before climate-induced shifts are fully realized, the lower the vulnerability and the less adaptation that is required.

In this study a range of criteria were used to assess livelihood vulnerability to climate change (i.e., poverty, food security, demographic composition, strength of key infrastructure, and human health) and adaptive capacity (i.e., physical assets, education/skills, physical infrastructure, and access to markets) for the health and infrastructure sectors. Many of these criteria (e.g., poverty, food security, health, and household assets) are inextricably linked to the ability to access functioning ecosystems and the services they provide. In the LMB that dependency will persist for many decades. For infrastructure, the regulation of extreme monsoonal precipitation by forests and watersheds, for example, is critical. In some areas climate change poses a threat to these ecosystem services; in many areas current development trends are a more serious immediate threat to these same services.

This section presents several major non-climate factors that affect adaptation planning in terms of: (i) their impact on rural health and infrastructure provision, and (ii) their environmental impacts which, in turn, affect vulnerability and adaptive capacity. Each of these non-climate change drivers of change are

raised as key issues by other theme groups in the study; here their social and economic implications are considered in these narrower contexts.

2.1 HYDROPOWER DEVELOPMENT

Hydropower dams are associated with a range of environmental risks, such as altered downstream water regimes, reductions in fishery productivity, and loss of downstream sediment transfer. Subsistence-based communities in the vicinity of dams may be subject to rising poverty and food insecurity due to: (i) loss of capture fisheries and riverside agriculture, (ii) inundated farm-land in upstream areas, (iii) reduced sediment transfer to downstream floodplains causing lower agricultural productivity, and (iv) forced relocation to less fertile land.

Although there are substantial environmental and social risks associated with dams, their development may also be associated with improvements. In the infrastructure sector, dam access roads may provide surrounding communities with improved access to markets. Dams may also provide flood control benefits. Resettlement programs may improve health access, and stronger communal and household buildings, as well as access to electricity (for example, see NTPC 2008).

In the long term, it may be that government revenue and other broad benefits of hydropower development trickle down to affected communities. But the direct, short and medium term impacts are likely to be that hydropower dams will increase local poverty and food insecurity, and thereby represent a threat to rural health. For infrastructure, the outcome is less discernible because there is significant capacity for dams to increase access to improved and more abundant infrastructure resources, particularly roads.

2.2 LAND CONCESSIONS

A range of activities are associated with expanding concessions, including plantations, logging, hydropower, mining, intensive livestock, and building factories to process agricultural products. These projects often involve: (i) displacement of communities without formal land tenure, (ii) reduced access to natural resources for communities adjacent to new land concessions, and (iii) degradation or removal of ecosystem services previously located in land concessions. In the absence of strong social and environmental protection and regulation, land concessions have become major drivers of landlessness and poverty.

2.3 DEFORESTATION, ILLEGAL LOGGING, POACHING

Land concessions are a major driver of forest loss and, by providing access to previously inaccessible areas, introduce or intensify illegal logging and poaching in surrounding areas. However, the degradation of forest resources is a much broader issue than land concessions. The direct negative impacts on food security and community health of the loss of natural forest resources were discussed earlier. Less visible, but just as important for community health, is the role of watershed protection in soil water retention and the mitigation of flood events. Those last factors are highly relevant to infrastructure resilience, but also health in terms of asset loss and crop destruction from flood events, landslides, and land degradation.

2.4 POPULATION GROWTH AND MIGRATION

Regional population growth is increasing pressure on natural systems and the services they provide in rural areas. There has been a growing trend in rural-rural migration to access remaining forest areas, leading to conversion to agricultural land. On current trends, continued population growth on UN projections (Section 1) would see a further degradation of natural resources and reduced climate change resilience in rural communities. That forecast is balanced somewhat by rising rural-urban migration; all countries in the LMB except for Cambodia are projected to have declining rural populations by 2025. Whether the shift of large numbers of people out of rural areas necessarily improves access to natural resources for those remaining is an open question: subsistence farming may be replaced by larger economic concessions that have a bigger natural systems footprint than existing rural communities. Another important question is whether rural-urban migrants are able to access social services, training, housing, and, more generally, livelihood support once they have relocated to cities. An important element of rural-based adaptation may therefore be preparing households to make this transition and ensuring that their welfare actually does improve.

3 ADAPTATION PLANNING

In the USAID Mekong ARCC project an extensive range of health and infrastructure adaptation options was identified for hotspot provinces and livelihood zones in the LMB.[11] Sections 3.1 and 3.2 present an overview, beginning with central focus areas for adaptation in each sector. These critical areas address the four major issues identified in the vulnerability assessment: water-borne and vector-borne disease, maternal and child health, roads, and water supply infrastructure.

Following the broader overview of focus areas, Section 3.3 identifies detailed strategies for adaptation in particular livelihood zones of the LMB. Section 3.4 presents a subsequent set of adaptation options for hotspot provinces, including any potential synergies with other sectors of the USAID Mekong ARCC project. Some of these strategies and options are broadly applicable throughout the basin, whereas others will only be applicable in specific circumstances. Strategies that target rural communities have been emphasized in this exercise. Our approach is to take a broad overview of adaptation options that, based on available evidence, are likely to be of importance; it should be noted that this represents only the first illustrative step towards the identification of specific adaptation plans in particular communities.

The annexes contains supporting material for this section, include: (i) the tables used to generate the adaptation options that address specific threats ranked as high or very high in the vulnerability assessments, and, (ii) detailed adaptation phasing tables for livelihood zones.

3.1 FOCUS AREAS FOR ADAPTATION IN THE HUMAN HEALTH SECTOR

Adaptation measures in the health sector include those that reduce exposure to events and those that mitigate the full impacts after those events occur. Four main focus areas are identified which relate to the key climate change vulnerabilities in the health sector (water-borne and vector-borne disease, and maternal and child health):

(H1) **Addressing the adaptation deficit in the health sector.** Particularly important to maternal and child health is the continuing lack of adequate health access for many poor households and/or remote communities. Addressing this lack of personnel, equipment, and affordability is the starting point for adaptation in the health sector. Current gaps in capacity to deal with current climate and social conditions are often known as the 'adaptation deficit'. The significant

[11] The specific adaptation strategies identified in the following pages were obtained through a literature review of health and infrastructure sector adaptation that included projects and academic research in the LMB and globally. Key reference materials for this exercise included: WHO/WMO (2012), Portier et al. (2012), World Bank (2011a, 2011b, 2011c), Costello et al. (2009), McMichael et al. (2006) Sterrett (2011), Bapna et al. (2009), IPCC (2012), Douven et al. (2009), Committee on Climate Change and U.S. Transportation (2008), and ADB (2011). A list of potential adaptation options were obtained for each sector from this body of literature. The three most appropriate options were assigned to each climate threat that was assessed as high or very high for each livelihood zone of each province. Potential adaptation options were collated across province and livelihood zones. Between three and five options were selected for each livelihood zone that are the most significant in terms of their broad benefit to enhancing resilience. This selection process was based on the information found in the CAM matrices. In addition to the options identified through the literature review, a number of additional options were identified on the basis of expert judgment.

adaptation deficit in the region simply means that current development activities in the health sector (e.g., health personnel training, immunization programs, institutional capacity programs, and budgetary support) need to be supported and extended by governments and donors alike.

(H2) **Warning, prevention, and response systems for vector-borne and water-borne disease.** There are three key factors that limit the spread of water-borne and vector-borne disease associated with extreme precipitation events: prior knowledge (e.g., weather forecasts) that enables communities and government agencies to take precautionary measures that reduce risk (e.g., store water and food, establish shelter locations, prepare response systems, stockpile medicines, etc.); education and other prevention measures that mitigate damage in the presence of the hazard (e.g., education regarding water-borne disease, use of safer water sources); and, efficient deployment of response systems to identify and address the spread of disease (e.g., site monitoring in affected areas, operation of refuges and emergency health centers). Strengthening the capacity of LMB governments and non-government agencies to prepare for and respond to current flooding events will be an important first step to adapting to more extreme events in the future.

(H3) **Incorporating climate change into the design, technology, and location of health-related infrastructure**. A critical concern in a weather-related health emergency is the exposure of and damage to water supply and sanitation infrastructure, health facilities, and major access roads. Failed functioning of these supporting infrastructures has the capacity to magnify and extend the duration of health emergencies, particularly the spread of disease. These have been major issues during and following recent flood events in the region. Given that such events are projected to worsen, it is critical for measures that address this issue incorporate future climate, e.g., areas exposed to 1 in 100 year events may begin to experience the same extreme weather as 1 in 20 year events, and infrastructure should be relocated accordingly.

(H4) **Protection of ecosystem services that support community health**. As mentioned throughout this report, NTFPs (both for food and commercial use), fisheries (particularly for protein), and clean freshwater supply are central components of rural livelihoods. During emergency situations, such as crop failures and flood events, access to these services or stores of them are critical to food security and health; the degradation of these services, therefore, increases the threat posed to maternal and child health, as well as the prospects for spread of disease. The LMB's rural ecosystem services are under threat by development throughout the region and their degradation both raises community vulnerability and reduces adaptive capacity.

3.2 FOCUS AREAS FOR ADAPTATION IN THE RURAL INFRASTRUCTURE SECTOR

Adaptation measures in the infrastructure sector aim to strengthen the capacity to withstand extreme physical events (e.g., floods, flash floods, and landslides) or avoid their impacts in the first place. Two key components of the infrastructure sector were identified as particularly vulnerable to climate change: roads and water supply infrastructure (i.e., irrigation and drinking water infrastructure). Addressing these issues, among broader types of infrastructure, are three major focus areas for adaptation:

(I1) **Implementation of community-based bioengineering projects.** Key threats to roads and water supply infrastructure are flooding, flash floods, and landslides. In many parts of the LMB, major contributors to such events at present are land clearing and land degradation induced by human activities. Forested land absorbs surface moisture and strengthens soil stability, where the latter is particularly important on sloping land. An important and efficient priority for adaptation

in the basin must therefore be bioengineering projects (see box below) that provide protection to critical infrastructure.

(I2) **Revision or implementation of design standards for rural infrastructure to incorporate climate change.** In addition to reducing exposure, it is critical that infrastructure is capable of withstanding events, such as the integrity of road surfaces and embankments when inundated with flooding, and become usable as soon as possible following such an event. Design features such as materials, support structures, and drainage systems, are all key considerations. A specific example is coverage structures for groundwater bores providing drinking water. Where present, design standards for infrastructure should be upgraded to reflect future climate; where absent they should be implemented. Existing road and water infrastructure may require upgrades, or new climate change resilient infrastructure may be required.

(I3) **Revision of infrastructure planning given threats posed by climate change.** Two components of infrastructure planning are important in this context: location and infrastructure requirements. The first is a straightforward proposition: insofar as feasible, roads and water supply infrastructure should be located where their exposure to climate threats is minimized. The second pertains to the identification of infrastructure needs to reduce climate change impacts. For example, increasing the number of road access points to a community in a flood-prone sub-catchment, identifying necessary extensions to irrigation networks, and alternatives to submerged groundwater bores.

Most of the proposed adaptation strategies that follow satisfy more than one of these four priorities for health and three for infrastructure. The specific priorities addressed are indicated in parentheses (e.g., *I1*, *I2,* etc.)

BIOENGINEERING

"Bioengineering" refers to the use of vegetation to improve the stability of slopes and shorelines that are susceptible to erosion and inundation. This activity is usually conducted in the interests of protecting key infrastructure (such as roads) and land, as well as preventing flooding or inundation. Bioengineering is often a low-cost alternative to major structural works (such as concrete embankments) and is also more adaptable to changed conditions. Examples of bioengineering projects include: re-vegetation of hill slopes along roads in Nepal (World Bank 2012); and, mangrove planting in coastal regions of the Mekong Delta (GIZ 2013). A participatory approach to implementation involving local communities increases the chances of such projects being sustainable. The use of local knowledge and labor increases the stake that communities have in maintaining the benefits of a project, as well as increases the social costs of engaging in activities that undermine it (e.g., land-clearing).

3.3 LIVELIHOOD ZONE ADAPTATION PRIORITIES

3.3.1 DELTA

Strengthen natural coastal protection from inundation through community-based rehabilitation and protection programs, particularly for mangrove ecosystems (*H4*, *I1*). Degradation of mangrove ecosystems by anthropogenic and natural causes is a major factor in the exposure of coastal zone livelihoods more generally to climate change. The continuing viability of farming, aquaculture, and NTFPs, as well as the integrity of infrastructure and human health, are all contingent upon protection of the low-elevation deltaic land and ecosystems from inundation and the more intense flooding identified in climate change projections. Some current responses to inundation threats may in the longer term constitute maladaptation; for example, the construction of sea dykes may prevent a natural recession of mangroves and effectively exasperate coastal erosion in the longer term. A current AusAID/GIZ coastal rehabilitation and climate change project located in the Kien Giang Biosphere Reserve (see AusAID 2013) should produce valuable guidance on needed site-specific actions and the opportunities for their replication across the Mekong Delta.

Notwithstanding the importance of protection, the costs involved may eventually outweigh the benefits. IPCC (2007) points out that a staged and managed retreat of infrastructure and communities from the coast may, in some cases, be a more efficient allocation of resources. This is an important consideration and any decision would have to be informed by scientific research and monitoring, as well as economic analysis of the trade-offs involved.

Improvements to canal networks that are required to cope with more intense flood events, particularly to ensure effective drainage of fields and waterways (*I2*, *I3*). The low drainage capacity of the *Delta*'s dense system of canals and other waterways has been a significant factor in the duration and depth of major flood events. Failure of individual infrastructure, such as embankments and dykes, may have serious impacts elsewhere due to the interconnected nature of the system. The strength of the entire system is therefore a critical concern, particularly as the bulk of flood protection infrastructure was not designed with climate change in mind. A system-wide process of ongoing planning and management is therefore required. A Netherlands-Vietnam project (2011-2013) is developing a Mekong Delta Plan (Vietnam-Netherlands Cooperation 2011) that is considering these issues.

Although primarily an infrastructure issue, health is an also an important consideration. The degree of damage caused to health by flooding is often a direct consequence of the duration of these events. As time goes on, isolated households are more exposed to unsafe drinking water, insufficient food, and other factors that increase susceptibility to disease.

Support the dissemination of household infrastructure that reduces the exposure of communities to water-borne disease during flood events, such as raised rainwater tanks, floating toilets, and solar water filters (*H1*, *H3*)**.** Lack of clean water is a major cause of water-borne disease during flood events as groundwater sources are no longer available and/or contaminated. Raised rainwater tanks in strategic locations, particularly difficult to reach areas, would provide a critical emergency source of water. The first domestically produced floating toilets in the Delta were recently introduced (Saigon Times 2012) and similar technology has also been deployed in Cambodia. Poor access to sanitation is a major health issue even outside of flood events; development of local supply chains to disseminate such technology would therefore also address the adaptation deficit. In recent

years, a Lao PDR company (Sunlabob 2013) and the Swiss Development Agency (Helvetas 2013) have been involved in separate solar water disinfection projects within the LMB that could be up-scaled throughout the Delta region with greater research and investment.

3.3.2 FORESTED UPLANDS

Strengthen sustainable management of forest resources by developing stronger land tenure systems, enhancing capacity of protected area management, and providing communities with incentives to protect forests (*H4*, *I1*)**.** Forests are a critical source of food and other forest products that sustain livelihoods, particularly during emergency situations when crops and other food supplies may be damaged or inaccessible. Encroachment of agricultural land on forest areas as a result of informal land tenure, partly driven by migration towards dwindling natural resources, is a major cause of unsustainable use of forested lands. Illegal deforestation and other illegal activities in protected areas degrade forest resources and their availability to surrounding communities – and reduce community resilience. A range of other development pressures are present in these areas of the LMB, such as commercial plantations, hydropower, mining, increased accessibility of roads, and higher demand for timber and NTFPs due to increasing populations.

Governments and international non-government organizations (such as WWF, Forests and Fauna International, and Birdlife International) are involved in partnerships in various parts of the LMB to strengthen protected area management. Examples include: the Mondulkiri Protected Area cluster in Mondulkiri, Cambodia (WWF 2013), Nam Et-Phou Louey (WCS 2013), and Kien Giang Biosphere Reserve, Vietnam (AusAid 2013). Despite such initiatives, supposedly protected areas are being degraded rapidly due to the pressures outlined above. A renewed level of basin-wide investment is required to properly conserve these areas and the services they provide.

Forests are also important for protecting watersheds, reducing erosion and soil loss, and reducing the risk of flash flooding in upland areas. Community-based payments to protect forested areas are slowly developing in the LMB. For example, there are currently five such watershed protection programs in Vietnam and Thailand combined (Bennett et al. 2013) and Vietnam in particular is working to establish the policy conditions for extensive deployment of REDD+ mechanisms within Vietnam (Xuan et al. 2012). These projects are, however, in their infancy and further pilot projects would significantly drive wider dissemination.

Improve road access to remote communities, including extension of the road network, construction of embankments and bridges, and community-based bioengineering projects (*H3*, *I1*, *I2*, *I3*)**.** Communities in *Forested uplands* are the poorest and most isolated in the LMB. Improving the durability of road access to these communities would facilitate the provision of relief following extreme events and, more importantly, improve access to markets, health care, and livelihood opportunities year round. Community-based road user groups are needed for building and maintenance of rural roads emphasizing bioengineering methods that are designed, managed, and resourced locally. In addition to providing direct and sustainable benefits to the communities who use these resources, external financial incentives for such activities would inject further resources into communities and thereby reduce poverty and climate change vulnerability.

Improve access to maternal and pediatric healthcare, including child immunization programs and access to trained health professionals for pre and post-natal care *(H1)***.** Maternal and infant mortality rates in *Forested uplands* of the LMB are very high. This is a key component

of the adaptation deficit. Climate change is projected to increase the prevalence of conditions conducive to the spread of vector-borne disease, such as malaria and dengue fever, and water-borne disease. Children and recent mothers are particularly susceptible to such diseases as their immune systems are not as strong. If they are further weakened due to poor maternal and pediatric healthcare, then the health-related impacts of climate change would be greatly amplified.

3.3.3 INTENSIVELY USED UPLANDS

Reforestation and other locally managed bioengineering initiatives in riparian and sloping areas, especially those linked to strategic rural infrastructure (*I1, I3*)**.** Such programs could include community-based incentives, such as arrangements for payments for ecosystem services (PES), to strengthen slope stability on erosion-prone slopes. Concomitant to such programs would be improved planning that prohibited agriculture on erosion-prone sloping land or in some cases enforcement of similar planning that already exists.

Large areas of *Intensively used uplands* across the LMB are vulnerable to climate change due to land use practices, particularly deforestation to expand agricultural land in riparian and sloping areas. Programs to strengthen the stability of land and reduce erosion will protect the productivity of land and reduce the risk of death and injury from flash floods and landslides. Well-designed and sustainable incentive-based schemes at the community level are needed. The lessons from such a scheme in China, the Sloping Land Conversion Program (see Konig et al. 2012, Bennett 2008) are applicable to the LMB as well as Vietnam's recent experiences in regulation and piloting of PES in this livelihood zone.

Climate-sensitive design, siting and maintenance of major infrastructure in areas highly vulnerable to extreme events (*H3, I2, I3*)**.** Population density and incomes in *Intensively used uplands* are relatively high compared to *Forested uplands*. The capacity for governments to meet demand for additional infrastructure is likely to rise over time and it is critical that any new investments in, say, highway infrastructure incorporate future climate change in project design and supporting components (e.g., drainage systems).

The location or relocation of strategic infrastructure, such as health facilities and major roadlinks, away from vulnerable areas is a primary consideration. Further afield, the impact of the 2010 Pakistan floods was greatly exacerbated by the destruction of 39 major health facilities (WHO 2010). When such infrastructure is incapacitated or destroyed by extreme events, the impact of the initial event on isolated communities is magnified over time.

3.3.4 LOWLAND PLAINS AND PLATEAUS

Improve access to safe water and sanitation, including covered groundwater bores, rainwater tanks, water treatment technology, and covered latrines (*H1, H3*)**.** *Lowland plains and plateaus* areas may be subject to drought, flooding, and other events that restrict access to safe drinking water. In many remote areas of Lao PDR and Cambodia, surface water from rivers and lakes is a commonly used source. Poor sanitation facilities increase the risk of contamination and the spread of water-borne disease, particularly during floods. Increasing access to safe water and sanitation outside of extreme weather events is an important adaptation deficit strategy, as is strengthening the resilience of improved water and sanitation infrastructure to extreme weather events.

Construction of heat respite community centers for the benefit of vulnerable groups (*H3, I2*)**.** The young, elderly, and sick are highly exposed to illness and death resulting from heat stress. Many areas of the *Lowland plains and plateaus* are projected to experience increases in maximum temperature. A common current practice in some countries is to provide air-conditioned heat respite centers for exposed groups. Although this may not be an efficient strategy in all circumstances and would require supporting transportation infrastructure, particularly in areas with highly dispersed populations, it should be considered in areas where temperature rise is projected to be extreme and population density is sufficiently high. One option in off-grid areas would be the installation of air-conditioners powered by rooftop solar panels.

Education programs regarding water-borne disease and heat stress (*H1*)**.** Water-borne disease is a major cause of death and illness in *Lowland plains and plateaus*; heat stress is a significant future risk. Exposure to these risks may be partially mitigated by education programs targeting awareness and behavioural change, i.e. reducing physical activity during the late afternoon when temperatures remain above human tolerance levels. There are already a number of activities related to sanitation in the LMB, such as the Cambodia WASH Initiative that focuses on community-based education programs (WSSCC 2013).

Enhance food security and flood protection by strengthening sustainable management of forest and river resources (*H4, I1*)**.** This strategy would include developing stronger land tenure systems, enhancing capacity of protected area management, and supporting the capacity of authorities to pursue environmentally sustainable development. Encroachment of agricultural land upon forest areas as a result of informal land tenure, partly driven by migration towards dwindling natural resources, is a major cause of unsustainable use of forested lands. Illegal deforestation and other illegal activities in protected areas where sustainable use is permitted degrade forest resources and their availability to surrounding communities. Unsustainable fishing practices and the impacts of upstream developments (such as dams, mines, and agricultural land concessions) reduce the availability of fish and the viability of other resources. Watershed protection in particular will reduce the threat posed by flooding; community based bioengineering projects using local resources offer a sustainable pathway to strengthening already degraded riparian areas.

3.3.5 FLOODPLAIN

Climate change sensitive bridge construction, road elevation and design, and other civil engineering programs to secure road access to flood-prone communities (*I2, I3*)**.** Communities in floodplain areas are highly exposed to isolation during flood events. Ensuring the security of road access will reduce the vulnerability to subsequent food and water insecurity, disease epidemics, and raise the overall adaptive capacity.

Community managed bioengineering programs in riparian areas (*I1*)**.** Bioengineering is a cost-efficient form of watershed protection in riparian areas and the lack of natural infrastructure to provide flood protection is a central component of the adaptation deficit in the *Floodplain* zone. Pilot incentive schemes in favorable areas will provide the information necessary to upscale sustainable afforestation and reforestation activities throughout this livelihood zone.

Strengthen institutional capacity for provision of forecasting, early warning systems, and effective response for flooding and water-borne and vector-borne disease (*H2*)**.** The provision of information prior to flood events and on conditions for vector-borne disease will allow households to take preventative action that will reduce their exposure, such as moving assets to higher ground and the inoculation or destruction of livestock (in the case of zoonoses – or diseases transferred from animals to humans). The extension of mobile phone networks to remote areas may be a critical component of this strategy.

A key preventative strategy for reducing the spread of water- and vector-borne disease is the capacity to take action once the threat is present. For example, early knowledge that one community is affected by vector-borne disease may allow preventive measures, such as quarantine, which may limit the spread to neighboring communities.

The UNDP Disaster Risk Management program in three provinces of the Mekong Delta has engaged in an integrated fashion and provides lessons for *Floodplain* zones of the LMB (UNDP 2011). A particularly prominent feature of this program is the development of centralized disaster risk management centers at the provincial level that provide improved capacity for cross-sectoral coordination.

3.4 ADAPTATION OPTIONS FOR HOTSPOT PROVINCES

3.4.1 CHIANG RAI

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Address adaptation deficit	▪ Afforestation, reforestation, and other local bioengineering programs in riparian and sloping areas ▪ Education programs regarding water-borne disease ▪ Installation of rainwater tanks in higher elevation areas adjacent to lowland areas to provide emergency water supplies to lowland communities ▪ Upgrade groundwater infrastructure against flood contamination, including bore covers	▪ Strengthen the capacity of local and national disaster response systems ▪ Development and/or strengthening of reporting systems and surveillance programs for water-borne and vector-borne disease ▪ Widespread deployment of alternatives to groundwater for drinking water, such as extension of piped water and rainwater harvesting ▪ Extensive monitoring system for slope stability in landslide-prone areas	▪ Development and/or strengthening of national weather forecasting and extreme weather warning systems
Additional adaptation	▪ Community-based incentive programs to provide watershed protection, i.e., payments for ecosystem services (PES) programs ▪ Community-based incentive programs to improve management of erosion-prone slopes, i.e., payments for ecosystem services (PES) programs for reforestation ▪ Relocation of planned major infrastructure away from areas highly vulnerable to extreme weather events ▪ Research into protective infrastructure needs (such as dams and embankments) at the local level ▪ Incorporate climate change into infrastructure design standards	▪ Construction of community level infrastructure to protect riparian communities from flooding, flash flooding, and landslides, such as flood control dams, flood diversion channels, and drainage systems ▪ Bridge construction, road elevation, and other civil engineering programs to secure road access to flood-prone communities ▪ Relocation of health centers away from areas vulnerable to floods, flash floods, and landslides ▪ Raise bridge levels to accommodate higher flooding ▪ Install or increase capacity of drainage systems on road surfaces and in surrounding areas	▪ Relocation of household dwellings away from areas vulnerable to flash floods and landslides

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Adaptation to induce system shift	▪ Strengthen access to social security for ethnic minority groups, including provision of additional rights to stateless groups	▪ Replace all high-usage unsealed roads in the province with sealed roads	▪ Relocation of communities away from areas vulnerable to flash floods and landslides

Integration and synergies across other themes:
(i) slope and riparian forestry-related activities have strong synergies with **Agriculture** in farming areas, **NTFPs** in remote areas, and **Fisheries** in riparian areas,
(ii) community-focused flood protection measures to benefit **Agriculture** and **Livestock**,
(iii) reporting systems for vector-borne disease to benefit **Livestock**,
(iv) strengthening of national weather forecasting and extreme weather forecasting systems to benefit **Agriculture**, **NTFPs**, **Livestock**, and **Fisheries**.

Potential for negative impacts/maladaptation:
(i) rainwater tanks and local flood control dams may act as breeding grounds for vector-borne disease,
(ii) flood protection infrastructure that is poorly designed or inadequate to address future extreme weather may exacerbate the harm arising from flood events.

3.4.2 GIA LAI

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Address the adaptation deficit	▪ Education programs regarding heat stress and suitable behavior adjustments ▪ Targeted assistance programs to facilitate ethnic minority groups, accessing available but under-utilized health insurance ▪ Child nutrition programs ▪ Agricultural extension programs to raise yields on existing agricultural land ▪ Afforestation, reforestation, and other local bioengineering programs in riparian and sloping areas ▪ Community level incentive programs to reduce land clearing on and improve management of sloping land	▪ Extension of electricity access to unconnected communities ▪ Extensive monitoring system for slope stability in landslide-prone areas ▪ Strengthen the capacity of local and national disaster response systems ▪ Detailed research into protective infrastructure needs (such as dams and embankments) at the local level	▪ Development and/or strengthening of national weather forecasting and extreme weather warning systems, particularly for heat stress conditions
Additional adaptation	▪ Government enforcement of land clearing restrictions in forested areas ▪ Inclusion of climate change into existing plans for future infrastructure	▪ Construction of infrastructure to protect riparian communities from flooding and flash flooding, such as flood control dams, flood diversion channels, and drainage systems ▪ Construction of air-conditioned heat respite community centers for the benefit of young, elderly, and other vulnerable groups ▪ Raise bridge levels to accommodate higher floods ▪ Relocation of health centers away from areas vulnerable to floods, flash floods, and landslides ▪ Install or increase capacity of drainage systems on road surfaces and in surrounding areas	▪ Relocation of household dwellings away from areas vulnerable to flash floods and landslides

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Adaptation to induce system shift	▪ Introduction of building design standards to improve the capacity of dwellings to provide relief from heat stress	▪ Replace all high-usage unsealed road surfaces with sealed surfaces	▪ Relocation of entire communities away from areas vulnerable to flash floods and landslides

Integration and synergies across other themes:
(i) slope and riparian forestry-related activities have strong synergies with **Agriculture** in farming areas, **NTFPs** in remote areas, and **Fisheries** in riparian areas,
(ii) community-focused flood protection measures to benefit **Agriculture** and **Livestock**,
(iii) agricultural extension programs and extension of electricity network to benefit **Agriculture**,
(iv) strengthening of national weather forecasting and extreme weather forecasting systems to benefit **Agriculture**, **NTFPs**, **Livestock**, and **Fisheries**.

Potential for negative impacts/maladaptation:
(i) community heat respite centers may risk being a site for transmission of disease between vulnerable groups,
(ii) flood protection infrastructure that is poorly designed or inadequate to address future extreme weather may exacerbate the harm arising from flood events,
(iii) government enforcement of land clearing restrictions may have negative impacts on the livelihoods of communities living in and around forest areas.

3.4.3 KHAMMOUAN

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Address the adaptation deficit	▪ Protection of forest resources that act as emergency food sources through strengthened protected area management and land titling ▪ Maternal healthcare programs ▪ Increase access to safe water through improved groundwater sources outside flood events and rainwater tanks during flood events ▪ Afforestation, reforestation, and other local bioengineering programs in riparian and sloping areas	▪ Strengthen/develop the capacity of local and national disaster response systems ▪ Extensive monitoring system for slope stability in landslide-prone areas ▪ Develop and/or strengthen reporting systems and surveillance programs for water-borne and vector-borne disease ▪ Improve road access to remote communities, including extension of the road network, and construction of embankments and bridges ▪ Develop extensive slope monitoring program in critical areas ▪ Develop reporting systems and surveillance programs for water-borne and vector-borne disease	▪ Development and/or strengthening of national weather forecasting and extreme weather warning systems, particularly for heat stress conditions
Additional adaptation	▪ Review and/or introduction of design standards for new infrastructure that accommodate climate change ▪ Detailed assessment of the vulnerability of current public infrastructure to climate change	▪ Construction of infrastructure to protect riparian communities from flooding and flash flooding, such as flood control dams, flood diversion channels, and drainage systems ▪ Relocation of health centers and other key community infrastructure away from vulnerable areas ▪ Raise height of existing bridges to accommodate higher flood levels ▪ Install or increase capacity of drainage systems on road surfaces and in surrounding areas	▪ Relocation of household dwellings away from areas vulnerable to floods, flash floods, and landslides

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Adaptation to induce system shift	-	▪ Replace unsealed road surfaces with sealed surfaces, in conjunction with construction of embankments and bridges in floodways	▪ Relocation of entire communities away from areas vulnerable to floods, flash floods, and landslides

Integration and synergies across other themes:
(i) slope and riparian forestry-related activities have strong synergies with **Agriculture** in farming areas, **NTFPs** in remote areas, and **Fisheries** in riparian areas,
(ii) community-focused flood protection measures to benefit **Agriculture** and **Livestock**,
(iii) agricultural extension programs and extension of electricity network to benefit **Agriculture**,
(iv) strengthening of national weather forecasting and extreme weather forecasting systems to benefit **Agriculture**, **NTFPs**, **Livestock**, and **Fisheries**,
(v) reporting systems for vector-borne disease to benefit **Livestock**,
(vi) protection of forest resources to benefit **NTFPs**.

Potential for negative impacts/maladaptation:
(i) flood protection infrastructure that is poorly designed or inadequate to address future extreme weather may exacerbate the harm arising from flood events,
(ii) government enforcement of land clearing restrictions may have negative impacts on the livelihoods of communities living in and around forest areas.

3.4.4 KIEN GIANG

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Address the adaptation deficit	▪ Improve access to safe water and sanitation, particularly through construction of rainwater tanks, covering water bores, and covering latrines ▪ Strengthen dwelling design and materials to improve shelter protection from high temperatures ▪ Education programs regarding heat stress ▪ Install raised rainwater tanks to provide emergency water during flooding and further disseminate floating toilets ▪ Construction of raised community flood shelters ▪ Swimming lessons for children	▪ Extension of provincial electricity network to remote areas ▪ Strengthen surveillance and reporting systems for water- and vector-borne disease	▪ Development and/or strengthening of national weather forecasting and extreme weather warning systems, particularly for heat stress conditions, flooding, and vector-borne disease
Additional adaptation	▪ Detailed review of waterway infrastructure capacity and improvements to waterway network required by more intense flood events, particularly to the drainage capacity of fields and waterways ▪ Strengthen natural coastal protection from inundation through rehabilitation and protection programs, particularly for mangrove ecosystems ▪ Strengthen and add to existing sea walls and dykes ▪ Review of design standards ▪ Planting of *Melaleuca* forest and development of associated industry to provide alternative livelihoods to agriculture and increase forest cover	▪ Upgrade drainage capacity of fields and waterways ▪ Install or increase capacity of drainage systems on road surfaces and in surrounding areas ▪ Raise bridge levels and road embankments to accommodate higher floods ▪ Construction of air-conditioned heat respite community centers for the benefit of young, elderly, and other vulnerable groups	▪ Staged retreat and relocation of vulnerable infrastructure where cost-efficient to do so
Adaptation to induce system shift	-	Replace unsealed road surfaces with sealed surfaces	-

Integration and synergies across other themes:
(i) forestry-related activities have strong synergies with **Agriculture** in farming areas and **NTFPs** in remote areas,
(ii) community-focused flood protection measures to benefit **Agriculture** and **Livestock**,
(iii) agricultural extension programs and extension of electricity network to benefit **Agriculture**,

(iv) strengthening of national weather forecasting and extreme weather forecasting systems to benefit **Agriculture**, **NTFPs**, **Livestock**, and **Fisheries**,
(v) reporting systems for vector-borne disease to benefit **Livestock**,
(vi) coastal protection of mangroves to benefit **NTFPs**.

Potential for negative impacts/maladaptation:
(vii) flood protection infrastructure that is poorly designed or inadequate to address future extreme weather may exacerbate the harm arising from flood events, particularly by trapping floodwaters,
(viii) community heat respite centers may facilitate the spread of communicable disease.

3.4.5 MONDULKIRI

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Address the adaptation deficit	▪ Programs to improve maternal and pediatric healthcare, including child immunization programs ▪ Improve access to safe water and sanitation, including groundwater bores, rainwater tanks, water treatment technology, and covered latrines ▪ Strengthen community food security through agricultural extension programs and investments in irrigation infrastructure ▪ Education programs concerning the dangers of heat stress ▪ Improve access to safe water, including water storage infrastructure, rainwater tanks, and groundwater bores ▪ Strengthen sustainable management of forest resources by developing stronger land tenure systems and enhancing capacity of protected area management ▪ Education programs regarding water-borne disease ▪ Agricultural extension programs to improve crop yields ▪ Afforestation, reforestation, and other local bioengineering programs in riparian and sloping areas ▪ Develop and/or support microfinance schemes in rural areas to improve access to credit ▪ Strengthen distribution of mosquito nets by developing local supply chains	▪ Strengthen/develop the capacity of local and national disaster response systems ▪ Construction of infrastructure to protect riparian communities from flooding and flash flooding, such as flood control dams, flood diversion channels, and drainage systems ▪ Develop and/or strengthen reporting systems and surveillance programs for water-borne and vector-borne disease ▪ Improve road access to remote communities, including extension of the road network, and construction of embankments and bridges ▪ Extension of electricity network to remote areas and/or development of off-grid renewable energy and associated supply chains	▪ Development and/or strengthening of national weather forecasting and extreme weather warning systems, particularly for heat stress conditions
Additional adaptation	▪ Incorporate climate change into planned infrastructure development particularly the siting of health centers and other important buildings during flood emergencies	▪ Construction of air-conditioned heat respite community centers for the benefit of young, elderly, and other vulnerable groups ▪ Relocation of health centers and other key community infrastructure away from areas vulnerable to floods, flash floods, and landslides	▪ Relocation of household dwellings away from areas vulnerable to floods, flash floods, and landslides

Adaptation to induce system shift	-	▪ Replace unsealed road surfaces with sealed surfaces	▪ Relocation of entire communities away from areas vulnerable to floods, flash floods, and landslides

Integration and synergies across other themes:
(i) slope and riparian forestry-related activities have strong synergies with **Agriculture** in farming areas, **NTFPs** in remote areas, and **Fisheries** in riparian areas,
(ii) community-focused flood protection measures to benefit **Agriculture** and **Livestock**,
(iii) agricultural extension programs and extension of electricity network to benefit **Agriculture**,
(iv) strengthening of national weather forecasting and extreme weather forecasting systems to benefit **Agriculture**, **NTFPs**, **Livestock**, and **Fisheries**,
(v) reporting systems for vector-borne disease to benefit **Livestock**,
(vi) protection of forest resources to benefit **NTFPs**.

Potential for negative impacts/maladaptation:
(i) flood protection infrastructure that is poorly designed or inadequate to address future extreme weather may exacerbate the harm arising from flood events.
(ii) community heat respite centers may facilitate the spread of communicable disease.

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ANNEXES

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ANNEX 1

1.1 LIST OF ECOZONES

High-elevation moist broadleaf forest (Anammites)
High-elevation moist broadleaf forest (North Indochina)
Mid-elevation dry broadleaf forest
Low-elevation dry broadleaf forest
Low-mid elevation moist broadleaf forest
Upper floodplain (Chiang Saen to Vientiane)
Mid floodplain (Vientiane to Pakse)
Lower floodplain (Pakse to Kratie)
Tonle Sap swamp forest and Lower floodplain (Kratie to Delta)
Delta mangroves and saline water
Low-lying acidic area
Alluvial freshwater floodplain

1.2 LIST OF LIVELIHOOD ZONES BY ECOZONE

Forested uplands and Intensively used uplands

High-elevation moist broadleaf forest (Anammites); High-elevation moist broadleaf forest (North Indochina): Mid-elevation dry broadleaf forest (>250 m elevation). *Forested uplands*: < 50 persons per km^2; *Intensively used uplands*: > 50 persons per km^2.

Lowland plains and plateaus

Mid-elevation dry broadleaf forest (<250 m elevation); Low-elevation dry broadleaf forest; Low-mid elevation moist broadleaf forest.

Floodplain

Upper floodplain (Chiang Saen to Vientiane); Mid floodplain (Vientiane to Pakse); Lower floodplain (Pakse to Kratie); Tonle Sap swamp forest and lower floodplain (Kratie to Delta).

Delta

Delta mangroves and saline water; Low-lying acidic area; Alluvial freshwater floodplain.

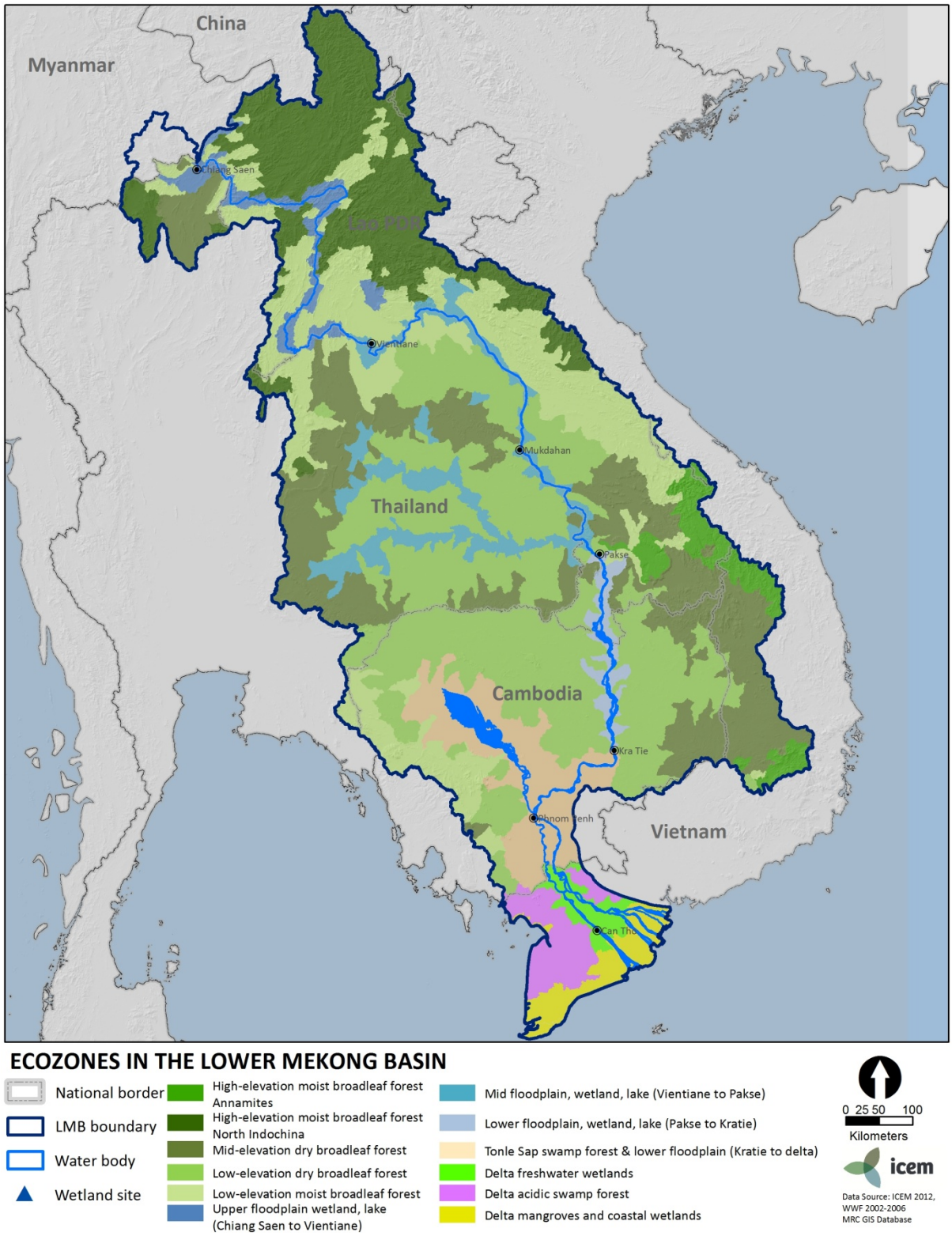

Figure 24: Ecozones of the Lower Mekong Basin

ANNEX 2

This Annex presents the detailed profiles of the hotspot provinces alongside the associated climate change vulnerability assessments of health and infrastructure within those provinces. The profiles and vulnerability assessments for each province are presented together because the assessment is informed by the contents of the profile. All provinces except Kien Giang contain more than one livelihood zone. The results for each livelihood zone are presented in the same assessment matrix, with any results that differ by livelihood zone indicated by the addition of a specific subscript: FU = *Forested uplands*; IUU = *Intensively used uplands*; LPP = *Lowland plains and plateaus*; F = *Floodplain*; D = *Delta*

2.1 CHIANG RAI PROVINCE (THAILAND)

2.1.1 OVERVIEW

Chiang Rai Province is a large rural province located in Northern Thailand. The province is characterized by a range of geography, from high mountains to extensive flatlands. Approximately 75% of the 1.2 million inhabitants live in rural areas. Poverty is moderately high by national standards: around 12% of the total population is considered to be living in poverty; by comparison, the national average is 7.8%. Notably, poverty levels range markedly between urban and remote upland areas.

In 2010, 37.4% of provincial GDP arose from the agricultural production (including fisheries) sector and 62.6% from the non-agricultural products sector. Rice farming is prominent, but only 22% of households identify this as their principal activity; rice is both a subsistence and commercial crop. A range of commercial crops is grown in the province, including: tea, sugarcane, oil palm, soy, groundnut, rubber, and various fruits and vegetables. As with the rest of the LMB, rural households engage in a portfolio of diverse livelihood activities, such as agriculture, fishing, labor, and crafts. Of the 20,000 registered fishers, 65% and 35% engage in subsistence and commercial fishing respectively. Some shifting cultivation occurs in remote areas of the province.

Health access is strong in the province as a whole compared to the rest of the LMB: infant mortality within one month averages 0.54% and there are 16 hospitals and 212 health stations. Access to improved drinking water and sanitation are strong, with 80% and 97% of the population respectively having access to these resources. Food security in the province is considered to be strong, partly due to a productive agricultural sector.

As with the rest of Northern Thailand, there is a significant population of 'hill tribe' ethnic minority groups and displaced groups in Chiang Rai; many of these lack formal citizenship and may be denied access to social services and economic opportunities.

2.1.2 LIVELIHOOD ZONE(S)

Intensively used uplands: 62%; *Lowland plains and plateaus*: 21%; *Floodplain*: 17%.

Intensively used uplands –The incidence of poverty is highest in this zone, particularly in Phan, Mae Suai, and Mueang Chiang Rai districts. Access to health care in remotes areas of this zone is restricted by the difficulties of transportation along relatively less well-developed roads. This zone is the area in which many hill tribe minority groups and displaced groups are located: these groups are among the poorest in Thailand. Upland rice is a major crop, although commercial crops such as tea are also extensively grown.

Population density ranges greatly in this zone, with different districts exhibiting the highest and lowest levels of density for the province. Certain districts in this zone exhibit the lowest levels of safe drinking water access.

Lowland plains and plateaus – This zone is a major area of agricultural activity in the province, particularly for perennial crops.

Floodplain – There are three major wetlands in this zone in Chiang Rai Province, one of which is a Ramsar protected wetland. Reportedly, there is a significant population of ethnic minorities residing in Mae Chan district.

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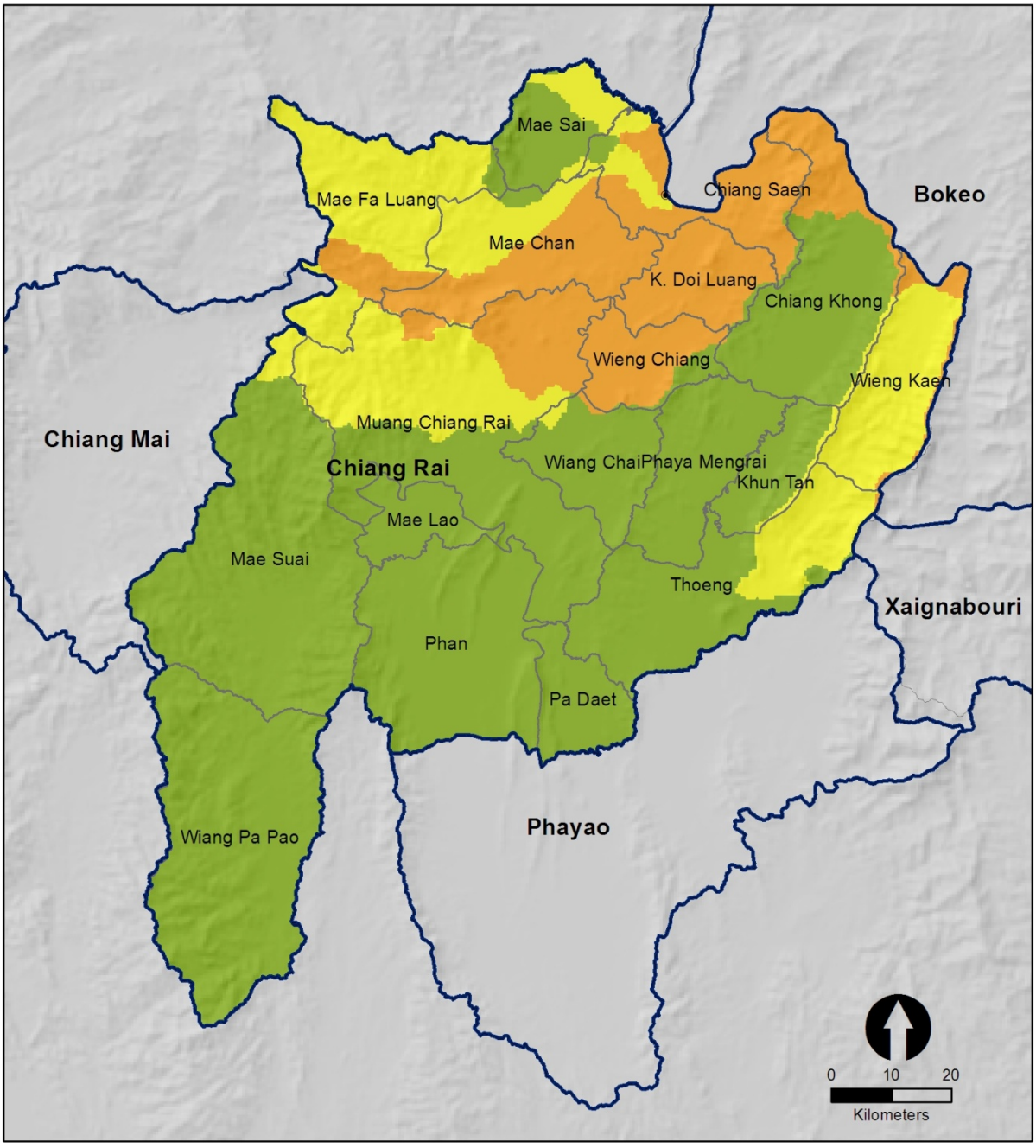

Figure 25: Districts of Chiang Rai Province and livelihood zones

2.1.3 SUMMARY OF KEY INDICATORS/SECTORS

Indicator/theme	Key statistic(s)	Description
Poverty	About 143,000 people or 11.93% of the total population in Chiang Rai are considered to be in poverty (in 2010).	In 2010, the province had the moderate poverty rate ranking of 7th out of the 17 provinces in the northern part of Thailand. The highest incidence of poor households occurs in Phan (551), Mae Suai (462), and Mueang Chiang Rai (372) districts. Most of these districts are located nearby national parks.
Food security	Principal livelihood occupations of households in Chiang Rai in 2010: rice farming, 24.58%; upland field crops, 6.85%; fishing, 0.03%; fruit tree and orchards, 1.79%, trade 4.61%; wage labor, 25.33%; governmental services and state enterprises, 1.68%; other 28.29% and undefined 6.84%	Overall food security is generally strong, although villages in remote areas and minority and displaced groups are vulnerable to food security. At least 33% of households across the province have agriculture as their main occupation. However, households exhibit a diversified portfolio of livelihood activities. Rice farming households was highest in Phan district (27,320). Subsistence-based rice farming remains a significant and essential activity for food security across many districts of the province.
Human health	16 hospitals and 212 health stations (in 2012) 319 doctors, 2,012 professional nurses and 89 technical nurses (in 2010) Infant mortality within 1 month: 0.54% (in 2010) Maternal mortality within 1 month: 0.05% (in 2010)	Chiang Rai's reported rates of infant and maternal mortality are low and equivalent to the national average. In 1992, the proportion of doctors to population was 1:9,757 whereas in 2010, that figure fell to 1: 3,756. Human health is clearly improving in the province. However, children and households in remote and upland areas may lack adequate provision of medical care due to distances to medical centers, and lack money for transportation (especially in the case of emergencies).
Population	Population: 1,198,218 (2010) Population density: ≈105 persons/km^2 (in 2008)	The population level has remained stable in the province over the last decade or so; in 2001 and 2009, the provincial population was 1,263,169 and 1,194,933 respectively. By population, Chiang Rai is the second largest province in Northern Thailand. By district, the largest population volume (in 2009) is Mueang Chiang Rai (13.18 % of total) and Phan (13.35 %), whereas the lowest population volume is Khun Tan, Weing Chiangrung and Padad districts (1.30, 1.35 and 1.40 % respectively). In 2008, the highest population density was Mae Sai (308.68 person/km^2), Mueang Chiang Rai (186.3 persons/km^2), and Wiang Chai districts

Indicator/theme	Key statistic(s)	Description
		(169.912 persons/km^2). There is a large population of ethnic minorities living in the province, in 2002 the total number was 200,154 and, by district, the largest populations were recorded in Mae Suai (39,819), Mueang Chiang Rai (20,821), Wiang Kaen (17,032) and Mae Chan (15,093).
Strength of key infrastructure	Number of villages and households which have inadequate clean drinking water for the entire year: 498 and 5,945 respectively (in 2008) Percentage of households with piped water: 97.15 % (in 2008)	79.9 % of the total population is reported to have access to improved drinking water sources, 99.2 % in urban areas and 75.4 % in rural areas (2008). High numbers of villages do not have adequate clean drinking water year-round in Thoeng (90), Phan (89), Mueang Chiang Rai (76) and Wiang Pa Pao (50). In Mae Chan and Mae Sai, the percentage of households with piped water was reported as 100 %.
Assets	Total farm holding land: 4,220.84 km^2 in province Number of farming households: 153,050 Number of total households in province: 446,346 Average farm size: 2.76 ha in province (in 2008)	In 2008, agricultural statistics of Thailand reported that total land in Chiang Rai Province was 11,678.37 km^2, which could be classified into 3 main types: forest land (5,165.62 km^2 or 44.22%), farm holding land (4,220.84 km^2 or 36.14 %), and unclassified land 2,292.91 km^2. Farm holding land can be divided into seven categories mainly based on agricultural purposes: 66.99% of land is engaged in rice farming, followed by upland field crop (16.59%), and fruit tree and perennial crop (12.54%). The remaining area is occupied by residential area (2.64%), pasture land (0.36%), waste land (0.15%), and miscellaneous land (0.73%). Regarding land ownership, 29.35% of farm holding lands belongs to farmers and the remaining 70.65% is rented farm and untitled farmland.
Education/skills	Primary school (7-12 years) enrollment: 96% Secondary school (13-18 years) enrollment: 76.6% (in 2005-2006)	During 2005-2006, children aged 3-5 years living in urban households were more likely to go to school compared to children in rural areas (88.9 % and 64.3% respectively). The percentage of boys in primary school was slightly higher than girls (96.5% and 95.5% respectively) whereas in secondary school, the percentage of girls (79.4%) was higher than boys (73.6%). The number of schools in the largest district Meaung Chiang Rai (125) was higher than in other districts (Weingchai: 28;

Indicator/theme	Key statistic(s)	Description
		Weingchiangrung: 15).
Physical infrastructure	Total number of villages with public telephone (in 2007): 1,050 Number of classrooms and students in Meaung Chiang Rai (1,400 and 35,896), Weingchai (229 and 3,500), Wiang Chiang Rung (147 and 2,706) (in 2010). Number of electric water pump stations in the province : 5	97.1 % of the population is reported to have access to improved sanitation facilities, with 100% in urban areas and 96.4 % in rural areas. Most of the major roads in villages were reported to be in good, weather-resistant condition and be paved or constructed with bitumen in 2007. In 2010, five large electric water pump stations for irrigation purposes were situated across Weingchai (1), Mae Chan (2), Phaya Mengrai (1) and Doi Luang districts (1). A number of villages do not have public telephones, the highest figure being reported in Thoeng (53) followed by Mae Suai (49), Mae Fa Luang (40) and Meaung Chiang Rai districts (33). There is no rail system in the province, but an extensive road network.
Access to markets	Number of major markets in the province: 7	There are seven major markets in the province. These are located in four districts: Meaung Chiang Rai (4), Phan (1), Mae Chan (1) and Mae Sai (1) as these areas are commercial hubs. Official statistics stated in 2010 that 1,791 villages received credit from village funds supported by the Thai government. Although the road network in the province is generally well constructed, access to markets in rural areas can be limited, particularly in the wet season when communities in lowland and floodplain areas can be completely cut off by flooding. Moreover, the mobility of communities in upland areas can be affected by landslips during this period.

Notes: 2011 data unless specified otherwise. References: Chiang Rai Official Website (2012), Office of the National Economic and Social Development Board (2012), Chiang Rai Governor Office (2012), Office of Agricultural Economics. Ministry of Agriculture and Cooperatives (2010), Chiang Rai Financial Office (2010), UNICEF (2011), Ministry of Public Health, Bureau of Policy and Strategy (2010), National Statistical Office (Thailand), Ministry of Information and Communication Technology (2012), Key Statistics of Thailand (in Thai and English).

Exposure	Sensitivity	Adaptive capacity
Location of people/assets	Poverty	Assets
Severity of threat	Food insecurity	Education/skills
Duration of threat	Human health	Physical infrastructure
	Strength of key infrastructure	Access to markets
	Demographic composition	

Notes: Assessment relates to all livelihood zones within the province unless otherwise specified. Subscripts relate to their corresponding livelihood zones: FU = *Forested uplands*; IUU = *Intensively used uplands*; LPP = *Lowland plains and plateaus*; F = *Floodplain*; D = *Delta*. For example, H_{FU} under the 'Exposure' heading indicates an assessment of High Exposure in the *Forested uplands* livelihood zone of the province.

2.1.4 CHIANG RAI PROVINCE - HEALTH CLIMATE CHANGE VULNERABILITY ASSESSMENT

THREAT		*IMPACT*					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Temperature	Moderately high increase in maximum temperature of approximately 2°C is projected across the year. Notably, the temperature rise at the beginning to the middle of the wet season (July to August) is projected to be in the vicinity of 3°C (rising to an average maximum of 34°C). Under baseline conditions maximum temperatures vary on average between 25.7°C to 35.5°C during the year, with temperatures peaking in	M_{IUU} H_{LPP} H_F	H_{IUU} M_{LPP} M_F	M_{IUU} H_{LPP} H_F	**Interpretation of threat** The threat of temperature rise is interpreted as the direct impact on human health (i.e., heat exhaustion) and the incidence of disease vectors. **Exposure** Exposure is considered to be medium to high across the province because the projected rise in temperature represents a significant change in exposure to heat stress (i.e., days above 35°C). However, Chiang Rai is a mountainous province and	[12] M_{IUU} H_{LPP} H_F	M_{IUU} M_{LPP} M_F

[12] Adaptive capacity is considered to be high in *lowland plains and plateaus* and *floodplain* due to access to healthcare centers, markets, and road networks. Moreover, school enrollment rates and access to sanitation are fairly high in the province as a whole. Adaptive capacity is considered to be medium in *intensively used uplands* because of the poorer state of the road network in these areas and the greater difficulty to access health services and markets.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	April and dropping to a minimum in December. With climate change, temperatures are projected to follow a similar pattern, but with a peak in maximum average temperature of 37°C. The proportion of days exceeding 35°C is projected to increase from 10% to 25%.				the rise in temperature is likely to be lower in the higher altitudes in *intensively used uplands*. **Sensitivity** Sensitivity is judged to be medium in *lowland plains and plateaus* and *floodplain* zones because of the relatively high level of health access, poverty reduction, and food security in the province as a whole and in these regions. However, sensitivity is considered to be high in *intensively used uplands* due to higher rates of poverty and the presence of ethnic minority groups who may not have full access to state health services. Moreover, access to health services in remote areas of the *intensively used uplands* zone may be hindered by distance. The rate of safe water access is also much lower in parts of this zone.		
Precipitation	Lowland areas of Chiang Rai show a strong seasonal pattern characterized by the monsoon rains from May to October. Peak rainfall occurs in August accounting for about 20% of the total annual rainfall. With climate change annual	L_{IUU} L_{LPP} L_F	H_{IUU} M_{LPP} M_F	M_{IUU} M_{LPP} M_F	**Interpretation of threat** The threat of higher precipitation is interpreted as the impact on health through greater accumulation of non-flood related stagnant water bodies and the consequent creation of breeding grounds for disease vectors.	[13] M_{IUU} H_{LPP} H_F	M_{IUU} M_{LPP} M_F

[13] See previous footnote. Moreover, the relatively low level of exposure to the threat raises relative adaptive capacity.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	rainfall is projected to increase from 1,600 mm/yr to 1,740 mm/yr (+140 mm/yr). Peak monthly rainfall in August and September is projected to increase from 325 to 345 mm/yr, and 252 to 284 mm/yr respectively. The size of major precipitation events is projected to increase.				**Exposure** Exposure is judged to be low across all livelihood zones because the increase in precipitation is mostly restricted to the wet season and the marginal impact is likely to be negligible. **Sensitivity** Sensitivity is judged to be medium in *lowland plains and plateaus* and *floodplain* zones because of the relatively high level of health access, poverty reduction, and food security in the province as a whole and in these regions. However, sensitivity is considered to be high in *intensively used uplands* due to higher rates of poverty and the presence of ethnic minority groups who may not have full access to state health services. Moreover, access to health services in remote areas of the *intensively used uplands* zone may be hindered by distance. The rate of safe water access is also much lower in parts of this zone.		
Change and shift in events							
Drought (see definition)	The incidence of drought is not projected to change, except for a decline in the probability of drought at the beginning of the dry season	NA	NA	NA	**Interpretation of threat** The threat is considered to be not applicable because climate change is not projected to affect the incidence of drought.	NA	NA

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
	(December).						
Flooding	The severity and incidence of flooding is likely to increase with higher precipitation and more extreme precipitation events.	M_{IU} H_{LP} VH F	H_{IU} H_{LP} H_F	M_I H_L V H_F	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by slow-onset flooding, as well as the attendant indirect impacts on human health through: increased incidence of water-borne and vector-borne disease through contamination of or lack of access to safe water supplies; and food insecurity caused by decreased access to forest resources and, in remote areas, access to markets. **Exposure** Exposure is judged to be high to very high in *lowland plains and plateau* and *floodplain* zones due to relative flatness of this terrain and proximity of surrounding water bodies to communities, combined with projections of higher rainfall and more intense rainfall events. Exposure is considered to be lower to prolonged flooding in *intensively used uplands* due to the higher drainage capacity of sloping land.	[14]M_I M_{LPP} M_F	M_I H_L V H_F

[14] Adaptive capacity is considered to be medium in *lowland plains and plateaus* and *floodplain*. Access to healthcare centers, markets, and road networks is generally strong outside flood events, but lack of access to roads during flood events may seriously hinder adaptive capacity. Adaptive capacity is considered to be medium in *intensively used uplands* because of the poorer state of the road network more generally in these areas and the greater difficulty to access markets.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
					Sensitivity Sensitivity is judged to be high in *lowland plains and plateaus* and *floodplain* zones. Despite the relatively high level of health access, poverty reduction, and food security in the province as a whole and in these regions, as well as the generally strong condition of road infrastructure, communities in these areas are frequently cut off in times of flood due to road flooding. Sensitivity is considered to be high in *intensively used uplands* due to higher rates of poverty and the presence of ethnic minority groups who may not have full access to state health services. The rate of safe water access is also much lower in parts of this zone.		
Flash floods	The severity and incidence of flash flooding is likely to increase with higher precipitation and more extreme precipitation events.	H_{IU} U M_{LP} P L_F	H_{IU} U M_{LP} P M_F	H_I UU M_L PP M_F	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by flash flooding, as well as the attendant indirect impacts on human health through damage to assets. **Exposure** Exposure is considered to be high in *intensively used uplands*	[15]M_I UU H_{LPP} H_F	H_I UU M_L PP M_F

[15] Adaptive capacity is considered to be high in *lowland plains and plateaus* and *floodplain* due to access to healthcare centers, markets, and road networks. Moreover, school enrollment rates and access to sanitation are high in the province as a whole. Adaptive capacity is considered to be medium in *intensively used uplands* because of the poorer state of the road network in these areas and the greater difficulty to access health services and markets as a result.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					due to the level of the climate threat and the intensive nature of land cultivation in many sloping areas and, hence, the reduced capacity of soil to absorb water. Exposure is considered to be medium to low in *lowland plains and plateaus* and *floodplain* due to the assumed varying degrees of slope (or lack of) in these zones. **Sensitivity** Sensitivity is judged to be medium in *lowland plains and plateaus* and *floodplain* zones because of the relatively high level of health access, poverty reduction, food security in the province as a whole and in these regions. However, sensitivity is considered to be high in *intensively used uplands* due to higher rates of poverty and the presence of ethnic minority groups who may not have full access to state health services. Moreover, access to health services in remote areas of the *intensively used uplands* zone may be hindered by distance. The rate of safe water access is also much lower in parts of this zone.		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Landslides	The incidence of landslides is likely to increase with higher precipitation and more extreme precipitation events.	H_{IUU} M_{LPP} VL_F	H_{IUU} M_{LPP} M_F	H_{IUU} M_{LPP} L_F	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by landslides, as well as the attendant indirect impacts on human health through damage to assets and/or reduced road access. **Exposure** Exposure is considered to be high in *intensively used uplands* due to the level of the climate threat and the intensive nature of land cultivation in many sloping areas and, hence, the reduced capacity of soil to absorb water. Exposure is considered to be medium to low in *lowland plains and plateaus* and *floodplain* due to the assumed varying degrees of slope (or lack of) in these zones. **Sensitivity** Sensitivity is judged to be medium in *lowland plains and plateaus* and *floodplain* zones because of the relatively high level of health access, poverty reduction, and food security in the province as a whole and in these regions. However,	[16]M_{IUU} H_{LPP} H_F	H_{IUU} M_{LPP} L_F

[16] Adaptive capacity is considered to be high in *lowland plains and plateaus* and *floodplain* due to access to healthcare centers, markets, and road networks. Moreover, a large proportion of villages are reported to have access to credit – these are most likely to be in the more easily accessed floodplain and lowland areas. Adaptive capacity is considered to be medium in *intensively used uplands* because of the poorer state of the road network in these areas and the greater difficulty to access health services and markets as a result.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
					sensitivity is considered to be high in *intensively used uplands* due to higher rates of poverty and the presence of ethnic minority groups who may not have full access to state health services. Landslides can be highly destructive events and would have lasting indirect impacts on health if they affected livelihood activities or assets. Moreover, access to health services in remote areas of the *intensively used uplands* zone may be hindered by distance.		

2.1.5 CHIANG RAI PROVINCE - INFRASTRUCTURE CLIMATE CHANGE VULNERABILITY ASSESSMENT

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
Temperature	Moderately high increase in maximum temperature of approximately 2°C is projected across the year. Notably, the temperature rise at the beginning to the middle of the wet season (July to August) is projected to be in the vicinity of 3°C (rising to an average maximum of 34°C). Under baseline conditions	NA	NA	NA	**Interpretation of threat** The threat of temperature rise is not considered to be applicable to infrastructure in this case.	NA	NA

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
	maximum temperatures vary on average between 25.7°C to 35.5°C during the year, with temperatures peaking in April and dropping to a minimum in December. With climate change, temperatures are projected to follow a similar pattern, but with a peak in maximum average temperature of 37°C. The proportion of days exceeding 35°C is projected to increase from 10% to 25%.						
Precipitation	Lowland areas of Chiang Rai show a strong seasonal pattern characterized by the monsoon rains from May to October. Peak rainfall occurs in August accounting for about 20% of the total annual rainfall. With climate change annual rainfall is projected to increase from 1,600 mm/yr to 1,740 mm/yr (+140 mm/yr). Peak monthly rainfall in August and September is projected to increase from 325 to 345	L_{IU} U L_{LPP} L_F	M_I UU L_{LP} P L_F	M_I UU L_{LP} P L_F	**Interpretation of threat** The threat of higher precipitation is interpreted as the direct impact on roads, bridges, and buildings of higher precipitation (i.e., not indirect impacts through, for example, flooding). **Exposure** Exposure is judged to be low across the province because the additional rainfall occurs during the rainy season and likely to have a marginal impact. **Sensitivity**	[17]M IUU H_{LP} P H_F	M_I UU L_{LP} P L_F

[17] Adaptive capacity is considered to be high in *lowland plains and plateaus* and *floodplain* due to access to healthcare centers, markets, and road networks. Moreover, a large proportion of villages are reported to have access to credit – these are most likely to be in the more easily accessed floodplain and lowland areas. Adaptive capacity is considered to be medium in *intensively used uplands* because of the poorer state of the road network in these areas and the greater difficulty to access markets as a result.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	mm/yr, and 252 to 284 mm/yr respectively. The size of major precipitation events is projected to increase.				Sensitivity is judged to be low to medium across the province because the road network is largely paved. The assessment is different for *intensively used uplands* because the road system in remote areas is more likely to be unpaved and susceptible to pot holes and also buildings and other infrastructure are likely to be poorer among poorer communities in this region.		
Change and shift in events							
Drought (see definition)	The incidence of drought is not projected to change, except for a decline in the probability of drought at the beginning of the dry season (December).	NA	NA	NA	**Interpretation of threat** The threat is considered to be not applicable because climate change is not projected to affect the incidence of drought.	NA	NA
Flooding	The severity and incidence of flooding is likely to increase with higher precipitation and more extreme precipitation events.	L_{IU} H_{LP} VH_F	H_{I} M_{L} M_{F}	M_{I} H_{L} VH_F	**Interpretation of threat** The threat is interpreted as the risk of damages to infrastructure caused by slow-onset flooding. These may include: roads and bridges being eroded by floods, buildings water-damaged or destroyed, damage to irrigation infrastructure, and drinking water supply infrastructure (particularly groundwater bores) being contaminated with dirty surface water.	[18]L_{I} M_{LP} M_{F}	M_{I} H_{L} VH_{F}

[18] Adaptive capacity is considered to be high in *lowland plains and plateaus* and *floodplain* due to access to markets and road networks. Moreover, a large proportion of villages are reported to have access to credit – these are most likely to be in the more easily accessed floodplain and lowland areas. Adaptive capacity is considered to be medium in *intensively used uplands* because of the poorer state of the road network in these areas and the greater difficulty to access markets as a result.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
					Exposure Exposure is judged to be high to very high in *lowland plains and plateau* and *floodplain* zones due to relative flatness of this terrain and proximity of surrounding water bodies, combined with projections of higher rainfall and more intense rainfall events. Exposure is considered to be low to prolonged flooding in *intensively used uplands* due to the higher drainage capacity of sloping land. **Sensitivity** Sensitivity is considered to be high in *intensively used uplands* due to poorer state of road infrastructure and likely poorer infrastructure across the board due to higher poverty levels in some of this zone. Sensitivity is considered to be medium in *lowland plains and plateaus* and *floodplain* zone due to the higher strength of roads and, given the lower rates of poverty and proximity to the provincial capital, likely stronger buildings and other infrastructure.		
Flash floods	The severity and incidence of flash flooding is likely to increase with higher	H_{IU} U M_{LP}	H_{I} UU M_{L}	H_{IU} U M_{L}	**Interpretation of threat** The threat is interpreted as the risk of destruction or major	[19]L_{I} UU M_{LP}	H_{I} UU M_{L}

[19] Adaptive capacity is considered to be high in *lowland plains and plateaus* and *floodplain* due to access to markets and road networks. Moreover, a large proportion of villages are reported to have access to credit – these are most likely to be in the more easily accessed floodplain and lowland areas. Adaptive capacity is considered to be medium in *intensively used uplands* because of the poorer state of the road network in these areas and the greater difficulty to access markets as a result.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	precipitation and more extreme precipitation events.	P L_F	PP M_F	PP M_F	damages to infrastructure caused by sudden flash flooding. These may include: roads and bridges badly eroded or swept away by floods, buildings heavily damaged by water or destroyed, damage to irrigation infrastructure, and drinking water supply infrastructure (particularly groundwater wells) being contaminated with dirty surface water. **Exposure** Exposure is considered to be high in *intensively used uplands* due to the level of the climate threat and the intensive nature of land cultivation in many sloping areas and, hence, the reduced capacity of soil to absorb water. Exposure is considered to be medium to low in *lowland plains and plateaus* and *floodplain* due to the assumed varying degrees of slope (or lack of) in these zones. **Sensitivity** Sensitivity is considered to be high in *intensively used uplands* due to poorer state of road infrastructure and likely poorer infrastructure across the board due to higher poverty levels in some of this zone. Sensitivity is considered to be medium in *lowland plains and plateaus* and *floodplain* zone due to the higher strength of roads and, given the	P M_F	PP M_F

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
					lower rates of poverty and proximity to the provincial capital, likely stronger buildings and other infrastructure.		
Landslides	The incidence of landslides is likely to increase with higher precipitation and more extreme precipitation events.	H_{IU} M_{LP} VL_F	H_{IUU} M_{LPP} M_F	H_{IU} M_{LPP} L_F	**Interpretation of threat** The threat is interpreted as the risk of destruction or major damages to infrastructure caused by landslides. These may include: roads and bridges badly eroded or swept away by floods, buildings heavily damaged or destroyed, water supply infrastructure (particularly groundwater wells) being contaminated with dirty surface water. **Exposure** Exposure is considered to be high in *intensively used uplands* due to the level of the climate threat and the intensive nature of land cultivation in many sloping areas and, hence, the reduced capacity of soil to absorb water. Exposure is considered to be medium to low in *lowland plains and plateaus* and *floodplain* due to the assumed varying degrees of slope (or lack of) in these zones. **Sensitivity** Sensitivity is considered to be	[20]L_{IUU} M_{LP} M_F	H_{IUU} M_{LPP} L_F

[20] See previous footnote. Moreover, landslides can be extremely destructive events and would take a prolonged period and high level of investment to restore and rebuild infrastructure.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					high in *intensively used uplands* due to poorer state of road infrastructure and likely poorer infrastructure across the board due to higher poverty levels in some of this zone. Sensitivity is considered to be medium in *lowland plains and plateaus* and *floodplain* zone due to the higher strength of roads and, given the lower rates of poverty and proximity to the provincial capital, likely stronger buildings and other infrastructure.		

2.2 GIA LAI PROVINCE (VIETNAM)

2.2.1 OVERVIEW

Gia Lai is a province of Vietnam's Central Highlands region. The population is a mix of recent migrants from elsewhere in Vietnam and indigenous ethnic minorities. The latter group experiences much higher levels of poverty and tends to live on more marginal land in upland areas.

Overall, the levels of income, food insecurity, and access to public services are relatively superior to many other parts of the LMB, particularly Cambodia and Lao PDR. Access to electricity is the norm, and access to safe drinking water and sanitation are also superior to other rural areas in the region, although access is by far not universal. As mentioned above, the social conditions of ethnic minorities are, in general, markedly poorer than those of Kinh groups.

Industrial crops comprise over two-thirds of all agricultural land use in the province. This reflects a major expansion in rubber and coffee cultivation that has occurred in recent decades. The latter trend has been a major driver of deforestation and land degradation, particularly erosion on steep slopes, is now a major issue for wealthy smallholders and ethnic minorities alike.

The impacts of climate change, exacerbated by the scale of land conversion, are already being felt in the province. Flash floods in particular have been increasing due to deforestation of sloping land. Storms in 2009 destroyed thousands of hectares of rubber and dozens of hectares of pepper. Variable weather conditions in recent years have caused acute difficulties for farmers of specialty commercial crops such as cashews.

2.2.2 LIVELIHOOD ZONE(S)

Intensively used uplands: 68%; *Lowland plains and plateaus*: 32%.

Intensively used uplands – In this area there is a greater presence of agriculture (intensive or otherwise) on sloping land. Ethnic minorities are also more present in upland areas and it is assumed that poverty rates are therefore higher in this zone compared to the other zone. Remote ethnic communities have: less access to health and education services, as well as markets; and greater exposure to food insecurity.

Lowland plains and plateaus – In this area there is a greater area of relatively flat land susceptible to flooding. However, the lower presence of sloping land may make farming less marginal.

Key references

General Statistics Office of Vietnam (GSO) (2011), Western Highlands Agro-Forestry Scientific & Technical Institute (2012), USAID (2008), WRIENET (2006).

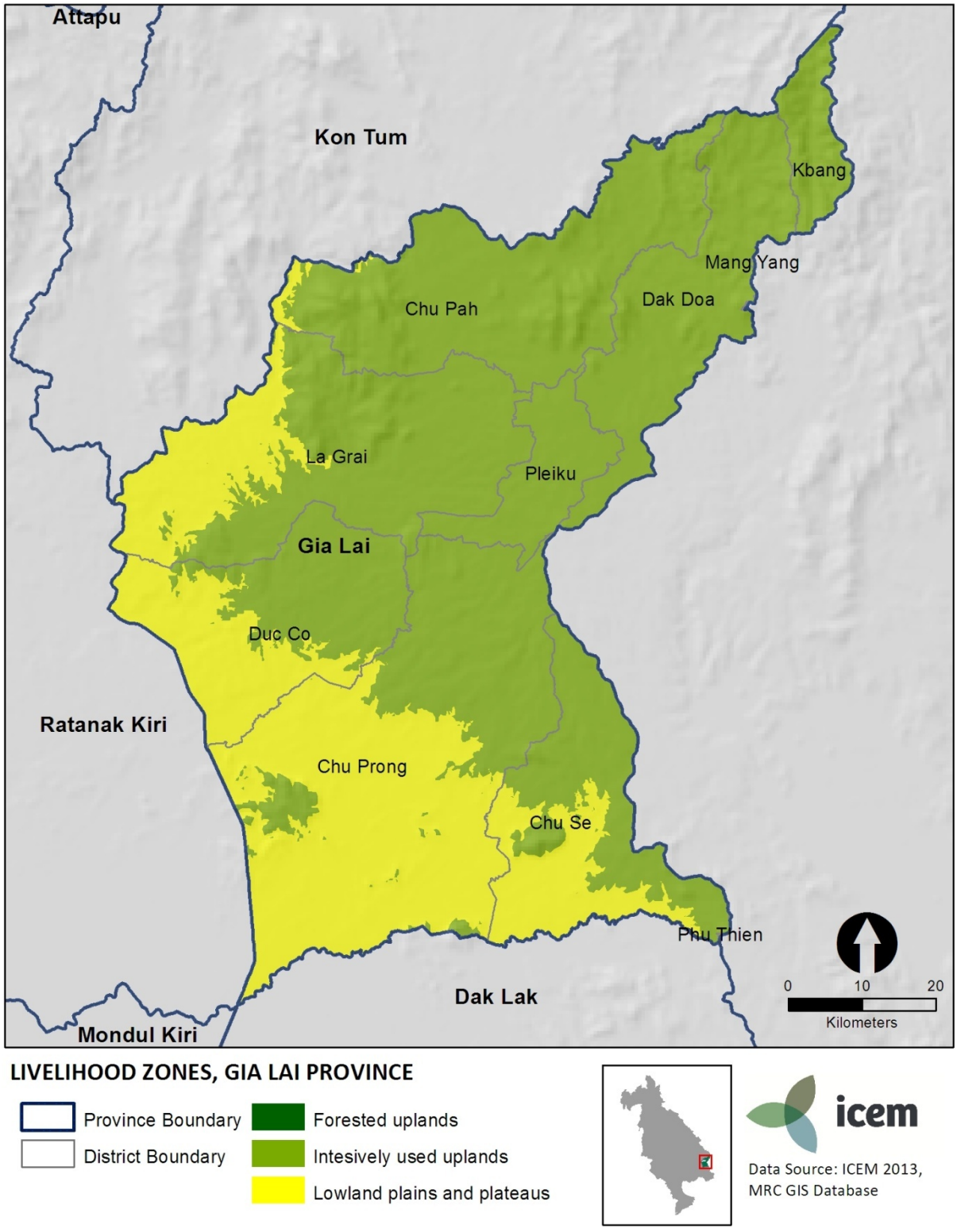

Figure 26: Districts of Gia Lai Province and livelihood zones

2.2.3 SUMMARY OF KEY INDICATORS/SECTORS*

Indicator/theme	Key statistic(s)	Description
Poverty	Poverty rate: 25.9% (Vietnam national standards)	Poverty is heavily concentrated in minority groups (84% of households below the poverty line), whom tend to live at high altitudes and many of which continue to engage in slash and burn cultivation. These groups have much lower access to health care, electricity, and other services. Urban incomes: 1.137 million VND/month. Rural incomes: 0.596 million VND/month. Highest income quintile earns around 8 times the amount of the lowest income quintile.
Food security	Stunting prevalence (moderate + severe) in children under 5 years: 36.2% Wasting prevalence in children under 5 years: 9.3%	Industrial crops (e.g., coffee and rubber) comprise over two-thirds of agricultural land in Sesan catchment of Gia Lai. Agricultural yields of cassava, maize, and rice in remote ethnic communities are only 50 to 60% of yields elsewhere. Unsustainable fishing techniques (e.g., thick nets and electricity) have substantially reduced the quantity of fish resources.
Human health	Commune health stations: 209^ Regional polyclinics: 16^ Hospitals: 17^ Infant mortality rate: 2.7% Under five mortality rate: 3.94% Full immunization coverage for children under 1 year old: 94.1%	80% of communes have a health station headed by doctors with 6 years of experience; voluntary health workers with limited training provide health service outreach to remote villages. Targeted health insurance schemes offer poor ethnic minority groups 20 million VND in medical care costs for 3% of minimum salary, or 189,000 VND; this does not cover indirect costs like transport and meals, which is covered by external donors. Constraints: shortage of specialist doctors, lack of access to rehabilitation centers for people with disabilities, ethnic minorities not taking advantage of health insurance scheme.
Population and demography	Population: 1.322 million Population growth rate: 1.57% Population density: 85 persons/km^2 (Gia Lai); 227	Ethnic minority groups represent 44% of the population. These include: Gia Rai, Xe Dang, Ba Na, Gie Trieng. Household size: lowest income quintile, 5.5 people; highest income quintile, 3.9 people. Net migration rate: 1.9% (i.e., net out-migration).

Indicator/theme	Key statistic(s)	Description
	persons/km^2 (Sesan Basin in Gia Lai)	
Strength of key infrastructure	House type: permanent, 14.9%; semi-permanent, 78.5%; temporary, 4.8%, temporary and other house, 1.9%.	Major 'national' roads are generally paved with bitumen and in good condition; 'local' and 'district' roads are generally in poor condition, narrow-width, uneven distribution, made of earth, and may not be used in all seasons. Land clearing for agriculture has increased the rate of erosion. Cassava yields are very low and this is a major driver of new deforestation and eventual degradation of sloping agricultural land. Between 2005 and 2010 the forest area of the province fell from 761,847 ha to 648,790 ha.
Assets	NA	Many ethnic minorities have sold their allocated lands to Kinh migrants and have relocated to remaining forested land. But this strategy has become less viable as the government has increasingly enforced environmental regulation. Ethnic minority groups are less likely to have access to perennial crops, and have larger plots of more marginal (particularly sloping) land. Per capita livestock: buffalo, 0.012; cattle, 0.262; pigs, 0.296; poultry, 1.33.
Education/skills	Literacy rate in population above 15 years: 82.5% Percentage of 6 year olds in school: 96% Primary schools: 213 Lower secondary schools: 147 Upper secondary school: 31 Primary and lower secondary combined: 70	Education coverage at the basic level is strong in Gia Lai, even in remote areas where 'satellite schools' (i.e., ones that are connected to a larger core school) are available in every village. However, the usefulness of satellite schools is exhausted quite quickly and core schools can be too far away for ethnic minority children to attend. Consequently, there is a high drop out rate after grade 3 for ethnic minorities.
Physical infrastructure	Main source of lighting: electricity, 99.5%. Use of hygienic toilet facilities: 36.8% of households	Pleiku airport is a small airport with regular fights to Ho Chi Minh city. Extensive highway and road network throughout the province though can be limited in remote areas. Ten major hydropower projects in the Upper Sesan Basin (including Kon Tum), and there are also a large number of smaller dams for both hydropower and irrigation purposes. Extensive infrastructure for irrigation. Volume of freight has

Indicator/theme	Key statistic(s)	Description
	Use of safe drinking water: 72.2% of households	increased from 1.146 million tonnes to 7.82 million tonnes between 2000 and 2010. Many farmers use groundwater bores to supply agricultural irrigation – groundwater levels are consequently in a state of rapid decline, thus limiting the supply of water for both agriculture and households.
Access to markets	NA	The Vietnam Bank for Social Policy provides loans to poor groups at relatively low interest rates. However, policy lending is a political activity (because of the lack of available collateral) that can be biased against ethnic minorities. Also, policy loans are capped at 20 million VND per household; insufficient to buy inputs for plots larger than a household garden. Consequently, only 18% of minority households in Vietnam are able to access VBSP credit.

Notes: *2010 data unless specified otherwise. ^2007. These indicators comprise the main inputs into the climate change vulnerability assessment of health and infrastructure. NA = Not available. References: General Statistics Office of Vietnam (GSO) (2011), Western Highlands Agro-Forestry Scientific & Technical Institute, USAID (2008), WRIENET (2006)

Exposure	Sensitivity	Adaptive capacity
Location of people/assets	Poverty	Assets
Severity of threat	Food insecurity	Education/skills
Duration of threat	Human health	Physical infrastructure
	Strength of key infrastructure	Access to markets
	Demographic composition	

Notes: Assessment relates to all livelihood zones within the province unless otherwise specified. Subscripts relate to their corresponding livelihood zones: FU = *Forested uplands*; IUU = *Intensively used uplands*; LPP = *Lowland plains and plateaus*; F = *Floodplain*; D = *Delta*. For example, H_{FU} under the 'Exposure' heading indicates an assessment of High Exposure in the *Forested uplands* livelihood zone of the province.

2.2.4 GIA LAI PROVINCE - HEALTH CLIMATE CHANGE VULNERABILITY ASSESSMENT

THREAT		*IMPACT*					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Temperature	Major increase in maximum temperature of around 3 to 4°C. Under baseline conditions maximum temperatures vary on average between 24 to 32°C during the year, with temperatures peaking in April, averaging 31.9°C and dropping to a minimum in December and January. In the presence of climate change temperatures are projected to follow a similar pattern, albeit with a very large upward shift in the mean temperature of around 3 to 4°C. Across the course of the year, the projected average maximum temperature is roughly equal to or exceeds historical maximum temperatures (i.e., the new average maximum temperature is equal to or exceeds past extremes). An upward shift of similar proportions is also projected for minimum temperatures.	VH	H_{IUU} M_{LPP}	VH_{IUU} H_{LPP}	**Interpretation of threat** The threat of temperature rise is interpreted as the direct impact on human health (i.e., heat exhaustion) and the incidence of disease vectors. **Exposure** Exposure is evaluated as very high because: (a) a dramatic shift in temperatures of 3 to 4°C is projected, wherein the old extreme is the new average, and (b) the number of days exceeding 35°C increases from 0% to 35%. Moreover, more than 68% of the population is engaged in agriculture and forestry, outdoor activities that would expose them to higher temperatures. **Sensitivity** Sensitivity is considered to be high in the	[21] M_{IUU} H_{LPP}	VH_{IUU} H_{LPP}

[21] Adaptive capacity is judged to be medium to high because there is, overall, relatively well-developed infrastructure in the province (including shelter and health services), access to education (knowledge to deal with health complications arising from higher temperatures), and electricity (to power fans and other cooling devices). However, ethnic groups typically have less land and other assets and therefore have less capacity to move into livelihood strategies where they are less exposed to higher temperatures.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	The rise in temperatures is particularly pronounced during the wet season (June to November). Daily maximum temperature is also projected to become more variable with climate change with an average range of 9.3°C compared to a range of 7.5°C under the baseline. Proportion of days where the temperature exceeds 35°C is projected to increase from 0% to 15%.				*Intensively used uplands* zone due to the higher concentration of poverty and food insecurity amongst ethnic groups and their lower access to health services. In the *Lowland plains and plateaus* zone, sensitivity is considered to be medium because, although Gia Lai is a poor province by Vietnam standards (≈ 26% poverty), it is relatively wealthy and well-resourced by the standards of the rest of the LMB.		
Precipitation	Gia Lai shows a strong seasonal pattern characterized by the monsoon rains from May to November. Peak rainfall occurs in August often due to the combination of monsoon rains and tropical storms arriving from the Pacific Ocean and accounting for about 20% of the total annual rainfall. With climate change, annual rainfall is projected to increase from 1,945 mm/yr	L	H_{IUU} M_{LPP}	M_{IUU} M_{LPP}	**Interpretation of threat** The threat of higher precipitation is interpreted as the impact on health through greater accumulation of non-flood related stagnant water bodies and the consequent creation of breeding grounds for disease vectors. **Exposure** Exposure to this threat is defined as low because higher rainfall will generally be	[22] M_{IUU} H_{LPP}	M_{IUU} M_{LPP}

[22] Adaptive capacity is judged to be medium to high because there are, overall, relatively well-developed health services in the province. However, ethnic groups living in upland areas typically have poorer health access and therefore the population living in the *intensively used uplands* zone is considered to have moderate adaptive capacity overall.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	to 2,110 mm/yr (+165 mm/yr). Peak monthly rainfall in August is projected to increase from 390 to 430 mm/yr. The largest projected monthly increase in rainfall is 42 mm during the height of the wet season in August (shift from 387 mm to 429 mm). Rise in precipitation is mostly restricted to the wet season.				occurring in periods when there is already high rainfall (May to September). **Sensitivity** Sensitivity is considered to be high in the *Intensively used uplands* zone due to the higher population of ethnic groups and their lower access to health services. In the *Lowland plains and plateaus* zone, sensitivity is considered to be medium because the Gia Lai population has better health standards and healthcare access compared to the rest of the LMB; for example, by official statistics vaccinations are almost universally subscribed.		
Change and shift in events							
Drought	Comparison of monthly rainfall and Potential Evaporation (PET) conditions gives an agricultural definition of drought. Under historic conditions drought is a typical occurrence between December and March. In April and May drought occurs in around half of the years for baseline and under climate change. With climate change there will no changes in drought trends.	NA	NA	NA	The threat is considered to be not applicable because climate change is not projected to affect the incidence of drought.	NA	NA

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Flooding	Higher rainfall during the wet season and more intense rainfall events are likely to cause an increase in the magnitude and frequency of flooding.	M_{IUU} H_{LPP}	H_{IUU} M_{LPP}	M_{IUU} H_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by slow-onset flooding, as well as the attendant indirect impacts on human health through: increased incidence of water-borne and vector-borne disease through contamination of or lack of access to safe water supplies; and food insecurity caused by decreased access to forest resources and, in remote areas, access to markets. **Exposure** Exposure is considered to be medium in *Intensively used uplands* because sloping land is less likely to accumulate a large build-up of floodwater. In *Lowland plains and plateaus* exposure is considered to be high because of a greater confluence of surface water bodies (such as rivers in the Sesan Basin near the Cambodia border)	[23] M_{IUU} H_{LPP}	M_{IUU} M_{LPP}

[23] Adaptive capacity is judged to be medium to high because there are, overall, relatively well-developed health services in the province. However, ethnic groups living in upland areas typically have poorer health access and therefore the population living in the *Intensively used uplands* zone is considered to have moderate adaptive capacity overall.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					Sensitivity Sensitivity is considered to be high in the *Intensively used uplands* zone due to the higher population of ethnic groups and their lower access to health services. In the *Lowland plains and plateaus* zone sensitivity is considered to be medium because the broad Gia Lai population has better health standards and healthcare access compared to the rest of the LMB.		
Flash floods	More intense rainfall events are likely to cause an increase in the magnitude and frequency of flash flooding.	VH_{IUU} M_{LPP}	H_{IUU} M_{LPP}	VH_{IUU} M_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by flash flooding, as well as the attendant indirect impacts on human health through damage to assets. **Exposure** Exposure in *Intensively used uplands* is considered to be very high because: (a) the magnitude of extreme rainfall events	[24] L_{IUU} M_{LPP}	VH_{IUU} M_{LPP}

[24] Adaptive capacity is judged to be low to medium despite there being relatively well-developed health services in the province overall. Flash floods are extreme, destructive events that would severely affect the capacity of communities both rich and poor to generate income and secure household health. In upland areas there is also a risk that they will limit access to health facilities due to flash floods damaging poor quality roads in regional areas. Beyond the poorer health access of ethnic groups, these groups also have difficulty in accessing credit. For these reasons the overall population living in the *intensively used uplands* zone is considered to have low adaptive capacity.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					is expected to increase, as is rainfall overall (and therefore soil will be more saturated), and (b) previous deforestation on sloping land in this area has already reduced the capacity of soil to hold water and increased the likelihood of flash floods and consequent death or injury occurring. A key asset in these areas is farmland and water supply infrastructure (such as irrigation channels and water bores). Industrial crops are farmed intensively and farmers make significant investments in such, which must be remade by selling harvest. A loss of an entire crop through a flash flood would therefore have major impacts on food security, poverty, and, consequently, health, even among relatively better off farmers. As mentioned previously, the socio-economic situation amongst ethnic communities in this region is low. Exposure in the *Lowland plains and plateaus* zone is considered to be medium under the assumption that there is less sloping land and greater capacity to absorb incoming water across a wider area.		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					Sensitivity Sensitivity is considered to be high in the *Intensively used uplands* zone due to the higher population of ethnic groups and their lower access to health services. In the *Lowland plains and plateaus* zone sensitivity is considered to be medium because the broad Gia Lai population has better health standards and healthcare access compared to the rest of the LMB.		
Landslides	Higher rainfall during the wet season and more intense rainfall events are likely to cause an increase in the magnitude and frequency of landslides.	VH_{IUU} M_{LPP}	H_{IUU} M_{LPP}	VH_{IUU} M_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by landslides, as well as the attendant indirect impacts on human health through damage to assets and/or reduced road access. **Exposure** Exposure in *Intensively used uplands* is considered to be very high because: (a)	[25]L_{IUU} M_{LPP}	VH_{IUU} M_{LPP}

[25] Adaptive capacity is judged to be low to medium despite there being relatively well-developed health services in the province overall. Landslides are extreme, destructive events that would severely affect the capacity of communities both rich and poor to generate income and secure household health. In upland areas there is also a risk that they will limit access to health facilities due to damage to the limited and relatively low standard network of roads in regional areas. Beyond the poorer health access of ethnic groups, these groups would also have difficulty in accessing credit in the event of a health emergency caused by landslides. For these reasons the overall population living in the *intensively used uplands* zone is considered to have low adaptive capacity.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
					the magnitude of extreme rainfall events is expected to increase, as is rainfall overall (and therefore soil will be more saturated), and (b) previous deforestation on sloping land in this area (between 2005 and 2010 the forest area of the province fell from 761,847 ha to 648,790 ha) has already increased the level of soil erosion and increased the likelihood of landslides and consequent death or injury occurring. A key asset in these areas is farmland and water supply infrastructure (such as irrigation channels and water bores). Industrial crops are farmed intensively and farmers make significant investments in such, which must be remade by selling harvest. A loss of an entire crop through landslide damage or destroyed infrastructure would therefore have major impacts on food security, poverty, and, consequently, health, even among relatively better off farmers. As mentioned previously, the socio-economic situation amongst ethnic communities in this region is low. Exposure in the *Lowland plains and plateaus* zone is considered to be medium		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					under the assumption that there is less sloping land and therefore less chance of landslides. **Sensitivity** Sensitivity is considered to be high in the *Intensively used uplands* zone due to the higher population of ethnic groups and their lower access to health services. In the *Lowland plains and plateaus* zone sensitivity is considered to be medium because the broad Gia Lai population has better health standards and healthcare access compared to the rest of the LMB.		

2.2.5 GIA LAI PROVINCE - INFRASTRUCTURE CLIMATE CHANGE VULNERABILITY ASSESSMENT

THREAT		*IMPACT*					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Temperature	Major increase in maximum temperature of around 3 to 4°C. Under baseline conditions maximum temperatures vary on average between 24 to 32°C during the year, with temperatures peaking in April, averaging 31.9°C and dropping to a minimum in December and January. In the presence of climate change temperatures are projected to follow a similar pattern, albeit with a very large upward shift in the mean temperature of around 3 to 4°C. An upward shift of similar proportions is also projected for minimum temperatures. The rise in temperatures is particularly pronounced during the wet season (June to November). Daily maximum temperature is also projected to become more variable with climate change with an average range of 9.3°C compared to a range of 7.5°C under the baseline. The proportion of days where the temperature exceeds 35°C is projected to increase from 0% to 15%.	NA	NA	NA	**Interpretation of threat** The threat of temperature rise is not considered to be applicable to infrastructure.	NA	NA

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Precipitation	Gia Lai shows a strong seasonal pattern characterized by the monsoon rains from May to November. Peak rainfall occurs in August often due to the combination of monsoon rains and tropical storms arriving from the Pacific Ocean and accounting for about 20% of the total annual rainfall. With climate change, annual rainfall is projected to increase from 1,945 mm/yr to 2,110 mm/yr (+165 mm/yr). Peak monthly rainfall in August will increase from 390 to 430 mm/yr. The largest projected increase in rainfall is 42 mm during the height of the wet season in August (shift from 387 mm to 429 mm). Rise in precipitation is mostly restricted to the wet season.	L	H_{IUU} M_{LPP}	M_{IUU} L_{LPP}	**Interpretation of threat** The threat of higher precipitation is interpreted as the direct impact on roads, bridges, and buildings of higher precipitation (i.e., not indirect impacts through, for example, flooding). **Exposure** Exposure is low because the increase in rainfall is projected to occur during the wet season and the direct marginal impact of rainfall on infrastructure is therefore likely to be small. The exposure is low for both *Intensively used uplands* and *Lowland plains and plateaus* zones due to lack of information on projected rainfall changes in different areas. **Sensitivity** Sensitivity is evaluated as medium in *Lowland plains and plateaus* areas because levels of poverty are lower in	[26]M_{IUU} H_{LPP}	M_{IUU} L_{LPP}

[26] Adaptive capacity is evaluated as medium to high largely because the adaptive capacity required to respond to the threat is not substantial. However, the adaptive capacity of intensively used upland areas is considered to be lower because remote areas with poor roads may be cut off from markets (and repair services) due to the indirect impacts of precipitation, such as flash flooding and landslides.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					this area and in the province as a whole only 7% of housing is considered to be temporary (indicating relatively strong buildings). In *Intensively used uplands* zones sensitivity is evaluated as high because the quality of roads is lower and a substantial proportion of the population is poorer than the rest of the province and therefore likely to have weaker infrastructure.		
Change and shift in events							
Drought	Comparison of monthly rainfall and Potential Evaporation (PET) conditions gives an agricultural definition of drought. Under historic conditions drought is a typical occurrence between December and March. In April and May drought occurs in around half of the years for baseline and under climate change. With climate change there will be no changes in drought trends.	NA	NA	NA	The threat is considered to be not applicable because climate change is not projected to affect the incidence of drought.	NA	NA

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Flooding	Higher rainfall during the wet season and more intense rainfall events are likely to cause an increase in the magnitude and frequency of flooding.	L_{IUU} H_{LPP}	H_{IUU} M_{LPP}	M_{IUU} H_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of damages to infrastructure caused by slow-onset flooding. These may include: roads and bridges being eroded by floods, buildings water-damaged or destroyed, damage to irrigation infrastructure, and drinking water supply infrastructure (particularly groundwater bores) being contaminated with dirty surface water. **Exposure** Exposure is determined as low in *Intensively used upland* areas because it is assumed that sloping areas will reduce the incidence of slow-onset flooding. Exposure is determined as high for *Lowlands plains and plateaus* due to geographical reasons as well, moreover it is likely that households in this area live close to rivers and streams	[27]M_{IUU} H_{LPP}	M_{IUU} H_{LPP}

[27] Adaptive capacity is evaluated as low to medium in *intensively used upland* areas and in *lowlands plains and plateaus* areas respectively because of relative poverty and education levels. Moreover, the adaptive capacity of intensively used upland areas is considered to be lower because remote areas with poor roads may be cut off from markets (and repair services) due to the indirect impacts of precipitation, such as flash flooding and landslides, and a substantial proportion of ethnic households in remote areas have few assets (including land) from which they could generate resources to adapt.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					associated with the Sesan River Basin. **Sensitivity** Sensitivity for *Intensively used upland* areas and *Lowland plains and plateau* areas is determined to be high and moderate respectively due to relative poverty levels and the implications for the strength of key infrastructure. However, it should be noted that the sensitivity of *Lowland plains and plateau* areas would increase significantly if there were long-term impacts on irrigation infrastructure (whether through water contamination or damage to pipes and pumps) as a result of flooding; lack of information prevents this factor from taking a central role in the evaluation.		
Flash floods	More intense rainfall events are likely to cause an increase in the magnitude and frequency of flash flooding.	VH_{IUU} M_{LPP}	H_{IUU} M_{LPP}	VH_{IUU} H_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of destruction or major damages to	[28]L_{IUU} M_{LPP}	VH_{IUU} H_{LPP}

[28] Adaptive capacity is considered to be medium in *intensively used upland* areas because relative poverty may reduce the capacity to make infrastructure improvements and the loss of road networks due to flash floods would cut remote communities off from markets. However, the institutional capacity of local and national government to respond is relatively strong compared to the rest of the LMB.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					infrastructure caused by sudden flash flooding. These may include: roads and bridges being badly eroded or swept away by floods, buildings heavily damaged by water or destroyed, damage to irrigation infrastructure, and drinking water supply infrastructure (particularly groundwater wells) being contaminated with dirty surface water. **Exposure** Exposure for upland areas is determined as very high for *intensively used upland* areas due to the prevalence of deforestation on sloping land. For *lowland plateau and plains* areas, exposure is determined as medium rather than low because of the prevalence of deforestation in the province more generally and the consequent loss of soil water retention capacity. **Sensitivity** Sensitivity is either high or very high because flash floods are extremely destructive events and despite a		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					relatively higher standard of living in the province as a whole (compared to the rest of the LMB), key infrastructure is unlikely to be strong enough to withstand a flash flood. Moreover, the welfare impacts of these destructive events through loss of infrastructure are likely to be significant. Sensitivity is high in *intensively used upland* areas because of relatively higher poverty and the poorer condition of roads in remote areas.		
Landslides	Higher rainfall during the wet season and more intense rainfall events are likely to cause an increase in the magnitude and frequency of landslides.	VH_{IUU} M_{LPP}	H_{IUU} M_{LPP}	VH_{IUU} H_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of destruction or major damages to infrastructure caused by landslides. These may include: roads and bridges being badly eroded or swept away by floods, buildings heavily damaged or destroyed, water supply infrastructure (particularly groundwater wells) being	[29]L_{IUU} M_{LPP}	VH_{IUU} H_{LPP}

[29] Adaptive capacity is considered to be medium in *intensively used upland* areas because relative poverty may reduce the capacity to make infrastructure improvements and the loss of road networks due to landslides would cut remote communities off from markets. However, the institutional capacity of local and national government to respond is relatively strong compared to the rest of the LMB.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					contaminated with dirty surface water. **Exposure** Exposure for upland areas is determined as very high for *Intensively used upland* areas due to the prevalence of deforestation on sloping land – a major driver of erosion and increased risk of landslides. For *Lowland plateau and plains* areas, exposure is determined as medium rather than low because of the prevalence of deforestation in the province more generally and the consequent impact on erosion. **Sensitivity** Sensitivity is either high or very high because landslides are extremely destructive events and despite a relatively higher standard of living in the province as a whole (compared to the rest of the LMB), key infrastructure is unlikely to be strong enough to withstand a flash flood. Moreover, the welfare impacts of these destructive events through loss of infrastructure are		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					likely to be significant. Sensitivity is high in *Intensively used upland* areas because of relatively higher poverty and the poorer condition of roads in remote areas.		

2.3 KHAMMOUAN PROVINCE (LAO PDR)

2.3.1 OVERVIEW

Khammouan Province experiences some of the highest levels of poverty in Lao PDR. The low life expectancy in the province (56 years for men; 59 years for women) and high rate of child mortality (approximately one death per mother) are indicative of very poor health conditions. The quality of infrastructure is also generally low, although ongoing hydropower and mining activities in the province are contributing to expansion of the road network.

Rural households are heavily dependent on natural resources and are periodically exposed to food insecurity, whether through drought, floods, or price shocks. Extreme weather events have had a serious impact on food security and welfare in the recent past. In 2010, 22,660 people in Khammouan were in need of urgent food assistance due to a combination of late rains/drought and localized flooding (FAO 2011). During this period local rice production fell by 13% and rice prices rose by approximately 50% over a four-month period.

2.3.2 LIVELIHOOD ZONE(S)

Forested uplands: 17%; *Lowland plains and plateaus*: 78%; *Floodplain*: 5%.

Floodplain – In the *Floodplain* zone, the poverty rate is much lower: approximately 10 to 20% of the population, compared to 40% for the province as a whole. Population density is also higher and access to schools, markets, and electricity is higher. For example, deaths per 1,000 live births is <21 in Thakek (a district mostly consisting of *Floodplain* zone, as well as an urban center), compared to a figure four to five times higher in other districts of Khammouan. The population in *Floodplain* zones is also more likely to be dependent upon fishing for their livelihoods.

Forested uplands – In Khammouan, the *Forested uplands* zone largely comprises the northeastern district of Nakai. This district is the site of the Nam Theun 2 dam reservoir. A number of communities in this region were affected by the creation of the reservoir and were resettled in a World Bank program. The total number of affected people is approximately 7,200 or around 35% of the total population in the province of 20,600 people. Prior to this resettlement program, Nakai Province was by far the poorest district in Khammouan: half of all communes in the district experienced poverty rates above 60%; over 100 deaths per 1,000 live births were experienced; electricity use was less than 10% in most areas; and the main water source was rivers or other surface water. Following resettlement, the health and infrastructure situation has reportedly improved for these communities, but with smaller and poorer quality farm plots, less access to forests, NTFPs, and rivers. For the current purposes, we will consider the Nam Theun resettled villages to be experiencing different circumstances to the rest of the population and focus on the latter.

Lowland plains and plateaus – This area encompasses a large portion of the province and poverty levels vary. Communities in this zone of the province typically experience lower levels of socio-economic conditions compared to those in the floodplain zone. On the other hand, poverty levels are slightly lower than in remote upland areas. However, the overall levels of poverty, health, safe water access, and food security indicate a marginal and vulnerable existence in this particular zone and the province as a whole.

Key references

World Food Programme (2007), Lao Statistic Bureau (2010), Governance Reform and Livelihood Strengthening Programme (GPARLSP) (2006), FAO (2011), Nam Theun 2 Power Company Health Program Management Unit, Environment and Social Division (2008), DECIDE INFO (2012).

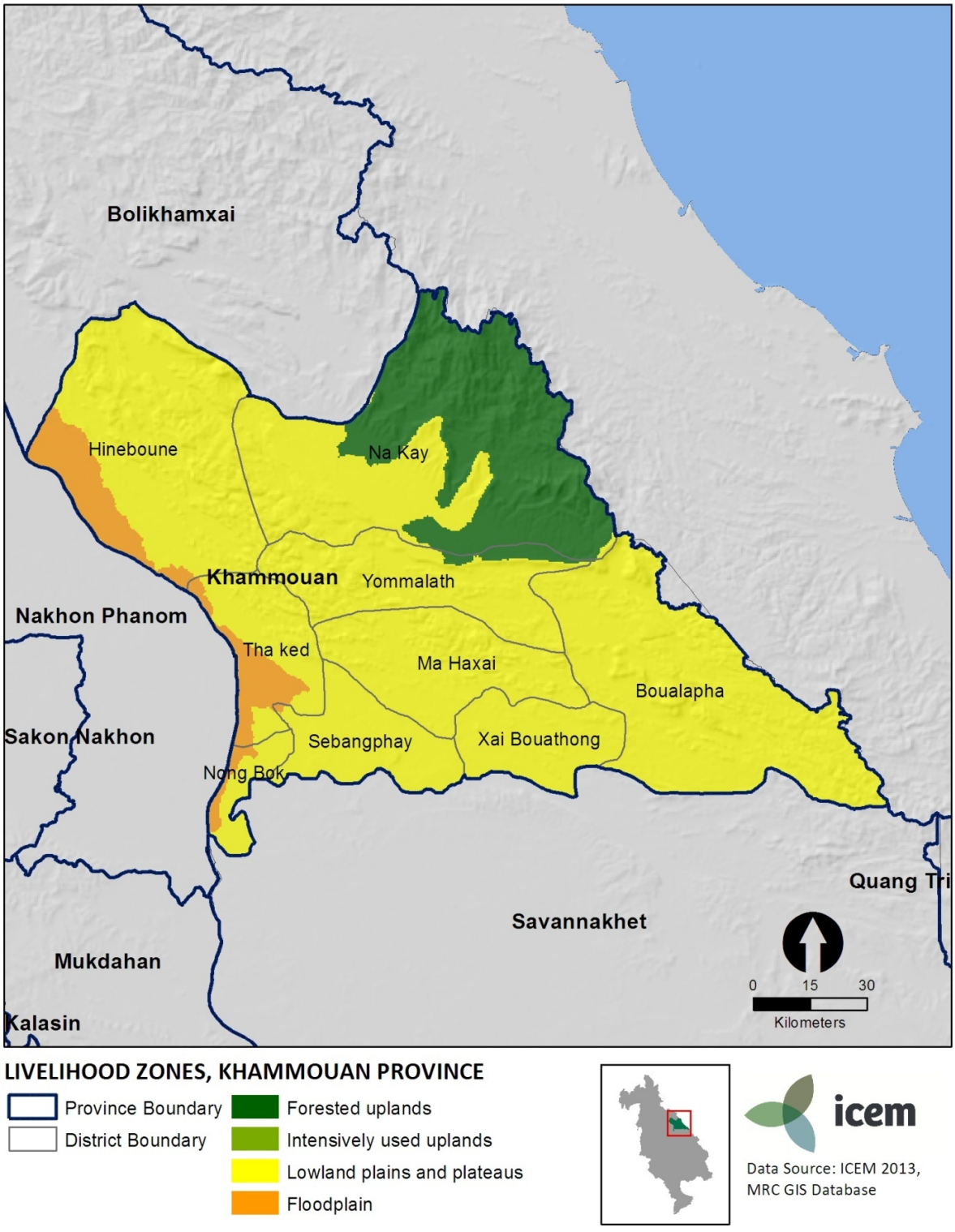

Figure 27: Districts of Khammouan Province and livelihood zones

2.3.3 SUMMARY OF KEY INDICATORS/SECTORS*

Indicator/theme	Key statistic(s)	Description
Poverty	40% (Lao PDR standard) (2009)	Khammouan Province experiences high levels of poverty. 59% of households state that lack of jobs is a restriction to earning higher income. The poverty rate is lowest in *Floodplain* and urban areas along the Mekong River, and highest among remote communities in higher elevation areas to the northeast of the province.
Food security	Level of household expenditure devoted to food: 74% Poor household food consumption: 1% Borderline household food consumption: 9%	Reported livelihood strategies: Agriculture (78%), Fishing (20%), Non-agricultural unskilled labor (18%), and Agricultural unskilled labor (18%). Proportion of households at risk of food insecurity due to: drought (20-39%); restricted forest access (>40%); price shock 11 months after harvest (10-20%). NTFPs are a critical source of food security in the majority of households, as well as a source of income. Estimated that the average rural family consumes the equivalent of US$280 per year in NTFPs (2005 dollars) and provides an average 55% of family cash income. Average net per capita rice production as a % of requirements was +15.2 (i.e., excess) from 2001-2005.
Human health	37% of population has access to safe water. 44% of population does not have access to a toilet.	Life expectancy: 56 years, men; 59 years, women. 78% of the population is covered by an anti-malaria program. 70% of the population has access to a midwife in their village; 34% have access to a health care worker in their village. Distance to nearest hospital: <10 km, 23.6%; 11-30 km, 54.5%, >31 km, 21.8%. Percentage of people having temporary health problems disrupting work in previous month: 45%. On average each woman in villages resettled by Nam Theun 2 experiences the death of at least one child; 83% of deaths occurred in children under the age of 5 years. 20% of resettled villagers from NT2 reported not consulting a health practitioner for treatment when ill because of fees. Rate of malaria is low, particularly in Nakai Plateau, despite high presence of mosquitoes because of the use of bed nets. In NT2 resettled villages, access to safe water and toilets is much higher: 74.5% of households have access to safe and adequate water, most (67.5%) comes from hand pumps; and toilet access is universal.

Indicator/theme	Key statistic(s)	Description
Population and demography	Population: 316,026 (2009) Population density 19 persons/km^2	3 main ethnic categories: (84.55% - Tai, Neua-Phouan, Phouthay; 14.84% - Nyo, Khumic, Vietic, Katuic; 0.61% - Hmong). 35% of population lives in upland areas; 65% lives in lowland areas and plains. 78% of households lives in rural areas. Dependency ratio is high at 84%. Average household size: 4.8 people.
Strength of key infrastructure	Main type of road: Gravel (52%), Earth (32%)	Note that infrastructure among communities resettled by NT2 is likely to be much stronger compared to infrastructure in other remote communities. For example, remote communities in Nakai typically use grass, wood, or other types of natural material as roofs.
Assets (land tenure, livestock, motorized transport)	Ownership by households: land, 99%; two-wheeled tractor, 46%; boat, 27%; fishing net, 73%	Main means of transport: Bicycle (24%), Motorbike (20%). 5% of households report receiving remittances. Average number of livestock per household: 2.9 cattle, 2.4 buffalo, 1.2 pigs, 0.9 goats. Average number of poultry per household: 11 (9 local chickens) (this is the lowest amount by all Lao provinces). 41% of households state that animal disease is a restriction to earning higher income. The quality of housing is low. Percentage of households operating a business: 20%. Percentage of households possessing particular goods: car, 4%; motorbike, 47%; bike, 42%; television, 60%; radio, 54%; mobile phone, 38%; refrigerator, 38%; washing machine, 2%; electric rice cooker, 22%. Most households have mosquito nets.
Education/skills	Percentage of villages with a: primary school, 82%; lower secondary school, 12%.	Regular operation of primary schools: 96%. Number of pupils per teacher: 19. Net school enrollment: 6-10 years, 75%; 11-15 years, 93%. But older generations have much lower education rates: e.g., 41% of the total population around NT2 has received no formal education. The quality of education is also low. Literacy rate (15+ years in NT2 resettled villages): Female, 28%; Male, 43%. 41% of households state that lack of knowledge is a restriction to earning higher income. Percentage of villages receiving agricultural extension workers: 31% (Lao PDR average 57%).
Physical infrastructure	74% of villages with some access to electricity, but 80% of domestic energy consumption is carbon based, i.e., forest	Average distance to nearest road: 7 km. Village accessibility during rainy season: 73%. Average distance to public transport: 8 km. 68% of households state that lack of irrigation is a restriction to earning higher income.

Indicator/theme	Key statistic(s)	Description
	biomass.	
Access to markets	53% and 32% of households state that, respectively, lack of access to markets and credit restrict earning higher income.	Average distance to district center: 5km. In rural areas with access to roads, percentage of food consumption in total expenditure/consumption: 63.8%; in areas without road access: 89%.

Notes: * 2007 data unless specified otherwise. These indicators comprise the main inputs into the climate change vulnerability assessment of health and infrastructure, with some additions. For sources see "Key references" earlier in this profile. NA indicates that data is not available.

Exposure	Sensitivity	Adaptive capacity
Location of people/assets	Poverty	Assets
Severity of threat	Food insecurity	Education/skills
Duration of threat	Human health	Physical infrastructure
	Strength of key infrastructure	Access to markets
	Demographic composition	

Notes: Assessment relates to all livelihood zones within the province unless otherwise specified. Subscripts relate to their corresponding livelihood zones: FU = *Forested uplands*; IUU = *Intensively used uplands*; LPP = *Lowland plains and plateaus*; F = *Floodplain*; D = *Delta*. For example, H_{FU} under the 'Exposure' heading indicates an assessment of High Exposure in the *Forested uplands* livelihood zone of the province.

2.3.4 KHAMMOUAN PROVINCE - HEALTH CLIMATE CHANGE VULNERABILITY ASSESSMENT

THREAT		*IMPACT*					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Temperature	Under baseline conditions maximum temperatures vary on average between 20.2 to 29.5°C during the year, with temperatures peaking in April, averaging 28.4°C and dropping to a minimum in December. With climate change, temperatures are projected to follow a similar pattern; however there is projected to be a positive shift in the mean temperature of about 2.0°C. Under baseline conditions average daily minimum temperatures range between 13.5 to 22.8°C, peaking in June and July. With climate change, temperatures are projected to follow a similar pattern; however there is projected to be a positive shift in the average of 0.9°C (19.7 to 20.8°C). Number of days exceeding 35°C is	L	VH_{FU} VH_{LPP} H_F	M	**Interpretation of threat** The threat of temperature rise is interpreted as the direct impact on human health (i.e., heat exhaustion) and the incidence of disease vectors. **Exposure** Exposure is estimated to be very low because the increase in temperature is not estimated to be high and will not have a strong direct impact on human health. However, slightly higher temperatures may provide improved breeding conditions for disease vectors. **Sensitivity** Sensitivity is high or very high because Khammouan is an extremely poor province compared to the rest of the	L_{FU}[30] L_{LPP} M_F[31]	M

[30] Adaptive capacity is considered to be low in *Forested uplands* and *Lowland plains and plateaus* zones because health access is poor, education is poor, and the level of physical infrastructure and assets that can offset manual labor is limited; for example, bikes are the main form of transport. However, given that the threat itself is very low, even a relatively low adaptive capacity should be sufficient to offset adverse consequences.

[31] Adaptive capacity is considered to be medium because of comparatively higher rates of education, access to markets, electricity, and physical infrastructure compared to the rest of the province.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	projected to change from 0 to about 2%.				LMB, with 40% of the population estimated to be poor by Lao standards. Baseline health conditions are very poor (e.g., only 37% of the population has access to safe water and the life expectancy of men is only 56 years) and >75% of health centers are either 11-30 km, or >30 km away from households. In *forested upland* areas (notwithstanding the improved living conditions of NT2 resettled communities) sensitivity is judged to be very high due to high rates of poverty (>60% in half of all communes in this zone) and this ranking is also given to *Lowland plains and plateaus* areas. *Floodplain* areas have much lower rates of poverty, better health conditions, and better access to services; therefore, sensitivity in this zone is judged to be high.		
Precipitation	Lowland areas of Khammouan show a strong seasonal pattern characterized by the monsoon rains from May to	L	H_{FU} H_{LPP} M_F	M	**Interpretation of threat** The threat of higher precipitation is interpreted as the impact on health	H[32]	L

[32] Adaptive capacity is judged to be high in all zones because communities are used to high rainfall events at present and, more importantly, most households have mosquito nets. The latter asset vastly reduces the incidence of mosquito-borne disease in the population, particularly malaria.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	November. Peak rainfall occurs in August accounting for about 25% of the total annual rainfall. With climate change annual rainfall is projected to increase from 2,610 mm/yr to 2,945 mm/yr (+335 mm/yr). Peak monthly rainfall in August is projected to increase from 645 to 700 mm/yr. The largest increases in rainfall (in % terms) are projected to occur during April, May (before the monsoon), and September (during the monsoon) (more than 20% increase in monthly rainfall in each case).				through greater accumulation of non-flood related stagnant water bodies and the consequent creation of breeding grounds for disease vectors. **Exposure** Exposure to this threat is defined as low because higher rainfall will generally be occurring in periods where there is already high rainfall (May to September). **Sensitivity** Sensitivity to the threat is medium to high because baseline health conditions are very low and poverty is high, despite the threat not representing a significant change in normal conditions (see above). Sensitivity is medium in *Floodplain* areas because of higher baseline health conditions, lower poverty, and better access to services.		
Change and shift in events							
Drought (see definition)	Comparison of monthly rainfall and Potential Evaporation (PET) conditions gives an agricultural definition of drought. According to this definition under	NA	NA	NA	**Interpretation of threat** The threat from increased drought is considered to be of little significance given the higher rainfall, moderately		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	historic conditions drought occurs in some years for January – April and Oct – Nov. Drought never occurs during the middle of the wet season, May – September. This trend is projected to continue with climate change with very little change in drought occurrence.				higher temperatures, and increased year-round soil water availability.		
Flooding	Higher rainfall is likely to increase the incidence and severity of flooding in riparian areas.	L_{FU} H_{LPP} VH_F	VH_{FU} VH_{LPP} H_F	M_{FU} VH_{LPP} VH_F	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by slow-onset flooding, as well as the attendant indirect impacts on human health through: increased incidence of water-borne and vector-borne disease; food insecurity caused by decreased access to forest resources and, in remote areas, access to markets; and, reduced access to safe water, particularly water bores. **Exposure** In *Forested upland* areas, exposure is considered to be low presuming that	[33] L_{FU} M_{LPP} L_F	M_{FU} VH_{LPP} VH_F

[33] Adaptive capacity is low or medium across all zones because the level of education is low; around 25% of villages across the province cannot be accessed during the rainy season, and access to credit and markets is a major limitation for 53% and 32% of households respectively. However, seasonal flooding is common and the population has experience coping with such events and households hold livestock asset that can be used as insurance. The inhabitants of *forested upland* areas and *floodplain* areas are both more likely to be cut off from markets and access to health centers in times of flooding, and their respective adaptive capacity is therefore considered to be low.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					higher-elevation areas will experience less slow-onset flooding than lower elevation areas. Conversely, exposure is considered to be very high in *Floodplain* areas because communities are living in riparian areas and are, by definition, living in a *Floodplain*. The major anticipated impacts are through indirect impacts on health through water-borne disease, restricted access to resources, and reduced access to safe water. Exposure is ranked high for communities in *Lowland plains and plateau* areas because, although potentially living in riparian areas, they may be less exposed to flooding. Some areas downstream of major dams (e.g., Nam Theun 2) may experience some flood protection. **Sensitivity** Sensitivity is considered to be very high or high in all livelihood zones because communities in all zones are poor, have poor health conditions, limited access to safe water (e.g., province-wide access is estimated to be 37%), and are heavily dependent on forest resources (e.g.,		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					province-wide it is estimated that NTFPs provide 55% of family cash income, the figure for *Forested uplands* would be higher. Over 40% of the population says that restricted forest access exposes them to food insecurity). Sensitivity is considered to be high rather than very high in the *Floodplain* zone because of lower poverty rates and better health conditions.		
Flash floods	Higher rainfall likely to increase the incidence and severity of flash floods in higher-elevation and sloping areas.	H_{FU} L_{LPP} L_F	VH_{FU} VH_{LPP} H_F	VH_{FU} H_{LPP} M_F	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by flash flooding, as well as the attendant indirect impacts on human health through damage to assets. **Exposure** In *forested upland* areas, exposure is considered to be high given that higher-elevation areas will have steeper slopes	[34]L_{FU} M_{LLP} M_F	VH_{FU} H_{LPP} M_F

[34] Adaptive capacity is low or medium across all zones because the level of education is low; around 25% of villages across the province cannot be accessed during the rainy season, and access to credit and markets is a major limitation for 53% and 32% of households respectively. The inhabitants of *forested upland* areas are likely to be much further from markets and access to health centers will be more difficult following flash flood events, and their adaptive capacity is therefore considered to be low.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					that will generate more flash floods. Areas downstream of locations of ongoing deforestation will experience increased incidence of flash floods due to lower watershed protection. The risk of death and injury from these events is considered to be significant given their sudden onset. Conversely, exposure is considered to be low in *Floodplain* and *Lowland plains and plateau* areas because, although communities are likely to be living in riparian areas, they are considered to be more highly exposed to slow-onset flooding than flash flooding given their flatter topography. **Sensitivity** Sensitivity is considered to be very high in all livelihood zones because communities in each zone are poor, experience poor health conditions, and limited access to safe water (e.g., province-wide access is estimated to be 37%). Injury or the death of a productive household member would have major impacts on the high number (on average) of dependents per household. Livestock		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					are frequent victims of flash flooding and represent a major part of a household's insurance strategy in times of food stress (e.g., an average household owns 7 larger livestock and 11 poultry). Sensitivity is considered to high rather than very high in the *Floodplain* zone because of lower poverty rates and better health conditions.		
Landslides	Higher rainfall likely to increase the incidence and severity of landslides in sloping areas.	H_{FU} M_{LPP} L_F	VH_{FU} VH_{LPP} H_F	VH_{FU} H_{LPP} M_F	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by landslides, as well as the attendant indirect impacts on human health through damage to assets and/or reduced road access. **Exposure** In *Forested upland* areas, exposure is considered to be high given that higher-elevation areas will have steeper slopes that will generate landslides. The risk of death and injury from these events is	[35] L_{FU} M_{LPP} M_F	VH_{FU} H_{LPP} M_F

[35] Adaptive capacity is low or medium across all zones because the level of education is low; around 25% of villages across the province cannot be accessed during the rainy season, and access to credit and markets is a major limitation for 53% and 32% of households respectively. The inhabitants of *forested upland* areas are likely to be further from markets and access to health centers will be more difficult following landslide events; their adaptive capacity is therefore considered to be low.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					considered to be significant given their violent nature. Exposure is considered to be low or medium in *Floodplain* and *Lowland plains and plateau* areas because they are less likely to be situated on sloping land. However, ongoing deforestation and consequent land degradation in *Lowland plains and plateau* areas is considered to raise potential exposure in these areas to medium. **Sensitivity** Sensitivity is considered to be very high in all livelihood zones because communities in each zone are poor, experience poor health conditions, and limited access to safe water (e.g., province-wide access is estimated to be 37%). Injury or the death of a productive household member would have major impacts on the high number (on average) of dependents per household. The loss of shelter or other assets would drive marginal groups into poverty. Sensitivity is considered to be high rather than very high in the *Floodplain* zone because of lower poverty rates and better health		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					conditions.		

2.3.5 KHAMMOUAN PROVINCE - INFRASTRUCTURE CLIMATE CHANGE VULNERABILITY ASSESSMENT

THREAT		*IMPACT*					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Temperature	Under baseline conditions maximum temperatures vary on average between 20.2°C to 29.5°C during the year, with temperatures peaking in April, averaging 28.4°C and dropping to a minimum in December. With climate change, temperatures are projected to follow a similar pattern; however there is projected to be a positive shift in the mean temperature of about 2.0°C. Under baseline conditions average daily minimum temperatures range between 13.5 to 22.8°C, peaking in June and July. With climate change, temperatures are projected to follow a similar pattern; however there is projected to be a positive shift in the average of 0.9°C (19.7 to 20.8°C). Number of days exceeding 35°C projected to change from 0 to about 2%.	NA	NA	NA	**Interpretation of threat** The threat is not considered to be relevant to infrastructure.	NA	NA

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Precipitation	Lowland areas of Khammouan show a strong seasonal pattern characterized by the monsoon rains from May to November. Peak rainfall occurs in August accounting for about 25% of the total annual rainfall. With climate change annual rainfall is projected to increase from 2,610 mm/yr to 2,945 mm/yr (+335 mm/yr). Peak monthly rainfall in August is projected to increase from 645 to 700 mm/yr. The largest increases in rainfall (in % terms) are projected to occur during April, May (before the monsoon) and September (during the monsoon) (more than 20% increase in monthly rainfall in each case).	M	H	M	**Interpretation of threat** The threat of higher precipitation is interpreted as the direct impact on roads, bridges, and buildings of higher precipitation (i.e., not indirect impacts though, for example, flooding). **Exposure** Exposure to this threat is defined as moderate because higher rainfall will generally be occurring in periods where there is already high rainfall (May to September). **Sensitivity** Sensitivity to the threat is high because the condition of roads is weak province-wide: 52% are gravel and 48% are earth. The latter impact (i.e., degradation of roads) is likely to be the greatest direct impact of precipitation. Given the high level of poverty in the province, it is likely that the condition of buildings and bridges is generally weak.	[36]L_F U L_{LPP} M_F	M_F U M_{LP} P M_F
Change and shift in events							
Drought (see definition)	(i) Comparison of monthly rainfall and Potential Evaporation (PET) conditions gives an agricultural definition of drought. According to this	NA	NA	NA	**Interpretation of threat** The threat is not considered to be relevant to infrastructure.	NA	NA

[36] Adaptive capacity is judged to be low in *forested upland* and *lowland plains and plateau* areas because the level of education, skills, and assets is low. Moreover, limited credit opportunities limit the ability for households or communities to repair damaged infrastructure. Adaptive capacity is judged to be medium in *floodplain* areas because of comparatively higher rates of education, access to markets, electricity, and physical infrastructure compared to the rest of the province.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	definition under historic conditions drought occurs in some years for January – April and Oct – Nov. Drought never occurs during the middle of the wet season, May – September. This trend is projected to continue with climate change with very little change in drought occurrence.						
Flooding	Higher rainfall likely to increase the incidence and severity of flooding in riparian areas.	L_{FU} H_{LP} VH_{F}	VH FU VH LPP H_F	H_F U VH LPP VH F	**Interpretation of threat** The threat is interpreted as the risk of damages to infrastructure caused by slow-onset flooding. These may include: roads and bridges being eroded by floods, buildings water-damaged or destroyed, water supply infrastructure (particularly groundwater wells) being contaminated with dirty surface water. **Exposure** In *Forested upland* areas, exposure is considered to be low presuming that higher-elevation areas will experience less slow-onset flooding than lower elevation areas. Conversely, exposure is considered to be very high in *Floodplain* areas	[37]L_F U M_{LP} L_F	M_F U VH LPP VH F

[37] Adaptive capacity is low or medium across all zones because the level of education is low; around 25% of villages across the province cannot be accessed during the rainy season, and access to credit and markets is a major limitation for 53% and 32% of households respectively. However, seasonal flooding is common and the population has experience coping with such events (i.e., situating key infrastructure such as grain stores at higher elevations). However, households are likely to take mitigation measures subject to past experience: the introduction of a new flood regime may exceed such measures. The inhabitants of *forested upland* areas and *floodplain* areas are both more likely to be cut off from markets in times of flooding, and their respective adaptive capacity to repair damaged or destroyed infrastructure is therefore considered to be lower.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
					because communities are living in riparian areas and are, by definition, living in a *Floodplain*. Exposure is ranked high for communities in *Lowland plains and plateau* areas because, although potentially living in riparian areas, they may be less exposed to flooding. Some areas downstream of major dams (e.g., Nam Theun 2) may experience some flood protection. **Sensitivity** Sensitivity is considered to be very high or high in all livelihood zones because communities in all zones are typically poor by the standards of the LMB and the capacity of infrastructure to withstand flooding is likely to be low. Sensitivity is considered to high rather than very high in the *Floodplain* zone because of lower poverty rates and, consequently, the existence of relatively stronger infrastructure.		
Flash floods	Higher rainfall likely to increase the incidence and severity of flash floods in higher-elevation and sloping areas.	H_{FU} L_{LPP} L_F	VH FU VH LPP H_F	VH FU M_{LP} P M_F	**Interpretation of threat** The threat is interpreted as the risk of destruction or major damages to infrastructure caused by sudden flash flooding. These may include: roads and bridges	[38]L_F U M_{LP} P M_F	VH FU M_{LP} P M_F

[38] Adaptive capacity is low or medium across all zones because the level of education is low, and access to credit and markets is a major limitation for 53% and 32% of households respectively. Households are likely to take mitigation measures subject to past experience; the introduction of a new regime for flash floods may exceed such measures. The inhabitants of *forested upland* areas are likely to be more remote from markets or be cut off from them during the rainy season when flash floods are likely to occur and adaptive capacity to repair damaged or destroyed infrastructure is therefore considered to be low.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
					being badly eroded or swept away by floods, buildings heavily damaged by water or destroyed, water supply infrastructure (particularly groundwater wells) being contaminated with dirty surface water. **Exposure** In *Forested upland* areas, exposure is considered to be high given that higher-elevation areas will have steeper slopes that will generate more flash floods. Areas downstream of locations of ongoing deforestation will likely experience increased risk of flash floods. The risk of severe damage to built infrastructure from these events is considered to be significant given their force. Conversely, exposure is considered to be low in *Floodplain* and *lowland plains and plateau* areas because, although communities are likely to be living in riparian areas, they are considered to be more highly exposed to slow-onset flooding than flash flooding given their flatter topography. **Sensitivity** Sensitivity is considered to be very high or high in all livelihood zones because communities in all zones are typically poor by the standards of the LMB and the capacity of infrastructure to		

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
					withstand flooding is likely to be low. Sensitivity is considered high rather than very high in the *Floodplain* zone because of lower poverty rates and, consequently, the existence of relatively stronger infrastructure.		
Landslides	Higher rainfall likely to increase the incidence and severity of landslides in sloping areas.	H_{FU} M_{LPP} L_F	VH FU VH LPP H_F	VH FU H_{LPP} M_F	**Interpretation of threat** The threat is interpreted as the risk of destruction or major damages to infrastructure caused by landslides. These may include: roads and bridges being badly eroded or swept away by floods, buildings heavily damaged or destroyed, water supply infrastructure (particularly groundwater wells) being contaminated with dirty surface water. **Exposure** In *Forested upland* areas, exposure is considered to be high given that higher-elevation areas will have steeper slopes that will generate landslides. Landslides are also very destructive, thus increasing the severity of the threat. The risk of complete destruction of rural infrastructure in the path of a landslide is a major concern. Exposure is	[39] L_{FU} M_{LPP} M_F	VH FU H_{LPP} M_F

[39] Adaptive capacity is low or medium across all zones because the access to markets and credit is a major limitation for 53% and 32% of households respectively. A devastating landslide could remove all assets available to households (such as livestock, buildings, and potentially land). The inhabitants of *forested upland* areas are likely to be more remote from markets or be cut off from them during the rainy season when landslides are likely to occur and adaptive capacity to repair damaged or destroyed infrastructure is therefore considered to be low.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
					considered to be low or medium in *Floodplain* and *Lowland plains and plateau* areas because they are less likely to be in situated on sloping land. However, ongoing deforestation and consequent land degradation in *Lowland plains and plateau* areas is considered to raise potential exposure in these areas to medium. **Sensitivity** Sensitivity is considered to be very high in all livelihood zones because communities are poor and infrastructure is highly unlikely to survive the powerful impact of a landslide.		

2.4 KIEN GIANG PROVINCE (VIETNAM)

2.4.1 OVERVIEW

Kien Giang is a southwestern province of the Mekong Delta. The landscape predominantly consists of intensively farmed rice paddies and accompanying waterways and road networks. Rural households typically engage in a livelihood mix of rice farming and fishing (including aquaculture and sea capture fisheries). Although the poverty rate in the province is low relative to the rest of the LMB (6% by Vietnam standards), the high rural population (1.4 million) means that the incidence of poverty is high. Moreover, the intensive nature of farming and the high exposure to extreme events (e.g., flooding from the Mekong mainstream and coastal storm surges) raises the vulnerability of households to fall below the poverty line.

The proximity of the coast is a defining factor in the natural and built environment in rural areas. Farming relies on a dense network of canals and dykes controlling water management, including the inflow of saline surface water. Soil fertility (due to high acidity) is generally poor, requiring intensive use of inputs in farming. These factors increase the exposure of rural households to extreme events, including flooding from the Mekong mainstream and coastal storm surges. Aquaculture is a common practice; conversion of land from rice to saline shrimp production involves a high level of risk.

The rural poor are typically landless or have very small land-holdings. Non-permanent housing comprises a majority of housing types in rural areas. Health access and food security for the entire population is relatively high, although significant discrepancies exist between different income groups. Provincial economic growth is high, facilitating the development of agro-food processing and other opportunities for rural incomes. However, the official annual rate of outward migration (0.7% of the total population), which is likely to be a significant under-estimate of actual migration, indicates that local opportunities are insufficient for a significant proportion of the population.

2.4.2 LIVELIHOOD ZONE(S)

Delta zone: ≈100%.

Key references

General Statistics Office of Vietnam (GSO) (2012), Mackay, P. and M. Russell (2011a), Mackay, P. and M. Russell (2011b), Mackay, P. (2009), United Nations (2010).

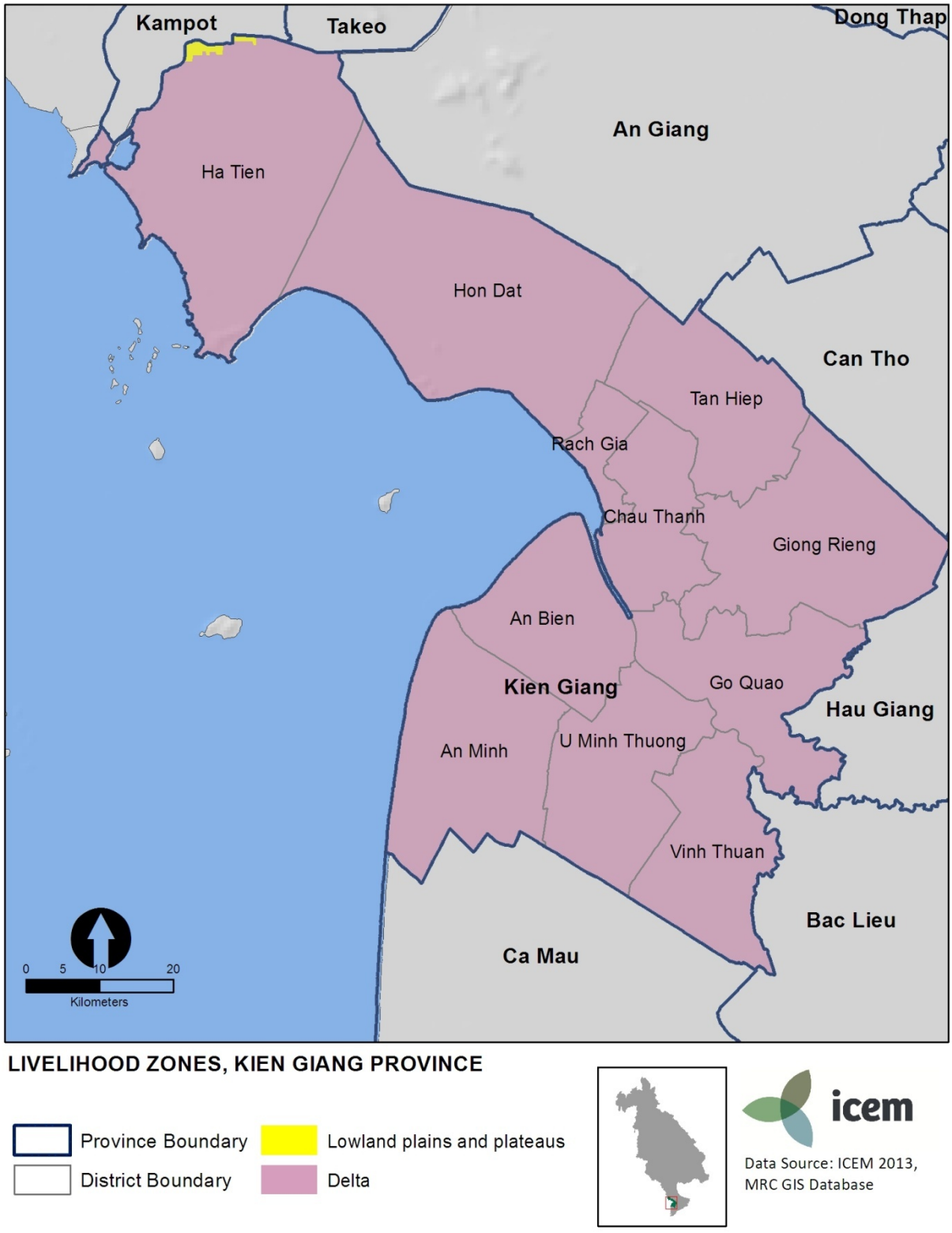

Figure 28: Districts of Kien Giang Province and livelihood zones

2.4.3 SUMMARY OF KEY INDICATORS/SECTORS*

Indicator/theme	Key statistic(s)	Description
Poverty	Provincial poverty rate: 7.2% (Vietnam standard)	Although the poverty rate in Kien Giang is relatively low compared to the rest of the LMB, the incidence of poverty is high: approximately 96,000 people#. The poverty rate by district varies from 1% to 15%. Income inequality is also very significant: monthly income per capita for the lowest quintile is 390,500 VND (≈US$19); the corresponding figure for the highest quintile is 3,050,700 VND (≈US$146).
Economy	GDP per capita: US$972 (2010) Sectoral share of GDP: agriculture, forestry and fisheries, 42%; industry and construction, 26; services and trade, 32%	Strong provincial economic growth of 12% per year from 2001-2010. Government-driven expansion in Small and Medium-Sized Enterprises: in 2005 only 240 registered companies, in 2010 there were 3,600 (mostly in agro-processing sectors and tourism). Industry and services are increasing as a share of GDP. Labor share by sector: agriculture, forestry and fisheries, 56%; industry: 12%; services and trade, 32%. The poor population often combines various livelihood activities, i.e., coastal fishing, agriculture, and aquaculture. There is a large seaport at Ha Tien for export overseas and to other provinces, as well as a growing tourism industry. Significant shift in agricultural practices over the last decade from low-yielding paddies to high-yielding shrimp cultivation. Two-thirds of land use in the province is for agriculture. The value of agricultural output doubled from 2004-2010. Retail sales of goods and services have increased by approximately 600% (at constant prices) between 2000 and 2011.
Food security	18.8% of children under 5 estimated to be underweight (approximately equal to national average)	The food security situation in Kien Giang is relatively strong. Yields of paddy rice have increased from 42.2 quintal/ha to 57.4 quintal/ha between 2000 and 2011. However, farmers (both rice and shrimp) are highly exposed to flooding and high yield losses in a single season. So although poverty is relatively low compared to the rest of the LMB, communities are exposed to sudden food insecurity, as flooding in 2011 showed. In relatively poor communities around U Minh Tuong (the district with the highest poverty rate), 28% of household expenditure is on food (below the national average of 46.7%) indicating a high level of self-sufficiency. Fish, whether from aquaculture or, in coastal areas, the sea, is a primary source of protein for a large majority of the population. Production of capture sea fishing has risen by 168.9 to 262.2 kilotonnes from 2000-2011; production of aquaculture and aquaculture shrimp has respectively

Indicator/theme	Key statistic(s)	Description
		risen by 9.9 to 110.5 kilotonnes and 1.76 to 34.7 kilotonnes over the same period.
Human health	Population per health establishment: 10,256 Population per doctor: 1,880 Proportion of people not expected to live to age 40: 5.4% (2004)	By the standards of the rest of the LMB access to health services is relatively strong. However, there are discrepancies in health access for the rich and poor. 46% of people use private health facilities for outpatient-visits. Population per patient bed: 430. However, 18.8% of children under 5 estimated to be underweight (approximately equal to national average), indicating a significant level of malnutrition.
Population and demography	Population size: 1.71 million Annual population growth: 1.3% Population density: 270 person/km^2 Dependency ratio: 0.43	Official net annual migration is estimated at -0.7% of the total population; the high level of temporary and unreported economic migration to, in particular, Ho Chi Minh City would suggest that this is a significant under-estimate. 73% of the Kien Giang population lives in rural areas. 16% of the population is comprised of ethnic minorities (Khmer 13%, poverty rate 18%; other groups 3%, poverty rate 32%). Average household size is 4.1 on average; 4.3 in lowest income quintile.
Strength of key infrastructure	Housing: 6.1% permanent, 43.9% semi-permanent, 23.2% temporary, 26.8% temporary and other	Housing is, in general, not particularly strong. Dyke systems have broken or been overtopped in previous flooding and coastal storm surge events. Flooding in inland areas is exacerbated by the replacement of floodplain with a managed dyke system and fields.
Assets (land tenure, livestock, motorized transport)	-	Most of the poor are either landless or have very limited landholdings. The average size of landholdings in U Minh Thuong is high (4.0 ha, compared to a Delta-wide average of 0.79 ha), but productivity is very low (paddy rice yield <2.5 t/ha). Aquaculture is becoming an increasingly important livelihood (intensive aquaculture can require significant assets): area used for aquaculture rose from 13,000 ha in 1995 to 127,523 ha in 2010. Poultry are maintained for home consumption by 25% and 10% of households in U Minh Thuong and Kien Luong respectively; fish are a more important source of protein than meat. Per capita livestock: buffalo, 0.005; cattle, 0.007; pigs, 0.19; poultry,

Indicator/theme	Key statistic(s)	Description
		3.4.
Education/skills	Population per teacher: 203. 83 Adult literacy ≈ 100% (Official statistics) Adult literacy = 90.3% (UNDP for 2004) School attendance: 68% (Kien Luong); 89% ages 7-11, 65% ages 12-18 (U Minh Thuong)	Overall literacy is higher than average compared to the rest of the LMB. However, the poor are likely to have lower access – "lack of money" was cited as the reason for non-attendance for 50% and 59% of school-age children in U Minh Thuong and Kien Luong respectively. In Vietnam, drowning is the largest cause of accidental death in pre-adolescent children due to lack of swimming ability; only 35% of children in the Mekong Delta can swim.
Physical infrastructure	Health establishments: 156 Water source: Wells (U Ming Thuong, 90%; Kien Luong, 44%) Percentage of population without access to clean water: 16.7% (2004)	There is an extensive electrical transmission network in the province, but coverage can be limited in rural areas. For example, 20% and 12% of households in Kien Luong and U Minh Thuong respectively; a further 8% and 11% had access to diesel generators. Shrimp farms require extensive infrastructure: dykes and bunds for water control, pumps, aerators, pond liners. An extensive road network and waterway network exist (for example, there are 83,000 inland boats). The volume of road and water freight has respectively increased by 569 to 1,698 kilotonnes and 1,201 to 4,091 kilotonnes between 2000 and 2010. Most households use rudimentary 'drop toilets' in rural areas. Private wells are the principal source of water in rural areas.
Access to markets	-	Strong access to markets for selling produce. Access to credit generally strong.

Notes: *2011 data unless specified otherwise. These indicators comprise the main inputs into the climate change vulnerability assessment of health and infrastructure, with some additions. # Based on official figures displayed elsewhere in this table. For sources see "Key references" earlier in this profile.

Exposure	Sensitivity	Adaptive capacity
Location of people/assets	Poverty	Assets
Severity of threat	Food insecurity	Education/skills
Duration of threat	Human health	Physical infrastructure
	Strength of key infrastructure	Access to markets
	Demographic composition	

2.4.4 KIEN GIANG PROVINCE - HEALTH CLIMATE CHANGE VULNERABILITY ASSESSMENT

THREAT		*IMPACT*					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
Temperature	Under baseline conditions maximum temperatures vary on average between 28.7°C to 34.3°C during the year, with temperatures peaking in April, averaging 33.7°C and dropping to a minimum in December and January. With climate change, temperatures are projected to follow a similar pattern, with a rise in the mean maximum temperature of 3°C year round. The proportion of days exceeding 35°C is projected to increase from 5% to 25%.	H	M	H	**Interpretation of threat** The threat of temperature rise is interpreted as the direct impact on human health (i.e., heat exhaustion) and the incidence of disease vectors. **Exposure** Exposure is deemed to be high because there is a substantial upward shift in the number of days exceeding 35°C and a risk of heat exhaustion where there may not have been one before. Most household workers are engaged in outdoor activities related to agriculture and fishing. **Sensitivity** Sensitivity is medium because the overall population has	H[40]	H

[40] Adaptive capacity is high because access to services is relatively good, although costs may preclude access for the poorest. Most households have access to electricity facilitating household cooling.

THREAT		*IMPACT*				*Adaptive capacity*	*Vulnerability*
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*		
					relatively higher standards of income, food security, and health compared to the rest of the LMB.		
Precipitation	Kien Giang Province shows a strong seasonal pattern characterized by the monsoon rains from May to November. Peak rainfall occurs in October, accounting for about 20% of the total annual rainfall. With climate change annual rainfall is projected to increase from 1,280 mm/yr to 1,370 mm/yr (+90 mm/yr), with the largest increases during October (259 to 285 mm/yr) and September (161 to 185 mm/yr).	VL	M	L	**Interpretation of threat** The threat of precipitation rise is interpreted as the increase in breeding grounds for disease vectors. **Exposure** Exposure is judged to be very low because the increase in precipitation would occur in the wet season and would be unlikely to be of sufficient magnitude to make more than a marginal impact on the level of surface water accumulation. **Sensitivity** Sensitivity is medium because the overall population has relatively higher standards of income, food security, and health compared to the rest of the LMB. Moreover, Kien Giang has a relatively low dependency ratio.	H	L
Change and shift in events							

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
Drought	The instance of drought is projected to increase at the end of the dry season (in April, drought occurrence will rise from 60% to 80%) and the beginning of the dry season (November, rise from 16% to 20%; December rise from 76% to 84%).	M	M	M	**Interpretation of threat** The threat is interpreted as the impact of reduced access to rainwater as a drinking water source. **Exposure** Exposure is considered to be medium. Despite a significant projected change in drought conditions towards the end of the dry season, groundwater is the dominant drinking water source in rural areas. Moreover, the greater level of precipitation and flooding could potentially increase the rate of groundwater recharge. **Sensitivity** Sensitivity is medium because the overall population has relatively higher standards of income, food security, and health compared to the rest of the LMB.	[41]M	M
Flooding	The concurrence of increased precipitation, wet season flows in the Mekong,	V H	H	V H	**Interpretation of threat** The threat is interpreted as the	M[43]	VH

[41] Adaptive capacity is considered to be medium because offsetting relatively strong access to markets and other physical infrastructure is the observation that groundwater wells are the most dominant form of water source. Therefore, it would be necessary to obtain alternatives either through expensive piped water systems or rainwater collection tanks. Moreover, the lack of assets in poor households, particularly land, would decrease the capacity to afford new investments such as a rainwater tank.

[43] Adaptive capacity is judged to be medium because the highly regulated nature of the waterways tends to trap floodwaters and prevent dispersion and therefore prolonging the extent of floods. On the other hand the level of assets, education, and access to markets is strong for most of the population.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
	sea level rise, and storm surges is projected to increase the incidence of flooding. The land area of the province projected to have flood depth >0.5 m for more than 2 months/year is projected to rise from 15% to 65%.[42]				risk of death and injury caused by slow-onset flooding, as well as the attendant indirect impacts on human health through: increased incidence of water-borne and vector-borne disease; food insecurity caused by loss of crops or income-generating assets; and, reduced access to safe water, particularly water bores. **Exposure** Exposure is considered to be very high because most of Kien Giang's land mass is susceptible to flooding and population density is very high. **Sensitivity** Sensitivity is considered to be medium because poverty and other welfare indicators are generally strong. Offsetting this trend is the observation that child malnutrition is relatively high – potentially indicating existing exposure to enteric and other disease associated with poor sanitary conditions. Flooding would greatly increase this exposure, however floods do happen on a seasonal basis and it is likely that the population is accustomed to		

[42] Increase in inundation area, and depth and duration of flooding is also indicated in recent modeling work in Mackay and Russell (2011).

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
					taking some precautionary measures.		
Flash floods	This threat is not applicable to this area						
Landslides	This threat is not applicable to this area						
Salinity	Mackay and Russell (2011b) project that saline intrusion will actually decrease as a result of climate change. This is due to the impact of additional flooding from local areas and the Mekong offsetting any increase in saline intrusion due to sea level rise and storm surges. On this basis, this threat is not deemed relevant to this particular area of the Delta.	-	-	-	-	-	-
Sea level rise/storm surges	Mackay and Russell (2011b) show that the impact of sea level rise is likely to manifest itself most prominently in terms of flooding (addressed above) and in terms of the height of storm surges. Given that the former is dealt with elsewhere in this table we address the latter issue here. Mackay and Russell (2011b) project that the increase in the combined effect of storm	L	M	M	**Interpretation of threat** The threat is interpreted as the risk of death or injury resulting from enhanced storm surges due to climate change. **Exposure** Exposure is considered to be low because the change in storm surge levels is not projected to be high. Although there may be greater risk of	[44]H	M

[44] Adaptive capacity is considered to be high given the relative level of infrastructure, assets, and access to markets in the province. Moreover, the major adaptation would be relocation of human beings away from immediate coastal areas during particular times.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
	surges and sea level rise will be moderate across the province, with the only major changes (with a 30 cm rise in sea levels by 2050) being in Ha Tien (6% to 13%) and the island province of Kien Hai (12% to 18%). Wave height and energy is expected to increase during storm events.				occupants of sea vessels being drowned during storms, it is likely that they will avoid being in vessels at these times. **Sensitivity** Sensitivity is medium because the overall population has relatively higher standards of income, food security, and health compared to the rest of the LMB.		

2.4.5 KIEN GIANG PROVINCE - INFRASTRUCTURE CLIMATE CHANGE VULNERABILITY ASSESSMENT

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
Temperature	Under baseline conditions maximum temperatures vary on average between 28.7°C to 34.3°C during the year, with temperatures peaking in April, averaging 33.7°C and dropping to a minimum in December and January. With climate change, temperatures are projected to follow a similar pattern, with a rise in	H	VL	M	**Interpretation of threat** The threat is interpreted as the effect of higher temperatures on the functioning of infrastructure such as roads, electricity distribution networks, and buildings. **Exposure**	H[45]	M

[45] Adaptive capacity is considered to be high because the overall level of assets, education, infrastructure, and markets is strong in the province. Moreover, the provincial government is well-resourced and has demonstrated a willingness to invest in infrastructure.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
	the mean maximum temperature of 3°C year round. The proportion of days exceeding 35°C is projected to increase from 5% to 25%.				All rural infrastructure in the province will be exposed to higher temperatures. **Sensitivity** Sensitivity is considered to be very low because it is not expected that there will be any serious impacts on the integrity of infrastructure. There may be some small losses in efficiency in electricity distribution and asphalt road surfaces may be more prone to degradation (through melting), but any impacts are likely to be very small.		
Precipitation	Kien Giang Province shows a strong seasonal pattern characterized by the monsoon rains from May to November. Peak rainfall occurs in October, accounting for about 20% of the total annual rainfall. With climate change annual rainfall is projected to increase from 1,280 mm/yr to 1,370 mm/yr (+90 mm/yr), with the largest increases during October (259 to 285	VL	M	L	**Interpretation of threat** The threat is interpreted as the direct impact of higher precipitation on buildings, roads, and other infrastructure. **Exposure** Exposure is considered to be very low because the higher projected rainfall would occur in the rainy season and the marginal impact is likely	H[46]	L

[46] Adaptive capacity is considered to be high because the overall level of assets, education, infrastructure, and markets is strong in the province. Moreover, the provincial government is well-resourced and has demonstrated a willingness to invest in infrastructure.

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
	mm/yr) and September (161 to 185 mm/yr).				to be small. **Sensitivity** Sensitivity is considered to be medium because Kien Giang has relatively higher standards of income compared to the rest of the LMB and more infrastructure which is, consequently, likely to be stronger. Not enough information is available to say however that sensitivity is low.		
Change and shift in events							
Drought	The instance of drought is projected to increase at the end of the dry season (April, rise from 60% to 80%) and the beginning of the dry season (November, rise from 16% to 20%; December rise from 76% to 84%).	-	-	-	**Interpretation of threat** Drought is unlikely to have an impact on rural infrastructure apart from groundwater bores. However, there is insufficient information to estimate the likely impact upon this resource.	-	-
Flooding	The concurrence of increased precipitation, wet season flows in the Mekong, sea level rise, and storm surges is projected to increase the incidence of flooding. The land area of the	VH	H	VH	**Interpretation of threat** The threat is interpreted as the risk of damages to infrastructure caused by slow-onset flooding. These may include: roads and	M [48]	VH

[48] Although the resources available to adapt to larger flooding are significant, the complex and large-scale nature of the province's canal system means that this is likely to be a lengthy and expensive process.

THREAT		*IMPACT*				*Adaptive capacity*	*Vulnerability*
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*		
	province projected to have flood depth >0.5 m for more than 2 months/year is projected to rise from 15% to 65%.[47]				bridges being eroded by floods, buildings water-damaged or destroyed, water supply infrastructure (particularly groundwater wells) being contaminated with dirty or saline-freshwater mixed surface water. **Exposure** Exposure is very high because almost all the infrastructure in the province is likely to be exposed to flooding. The nature of the waterway system is also likely to prolong the duration of flooding. **Sensitivity** Sensitivity is considered to be high because current infrastructure design standards and established tolerances are unlikely to be adequate to withstand or mitigate increased severity of flooding.		
Flash floods	This threat is not applicable to this area	-	-	-	-	-	-
Landslides	This threat is not applicable to this area	-	-	-	-	-	-

[47] Increase in inundation area, and depth and duration of flooding is also indicated in recent modeling work in Mackay and Russell (2011).

THREAT		IMPACT					
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*	*Adaptive capacity*	*Vulnerability*
Salinity	Mackay and Russell (2011b) project that saline intrusion will actually decrease as a result of climate change. This is due to the impact of additional flooding from local areas and the Mekong offsetting any increase in saline intrusion due to sea level rise and storm surges. On this basis, this threat is not deemed relevant to this particular area of the Delta.	-	-	-	-	-	-
Sea level rise/Storm surges	Mackay and Russell (2011b) show that the impact of sea level rise is likely to manifest itself most prominently in terms of flooding (addressed above) and in terms of the height of storm surges. Given that the former is dealt with elsewhere in this table we address the later issue here. Mackay and Russell (2011b) project that the increase in the combined effect of storm surges and sea level rise will be moderate across the province, with the only major changes (with a 30 cm rise in sea levels by 2050) being in Ha Tien (6% to 13%) and the island province of Kien Hai (12% to 18%). Wave height and energy is expected to	H	H	H	**Interpretation of threat** The threat is interpreted as the threat of repeated storm surges degrading coastal protection (such as mangroves and dykes) and further exposing coastal infrastructure to storm surges. **Exposure** Exposure is considered to be high due to the cumulative effect over decades of repeatedly more powerful storm surges. **Sensitivity** Sensitivity is considered to be high because current infrastructure design	[49] M	H

[49] Adaptive capacity considered to be medium because, despite the relatively high level of infrastructure and access to markets in the province, the scale of the challenge to adapt to a long-term threat across such a wide area of coast will be very high.

THREAT		*IMPACT*				*Adaptive capacity*	*Vulnerability*
Change and shift in regular climate	*Written description of the threat*	Exposure	Sensitivity	Impact	*Written explanation of what the impact is and reasons for score*		
	increase during storm events.				standards and established tolerances in coastal areas are unlikely to be adequate to withstand or mitigate increased severity of flooding.		

2.5 MONDULKIRI PROVINCE (CAMBODIA)

2.5.1 OVERVIEW

Mondulkiri is a sparsely populated province of Cambodia exhibiting high levels of poverty. Over 80% of households live in rural areas and the principal livelihood activities are agriculture and the collection of NTFPs; in riparian areas subsistence-based fishing is also prominent.

Natural resources are a principal component of livelihoods. Although over 65% of the province is designated as a protected area, deforestation for logging, mining, or agricultural land concessions is reducing access to natural resources. In total, 34% and 9% of the total province area has been granted as mining and agricultural land concessions respectively.

Food insecurity in the province occurs frequently, and often on a seasonal basis. The living conditions of the rural population are poor across a range of health and other social indicators. The quality and incidence of rural infrastructure is generally low: a high proportion of households use surface water for drinking; irrigation infrastructure is largely not available to communities; and, the poor quality of roads exposes many to isolation during the wet season.

Previous experience of climate-related natural hazards in Mondulkiri is indicative of the high vulnerability of the population to future climate change. Extreme floods, droughts, and insect infestations have all had serious impacts on welfare in recent years.

2.5.2 LIVELIHOOD ZONE(S)

Forested uplands zone: 23%; *Lowland plains and plateaus* zone: 77%.

Forested uplands – This zone occurs in the southeast of the province and largely encompasses the provincial capital district (Sen Monourom), Ou Reang district, and the eastern portion of Pech Chenda district. Poverty rates in *forested uplands* are comparatively lower; between 10% in some communes around Sen Monourom town and 33% in Ou Reang. District towns are in closer proximity in this zone. Access to electricity, health services, drinking water and other infrastructure is markedly better in this zone, particularly in and around Sen Monourom.

Lowland plains and plateaus – This zone encompasses Kaoh Neak district in the north, the western part of Pech Chenda, and the majority of Kae Seima district to the southwest. Kaoh Neak and Kae Seima alone comprise about 60% of the provincial population. Poverty is comparatively higher in this zone, between 50% and 60% in northern communes of Kaoh Neak, and access to infrastructure and health services is relatively lower.

Key references

NCDD (2009), NCDD) (2010), WWF/WCS (2009), IOM (2009), WCS (2008), WWF (2007).

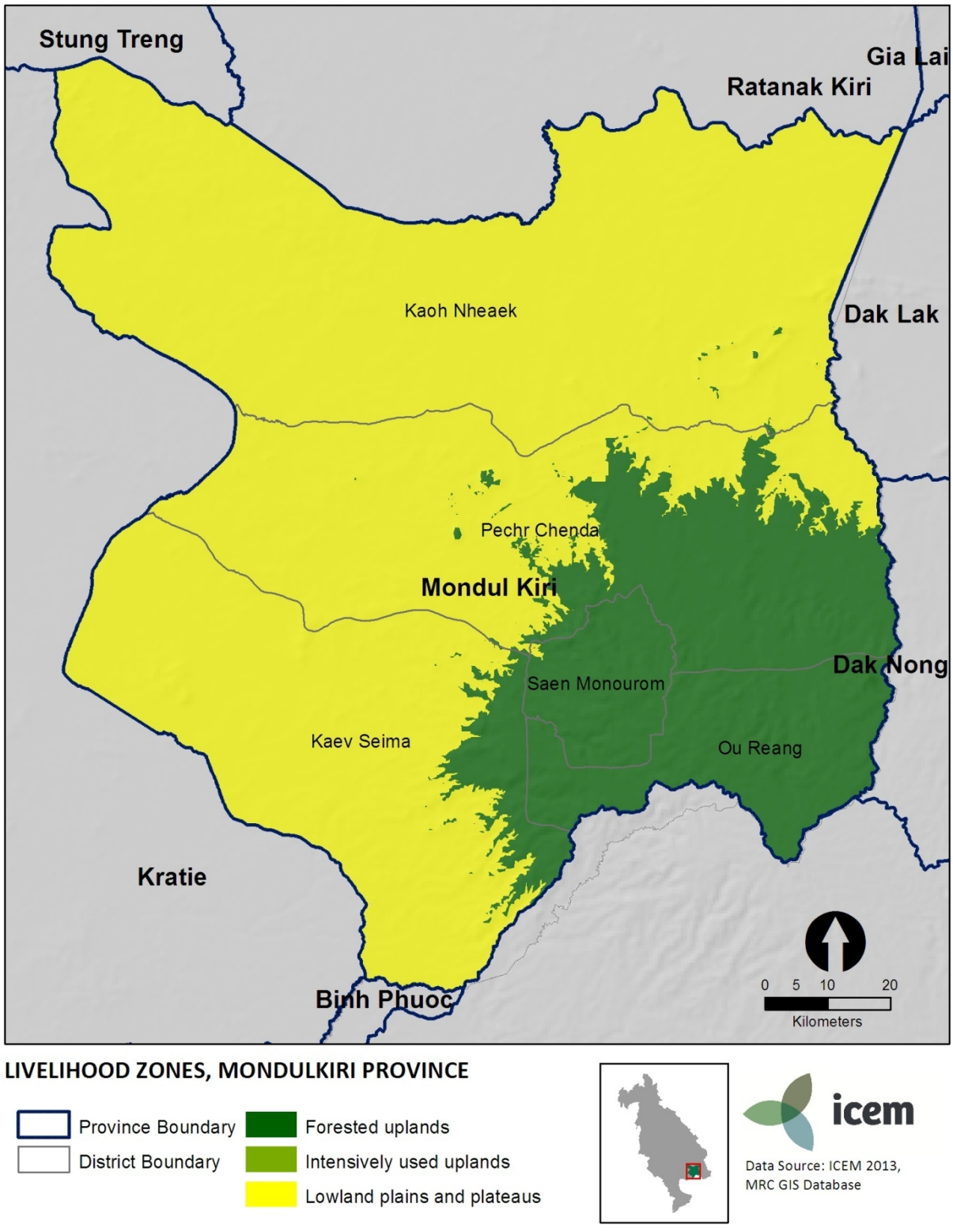

Figure 29: Districts of Mondulkiri Province and livelihood zones

2.5.3 SUMMARY OF KEY INDICATORS/SECTORS*

Indicator/theme	Key statistic(s)	Description
Poverty	37% of households in poverty (2010)	The province has the highest poverty rate in Cambodia. Poorest areas are Kae Seima and Koh Neak (both in *forested uplands* zone), both >40%. Poverty is lowest in urban areas; in rural areas, poverty tends to be lower in areas with better access to natural resources.
Food security	Livelihood activities of households around Mondulkiri Protected Forest (MPF): farming, 96%; NTFP collection, 92%; fishing, 79%; livestock rearing, 92%	The World Food Programme estimates that 16.1% of households are highly exposed to food insecurity, but this figure is probably higher on a seasonal basis. 83% of households across the province have agriculture as their main occupation. However, households characteristically have a very diversified portfolio of livelihood activities. Key commercial NTFPs include resin, hunting, and honey. NTFPs in the form of wild vegetables, root crops, and animals are an important source of emergency food. 53% of households around the MPF state that they are unable to produce enough rice to meet their needs; this reflects low use of inputs and poor soil fertility.
Human health	3 health clinics 15 pharmacies Infant mortality within 1 month: 4.5% Maternal mortality within 1 month of birth: 7.2%	Despite their availability in the province, nearly half of households do not use health services due to poor service, distance, or lack of money. Child mortality is high in many parts of the province: 21%, 14%, and 16% of children die below the age of 5 in Kae Seima, Kao Neak, and Pech Chreada districts respectively. Immunization is also less than fully subscribed, the equivalent figures for the same provinces for children 9-12 months old not receiving full immunization is: 35%, 15%, and 18%.
Population and demography	Population: 62,218 (2010) Population density: ≈4 persons/km^2 (province) Population under 17: 51% (2010)	Population is increasing rapidly due to in-migration from other parts of Cambodia; access to natural resources, particularly land, is a major pull-factor. Population rose from 49,612 to 62,218 between 2005 and 2010; permanent annual in-migration was estimated to be 2,326 people in 2008. Although 53% of the population was comprised of the Phnong ethnic minority (and there are a large number of other minority groups present), the ethnic Khmer population (35%) is growing rapidly in reflection of migration trends.

Indicator/theme	Key statistic(s)	Description
	Population over 65: 4.3% (2010) Population under 5: 18% (2010)	
Strength of key infrastructure	Ratio of people to year-round wells: Kae Seima, 224; Kao Neak, 158; Ou Reang, 78; Pech Chreada, 41; Sen Monourom, 108 House with thatched roof: 35% House with zine/fibro roof: 59%	A large proportion of drinking water in rural areas comes from surface water or other unsafe sources. In the dry season, it is reported that almost all households are accessing unsafe drinking water at some point. Rural roads are typically made of soil and are highly prone to erosion and degradation; in 2008 there were no bitumen roads reported in the province although this has since changed. Bridge infrastructure is also relatively weak: there are no concrete bridges in the province, but there are 15 wooden bridges and 11 bale bridges. Across the province there are 269 classrooms, of these 91 do not have a good floor, 21 do not have a good roof, and 25 do not have good walls.
Assets	8 families per bicycle 22 families per car/truck 419 families per tractor	20% of families engaged in rice farming own less than one hectare of rice land or no rice land. In rural areas land tenure is typically seen to be quite open and managed on an informal basis. There are numerous reports of communes being evicted from their land to make way for economic land concessions – strength of land rights is considered to be weak. Agriculture is largely un-mechanized. Livestock are an important livelihood asset as insurance against adverse crop seasons and, in the case of cattle/buffalo, to work the land. 44% of households raise cattle/buffalo and 31% use them for draft. 66% of households raise chickens and 40% raise pigs.
Education/skills	Lower secondary school (12-14 years) enrolment: 76% Ratio of secondary school children to teachers: 50 Illiteracy: Province, 37%; Kae Seima, 37%; Kao Neak, 40%; 25% Sen Monourom	There is a high level of school enrollment in the province, but resources are poor and the quality of education delivered is generally low. The class schedule is irregular. Illiteracy is high in the province as a whole and is higher in the *lowlands plains and plateaus* zone.

Indicator/theme	Key statistic(s)	Description
Physical infrastructure	25% of houses have electricity (including urban areas) Total number of schools: 90 Total number of schools: without water supply, 65; without toilets, 53.	Ratio of people to latrines: Mondulkiri Province, 38.9; Kao Neak, 612.6; Sen Monourom, 11.5. The most common forms of water supply are groundwater bores or surface water sources. Very few if any households are connected to piped water. Some major roads are sealed and in good, weather-resistant condition; however, most roads are made of earth and may be impassable in the wet season. In 2008, none of the 145 km of reported roads were paved or bitumen, but there has since been a major highway constructed through the south of the province to the Vietnam border. Many communities in riparian areas report being cut off from external services and markets during flooding, mostly in the wet season. Only 30 families are reported to have access to irrigation infrastructure. Total number of reported electricity connections is 1,501 and 907 of these are in Sen Monourom. Electricity coverage is limited in rural areas, in Koh Neak 10% of houses have electricity and 35% of houses have a battery light.
Access to markets	Number of markets operating at least weekly: 3	Official statistics state that 1,216 farmers received credit in 2008. However, US$10 million of the approximately US$11 million disbursed was to farmers in Sen Monourom, indicating a lack of access to credit in rural areas. In rural areas access to markets can be limited, particularly in the wet season when some communities can be completely cut off. However, the road network has improved in recent years and communities have been able to receive higher prices for their products in distant markets because they have been able to rely less on middlemen for transport.

Notes: *2008 data unless specified otherwise. These indicators comprise the main inputs into the climate change vulnerability assessment of health and infrastructure, with some additions.

Exposure	Sensitivity	Adaptive capacity
Location of people/assets	Poverty	Assets
Severity of threat	Food insecurity	Education/skills
Duration of threat	Human health	Physical infrastructure
	Strength of key infrastructure	Access to markets
	Demographic composition	

Notes: Assessment relates to all livelihood zones within the province unless otherwise specified. Subscripts relate to their corresponding livelihood zones: FU = *Forested uplands*; IUU = *Intensively used uplands*; LPP = *Lowland plains and plateaus*; F = *Floodplain*; D = *Delta*. For example, H_{FU} under the 'Exposure' heading indicates an assessment of High Exposure in the *Forested uplands* livelihood zone of the province.

2.5.4 MONDULKIRI PROVINCE - HEALTH CLIMATE CHANGE VULNERABILITY ASSESSMENT

THREAT		*IMPACT*					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Temperature	In lowland areas of the province and under baseline conditions maximum temperatures vary on average between 26°C to 34°C during the year, with	VH	H_{FU} VH_{LPP}	VH_{FU} VH_{LPP}	**Interpretation of threat** The threat of temperature rise is interpreted as the direct impact on human health (i.e., heat exhaustion) and	[50] L_{FU} VL_{LPP}	VH_{FU} VH_{LPP}

[50] Adaptive capacity is considered to be low to medium because the infrastructure to protect from extreme heat is not widespread, particularly health centers and electricity. Adaptive capacity is considered to be very low in lowland areas because access to infrastructure such as electricity and also access to markets is markedly lower than in upland areas.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	temperatures peaking in April and dropping to a minimum in December. With climate change, temperatures are projected to follow a similar pattern, with a rise in the mean maximum temperature of 3°C to 4°C year round. This means that average projected temperatures during April are estimated to rise to between 37°C and 39°C. The proportion of days exceeding 35°C is projected to increase from 5% to 25%. In upland areas maximum temperatures are typically 1°C to 2°C lower under the baseline and with projected climate change. Consequently the proportion of days exceeding 35°C is projected to increase from 3% to 15%. Across the course of the year, the projected average maximum temperature is roughly equal to or slightly less than historical maximum temperatures (i.e., the new average maximum temperature is equal to or exceeds past extremes). An upward shift of similar proportions is also projected for minimum temperatures.				the incidence of disease vectors. **Exposure** Exposure is deemed to be very high in both uplands and lowlands despite the temperature rise in the latter area being higher. Projected temperature rises and final temperatures of this magnitude are extreme. The rise in the proportion of days exceeding 35°C is particularly severe in lowland areas. Moreover, outdoor livelihood activities such as farming and NTFP-collecting raise the level of exposure. **Sensitivity** Sensitivity is high to very high because the overall level of poverty and food insecurity is high in the province as a whole. Health indicators suggest very low existing health standards and nutrition, for example one-fifth of children in Kae Seima district die before the age of 5. Moreover, there is a high dependency ratio, with over half of the population under 17 years old. The		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	The rise in temperatures is particularly pronounced during the wet season (June to November).				young and elderly are the groups most sensitive to heat stress. Sensitivity is deemed to be very high in lowland areas because the state of poverty, human health, and food insecurity is worse compared to upland areas.		
Precipitation	Both lowland and upland areas in Mondulkiri Province exhibit a strong seasonal pattern characterized by the monsoon rains from May to November. In lowland (upland) areas peak rainfall occurs in October, accounting for about 29% (24%) of rainfall. Under climate change annual rainfall is projected to increase from 1,854 mm/yr to 2,009 mm/yr (+165 mm/yr) in lowland areas and 1,943 mm/yr to 2,116 mm/yr (+173 mm/yr) in upland areas. In lowland areas the largest increases occur during October (471 to 539 mm/yr) and September (289 to 323 mm/yr); in upland areas the largest increases also occur	L	H_{FU} VH_{LPP}	M_{FU} H_{LPP}	**Interpretation of threat** The threat of higher precipitation is interpreted as the impact on health through greater accumulation of non-flood related stagnant water bodies and the consequent creation of breeding grounds for disease vectors. **Exposure** Exposure is considered to be low across the province because the rise in precipitation is occurring during the wet season when there is already a high level of rainfall and stagnant water.	[51] L_{FU} VL_{LPP}	M_{FU} VH_{LPP}

[51] Adaptive capacity is considered to be low to very low because of the lack of health centers to cope with the spread of disease. In upland areas access to health centers is relatively easier.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	during October (480 to 549 mm/yr) and September (304 to 340 mm/yr).				**Sensitivity** Sensitivity is considered to be high to very high because existing health conditions are poor, i.e., the rate of child immunization is low. Sensitivity is very high in lowland areas because of relatively poorer community health.		
Change and shift in events							
Drought (see definition)	The instance of drought is projected to increase in lowland areas at the end of the dry season (April, rise from 68% to 84%; May, rise from 4% to 12%; June, rise from 0% to 4%) and the beginning of the dry season (December rise from 64% to 68%). In upland areas the increase is projected to be restricted to April, rise from 56% to 80%.	H_{FU} VH_{LPP}	H_{FU} VH_{LPP}	H_{FU} VH_{LPP}	**Interpretation of threat** The threat is interpreted as the consequences of drought causing households to use unsafe water sources or to dedicate less water-use to hygiene related practices. Moreover, drought is likely to decrease crop yields and impact on the nutritional intake and incomes of households.	[52] L_{FU} VL_{LPP}	H_{FU} VH_{LPP}

[52] Adaptive capacity is considered to be low to very low because of the lack of health centers to cope with the spread of disease. Moreover, low level of education regarding hygiene practices and drinking water safety may reduce the capacity of households to respond to water shortages in a safe manner. In upland areas access to health centers is relatively easier.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					Exposure Exposure is considered to be high to very high because the significant increase in the probability of drought conditions will occur at the time when water supplies are already under pressure. Exposure is very high in lowland areas because that region is projected to have a greater increase in drought conditions across the year. **Sensitivity** Sensitivity is deemed high to very high because of prevailing poverty and health conditions in the province. Again, sensitivity is higher in lowland areas due to the relatively poorer level of those prevailing conditions.		
Flooding	Higher rainfall likely to increase the incidence and severity of flooding in	M_{FU} H_{LPP}	H_{FU} VH_{LPP}	M_{FU} VH_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of	[53] L_{FU} VL_{LPP}	M_{FU} VH_{LPP}

[53] Adaptive capacity considered to be low to very low fro the same reasons as those mentioned in previous footnote. In addition, communities have limited road or other infrastructure to mitigate their isolation during extreme flood events. During prolonged flood events water access is a critical issue and communities have insufficient infrastructure (i.e. few alternatives to surface water or groundwater bores) to access safe water.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	riparian areas, particularly lowland areas.				death and injury caused by slow-onset flooding, as well as the attendant indirect impacts on human health through: increased incidence of water-borne and vector-borne disease; food insecurity caused by loss of crops or income-generating assets; and, reduced access to safe water, particularly water bores. **Exposure** Exposure is judged to be medium to high because the large projected rise in precipitation is somewhat offset by the fact that communities already experience flooding on a regular basis. Exposure to slow-onset floods in lowlands is considered to be higher in lowland areas because many communities in this zone live in riparian areas that are more susceptible to slow-onset rather than flash flooding. Moreover, high rates of deforestation across the province have reduced the capacity of soil to absorb moisture during extreme precipitation events.		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					Sensitivity Sensitivity is judged to be high to very high because of the prevailing conditions in the province. In addition, communities in lowland areas are frequently cut off from outside access due to poor quality road infrastructure. The higher sensitivity of lowland areas arises from lower food security and higher poverty.		
Flash floods	Higher rainfall likely to increase the incidence and severity of flash floods in higher-elevation and sloping areas.	H_{FU} L_{LPP}	H_{FU} VH_{LPP}	H_{FU} M_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by flash flooding, as well as the attendant indirect impacts on human health through damage to assets. **Exposure** Exposure is considered to be high in upland areas because deforestation in the province has reduced the capacity of soil to absorb extra precipitation.	[54] L_{FU} VL_{LPP}	H_{FU} M_{LPP}

[54] Adaptive capacity is judged to be low to very low for reasons cited in previous footnotes. In addition, it should be noted that flash floods are extremely destructive and the likely damage to direct human health and indirect impacts through loss of livelihood-supporting infrastructure would be severe.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					Sloping and high elevation areas are also more generally susceptible to flash floods. Exposure is judged to be low in lowland areas because slow-onset floods are more common and flatter riparian areas have more capacity to distribute sudden, large volumes of precipitation. **Sensitivity** Sensitivity is judged to be high to very high because of the prevailing conditions in the province and the relative differences in health and income.		
Landslides	Higher rainfall likely to increase the incidence and severity of landslides in higher-elevation and sloping areas.	H_{FU} L_{LPP}	H_{FU} VH_{LPP}	H_{FU} M_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of death and injury caused by landslides, as well as the attendant indirect impacts on human health through damage to assets. **Exposure** Exposure is considered to be high in	[55] L_{FU} VL_{LPP}	H_{FU} M_{LPP}

[55] Adaptive capacity is judged to be low to very low for reasons cited in previous footnotes. In addition, landslides are highly destructive events and would require substantial adaptive capacity in terms of markets, health, and other infrastructure services to overcome negative consequences.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					upland areas because deforestation in the province has reduced the capacity of soil to absorb extra precipitation and prevent landslides. Sloping and high elevation areas are also more generally susceptible to landslides. Exposure is judged to be only low in lowland areas due to the lower prevalence of sloping land. **Sensitivity** Sensitivity is judged to be high to very high because of the prevailing conditions in the province and the relative differences in health and income. Moreover, landslides are devastating events that can have severe and lasting impacts on vulnerable populations.		

2.5.5 MONDULKIRI PROVINCE - INFRASTRUCTURE CLIMATE CHANGE VULNERABILITY ASSESSMENT

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Temperature	In lowland areas of the province and under baseline conditions maximum temperatures vary on average between 26°C to 34°C during the year, with temperatures peaking in April and dropping to a minimum in December. With climate change, temperatures are projected to follow a similar pattern, with a rise in the mean maximum temperature of 3°C to 4°C year round. This means that average projected temperatures during April are estimated to rise to between 37°C and 39°C. The proportion of days exceeding 35°C is projected to increase from 5% to 25%. In upland areas maximum temperatures are typically 1°C to 2°C lower under the baseline and with projected climate change. Consequently the proportion of days exceeding 35°C is projected to increase from 3% to 15%. Across the course of the year, the projected average maximum temperature is roughly equal to or slightly less than historical maximum temperatures (i.e., the new average maximum temperature is equal to or	NA	NA	NA	**Interpretation of threat** This threat is not interpreted as posing any direct threat to rural infrastructure in the province.	NA	NA

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
	exceeds past extremes). An upward shift of similar proportions is also projected for minimum temperatures. The rise in temperatures is particularly pronounced during the wet season (June to November).						
Precipitation	Both lowland and upland areas in Mondulkiri province exhibit a strong seasonal pattern characterized by the monsoon rains from May to November. In lowland (upland) areas peak rainfall occurs in October, accounting for about 29% (24%) of rainfall. Under climate change annual rainfall is projected to increase from 1,854 mm/yr to 2,009 mm/yr (+165 mm/yr) in lowland areas and 1,943 mm/yr to 2,116 mm/yr (+173 mm/yr) in upland areas. In lowland areas the largest increases occur during October (471 to 539 mm/yr) and September (289 to 323 mm/yr); in upland areas the largest increases also occur during October (480 to 549 mm/yr) and September (304 to 340 mm/yr).	L	H_{FU} VH_{LPP}	M_{FU} M_{LPP}	**Interpretation of threat** The threat is interpreted as the negative impacts on road and building infrastructure of higher precipitation. In this case the most important factor is the potential for more intense precipitation to increase erosion of unsealed roads. **Exposure** Exposure is deemed to be low because the increased volume of rainfall occurs during the wet season when there is already heavy precipitation. The marginal impact with additional rain is therefore likely to be minimal. **Sensitivity** Sensitivity is deemed high to very high due to the high volume of unsealed roads in the province. Sensitivity is	[56] M_{FU} L_{LPP}	M_{FU} M_{LPP}

[56] Adaptive capacity is considered to be low to medium because access to markets and credit is limited in the province. Furthermore, the availability of vehicles to assist the maintenance of the unsealed road network is likely to be limited. Adaptive capacity is medium in upland areas because they are closer to the main commercial center, the provincial capital Sen Monourom.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					lower in upland areas because the road network in that area contains some sealed roads.		
Change and shift in events							
Drought (see definition)	The instance of drought is projected to increase in lowland areas at the end of the dry season (April, rise from 68% to 84%; May, rise from 4% to 12%; June, rise from 0% to 4%) and the beginning of the dry season (December rise from 64% to 68%). In upland areas the increase is projected to be restricted to April, rise from 56% to 80%.	NA	NA	NA	**Interpretation of threat** Drought is unlikely to have an impact on rural infrastructure apart from groundwater bores. However, there is insufficient information to estimate the likely impact upon this resource. **Exposure** Exposure is considered to be high to very high because the significant increase in the probability of drought conditions will occur at the time when water supplies are already under pressure. Exposure is very high in lowland areas because that region is projected to have a greater increase in drought conditions across the year. **Sensitivity** Sensitivity is deemed high to very high because of prevailing poverty and health conditions in the province. Again, sensitivity is higher in lowland areas due to the relatively poorer level of those prevailing conditions.	NA	NA

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
Flooding	Higher rainfall likely to increase the incidence and severity of flooding in riparian areas, particularly lowland areas.	M_{FU} H_{LPP}	H_{FU} VH_{LPP}	M_{FU} VH_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of damages to infrastructure caused by slow-onset flooding. These may include: roads and bridges being eroded by floods, buildings water-damaged or destroyed, water supply infrastructure (particularly groundwater wells) being contaminated with dirty water. **Exposure** Exposure is judged to be medium to high because the large projected rise in precipitation is somewhat offset by the fact that communities already experience flooding on a regular basis. Existing infrastructure is likely to already be designed with the presence of floods in mind, although possibly not stronger flooding. Exposure to slow-onset floods is considered to be higher in lowland areas because many communities in this zone live in riparian areas that are more susceptible to slow-onset rather than flash flooding. Moreover, high rates of deforestation across the province have	[57] M_{FU} L_{LPP}	M_{FU} VH_{LPP}

[57] Adaptive capacity is considered to be low to medium because access to markets and credit is limited in the province. Furthermore, the availability of vehicles to assist the maintenance of the unsealed road network is likely to be limited. Adaptive capacity is medium in upland areas because they are closer to the main commercial center, the provincial capital Sen Monourom.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					reduced the capacity of soil to absorb moisture during extreme precipitation events. **Sensitivity** Sensitivity is judged to be high to very high because infrastructure such as roads, bridges, and buildings are generally made of materials that are less resistant to flood-damage. The higher sensitivity of lowland areas arises from improved road quality and other infrastructure in and around the provincial capital in upland areas.		
Flash floods	Higher rainfall likely to increase the incidence and severity of flash floods in higher-elevation and sloping areas.	H_{FU} L_{LPP}	H_{FU} VH_{LPP}	H_{FU} M_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of destruction or major damages to infrastructure caused by sudden flash flooding. These may include: roads and bridges being badly eroded or swept away by floods, buildings heavily damaged by water or destroyed, water supply infrastructure (particularly groundwater wells) being contaminated with dirty surface water.	[58] L_{FU} VL_{LPP}	H_{FU} H_{LPP}

[58] Adaptive capacity is judged to be low to very low for reasons cited in previous footnotes. In addition, it should be noted that flash floods are extremely destructive and the likely damage to direct human health and indirect impacts through loss of livelihood-supporting infrastructure would be severe.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					Exposure In upland areas, exposure is considered to be high given that higher-elevation areas will have steeper slopes that will generate more flash floods. Areas downstream of locations of ongoing deforestation will likely experience increased risk of flash floods. The risk of severe damage to built infrastructure from these events is considered to be significant given their force. Conversely, exposure is considered to be low in lowland areas because, although communities are likely to be living in riparian areas, they are considered to be more highly exposed to slow-onset flooding than flash floods given their flatter topography. **Sensitivity** Sensitivity is considered to be very high or high in all livelihood zones because communities in all zones are typically poor by the standards of the LMB and the capacity of infrastructure to withstand flash flooding is likely to be low. Sensitivity is considered to be high rather than very high in upland areas		

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					because of lower poverty rates and, consequently, the existence of relatively stronger infrastructure.		
Landslides	Higher rainfall likely to increase the incidence and severity of landslides in higher-elevation and sloping areas.	H_{FU} VL_{LPP}	VH_{FU} VH_{LPP}	VH_{FU} M_{LPP}	**Interpretation of threat** The threat is interpreted as the risk of destruction or major damages to infrastructure caused by landslides. These may include: roads and bridges being badly eroded or swept away by floods, buildings heavily damaged or destroyed, water supply infrastructure (particularly groundwater wells) being contaminated with dirty surface water. **Exposure** In upland areas, exposure is considered to be high given that higher-elevation areas will have steeper slopes that will generate landslides. Landslides are also very destructive, thus increasing the severity of the threat. The risk of complete destruction of rural infrastructure in the path of a landslide is a major concern. Exposure is considered to be low in lowland areas because they are less likely to be in situated on	[59]L_{FU} L_{LPP}	VH_{FU} M_{LPP}

[59] Adaptive capacity is judged to be low for reasons cited in previous footnotes. In addition, landslides are highly destructive events and would require substantial adaptive capacity in terms of markets and other infrastructure services to overcome negative consequences. This capacity is largely absent throughout the province.

THREAT		IMPACT					
Change and shift in regular climate	***Written description of the threat***	**Exposure**	**Sensitivity**	**Impact**	***Written explanation of what the impact is and reasons for score***	***Adaptive capacity***	***Vulnerability***
					sloping land. **Sensitivity** Sensitivity is considered to be very high in all livelihood zones because communities are poor and infrastructure is highly unlikely to survive the powerful impact of a landslide.		

ANNEX 3

The adaptation options identified in Sections 3.1 and 3.2 draw on an extensive literature review.[60] A maximum of five relevant options were identified for each impact associated with a high or very high vulnerability in the CAM assessment. These options were then collated in adaptation phasing tables for both hotspot provinces (Section 3.4) and livelihood zones (Section 3.3).

3.1 HEALTH ADAPTATION OPTIONS MATRIX

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
From CAM table		***Summarize from CAM***	***From CAM table***	
Chiang Rai - IUU	**Change and shift in events**			
	Flash floods	↑ rainfall and more intense rainfall events -> ↑ flash floods - High exposure partly due to intensive land use practices on sloping land; High sensitivity due to presence of ethnic groups and their higher rates of poverty and lack of health and safe water access	High	- Improve access to social security for ethnic minorities, including provision of rights to stateless groups - Afforestation, reforestation, and action to prevent deforestation in riparian and sloping areas - Relocation of living quarters away from vulnerable areas -Improve the capacity of local and national disaster response systems - Construction of protective infrastructure, such as check dams and flood diversion channels
	Landslides	↑ rainfall and more intense rainfall events -> ↑ landslides - High exposure partly due to intensive land use practices on sloping land; High sensitivity due	High	- Afforestation, reforestation, and activities to prevent deforestation in on sloping land - Regular monitoring of slope stability in vulnerable areas - Relocation of living quarters away from vulnerable

[60] Key reference materials for this exercise included: WHO/WMO (2012), Portier et al. (2012), World Bank (2011a, 2011b, 2011c), Costello et al. (2009), McMichael et al. (2006) Sterrett (2011), Bapna et al. (2009), IPCC (2012), Douven et al. (2009), Committee on Climate Change and U.S. Transportation (2008), ADB (2011).

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
		to presence of ethnic groups and their higher rates of poverty and lack of health and safe water access		areas - Development of forecasting and early warning systems - Construction of infrastructure reducing surface water flow, such as upstream dams and flood diversion channels
Chiang Rai - LPP	**Change and shift in events**			
	Flooding	↑ rainfall and more intense rainfall events -> ↑ flood severity and frequency - High exposure; High sensitivity due to communities often being cut off from road access during flooding	High	- Relocation of living quarters and health facilities away from vulnerable areas - Construction of protective infrastructure, such as dams, embankments, flood diversion channels, and drainage systems around residential areas - Reporting systems and surveillance programs for water-borne and vector-borne disease - Education regarding water-borne disease and personal hygiene -Installation of rainwater tanks in higher elevation areas to provide emergency water supply during floods
Chiang Rai - F	**Change and shift in events**			
	Flooding	↑ rainfall and more intense rainfall events -> ↑ flood severity and frequency - Very High exposure due to presence on floodplain; High sensitivity due to communities often being cut off from road access during flooding	Very High	- Development of forecasting and early warning systems for flooding and vector-borne disease - Reporting systems and surveillance programs for water-borne and vector-borne disease - Education regarding water-borne disease and personal hygiene -Installation of rainwater tanks in higher elevation areas to provide emergency water supply during floods - Improve quality of road access (i.e., bridge construction in floodways) to prevent isolation during flood events
Gia Lai - IUU	**Change and shift in regular climate**			

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
	Temperature	- Temperature ↑ of 3°C to 4°C - Very High exposure; High sensitivity, largely due to ethnic minority groups and their high poverty and limited access to health services and safe water.	Very High	- Improved access to healthcare for ethnic minority groups, including assistance to use available but under-utilized health insurance - Development of forecasting and early warning systems - Child nutrition programs - Education programs regarding the dangers of heat stress - Change in behavior patterns to avoid exposure
	Change and shift in events			
	Flash floods	↑ rainfall and more intense rainfall events -> ↑ flash floods - Very High exposure due to climate events and deforestation and intensive land use practices.	Very High	- Afforestation and reforestation on eroded sloping land - Government enforcement of land-clearing restrictions in forested areas and accompanying incentive programs - Agricultural extension programs to raise yields on existing agricultural land - Construction of protective infrastructure, such as dams and flood diversion channels
	Landslides	↑ rainfall and more intense rainfall events -> ↑ landslides - Very High exposure due to climate events and existing erosion due to deforestation and intensive land use practices.	Very High	- Afforestation, reforestation, and activities to prevent deforestation on sloping land - Regular monitoring of slope stability in vulnerable areas - Improve the capacity of local and national disaster response systems - Construction of infrastructure reducing surface water flow, such as upstream dams and flood diversion channels
Gia Lai - LPP	**Change and shift in regular climate**			
	Temperature	- Temperature ↑ of 3°C to 4°C - Medium sensitivity due to existing health services	High	- Development of forecasting and early warning systems - Improvements to shelter design - Improved access to electrical cooling devices - Education programs regarding the dangers of heat stress

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
				- Change in behavior patterns to avoid exposure
Khammouan - FU	**Change and shift in events**			
	Flash floods	↑ rainfall and more intense rainfall events -> ↑ flash floods - Very High exposure due to climate events and deforestation -Very High sensitivity due to poverty, poor health access	Very High	- Afforestation, reforestation, and activities to prevent deforestation in riparian and sloping areas - Relocation of living quarters and health facilities away from vulnerable areas - Improve the capacity of local and national disaster response systems - Construction of protective infrastructure, such as dams and flood diversion channels
	Landslides	↑ rainfall and more intense rainfall events -> ↑ flash floods - Very High exposure due to climate events and existing erosion due to deforestation -Very High sensitivity due to poverty, poor health access	Very High	- Afforestation, reforestation, and activities to prevent deforestation in on sloping land - Regular monitoring of slope stability in vulnerable areas - Relocation of living quarters and health facilities away from vulnerable areas - Improve the capacity of local and national disaster response systems - Construction of infrastructure reducing surface water flow, such as upstream dams and flood diversion channels
Khammouan - LPP	**Change and shift in events**			
	Flooding	↑ rainfall and more intense rainfall events -> ↑ flood severity and frequency - Very High exposure due to climate events and deforestation - Very High sensitivity due to poverty, poor health access - Major areas of concern are water-borne and vector-borne disease	Very High	- Protection of forest resources that act as emergency food sources - Increase access to safe water through improved groundwater sources outside flood events and rainwater tanks during flood events - Reporting systems and surveillance programs for water-borne and vector-borne disease - Improved access to maternal healthcare - Improve road access to remote communities, including raised roads and bridges.

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
	Flash floods	↑ rainfall and more intense rainfall events -> ↑ flash floods - Very High exposure due to climate events and deforestation -Very High sensitivity due to poverty, poor health access	High	- Afforestation, reforestation, and activities to prevent deforestation in riparian and sloping areas - Relocation of living quarters away from vulnerable areas - Improve the capacity of local and national disaster response systems - Construction of protective infrastructure, such as dams and flood diversion channels
	Landslides	↑ rainfall and more intense rainfall events -> ↑ landslides - Very High exposure due to climate events and existing erosion due to deforestation -Very High sensitivity due to poverty, poor health access	High	- Afforestation, reforestation, and activities to prevent deforestation on sloping land - Regular monitoring of slope stability in vulnerable areas - Relocation of living quarters away from vulnerable areas - Construction of infrastructure reducing surface water flow, such as upstream dams and flood diversion channels
Khammouan - F	**Change and shift in events**			
	Flooding	↑ rainfall and more intense rainfall events -> ↑ flood severity and frequency - Very High exposure due to climate events and deforestation - Major areas of concern are water-borne and vector-borne disease	Very High	- Afforestation, reforestation, and activities to prevent deforestation in riparian areas - Development of forecasting and early warning systems for flooding and vector-borne disease - Construction of protective infrastructure, such as dams, embankments, flood diversion channels, and drainage systems around residential areas - Reporting systems and surveillance programs for water-borne and vector-borne disease - Installation of rainwater tanks in higher elevation areas to provide emergency water supply during floods
	Change and shift in regular climate			

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
Kien Giang - D	Temperature	- Temperature ↑ of 3°C leading to ↑ in number of days >35°C from 5% to 25% - High exposure; Medium Sensitivity. - Relatively strong levels of health and education access, as well as relatively low poverty rate.	High	- Improve access to safe water and sanitation - Development of forecasting and early warning systems - Improvements to shelter design - Extension of provincial electricity network to remote areas - Education programs regarding the dangers of heat stress
	Change and shift in events			
	Flooding/sea level rise	- Increased precipitation, wet season flows in the Mekong and sea level rise likely to ↑ severity and frequency of floods - Very High exposure due to climate and also lack of drainage in the intensive system of fields and waterways - Medium sensitivity because poverty and other welfare indicators relatively strong and past experience of flood events - Major threats are water-borne and vector-borne disease, food insecurity from loss of crops or income-generating assets, reduced access to safe water	High	- Review infrastructure capacity and required improvements in waterway network - Review and upgrade drainage capacity of fields and waterways - Install raised rainwater tanks to provide emergency water during flooding - Development of forecasting and early warning systems for flooding and vector-borne disease - Construction of raised community flood shelters - Swimming lessons for children
Mondulkiri - FU	**Change and shift in regular climate**			
	Temperature	- Temperature ↑ of 3°C to 4°C leading to ↑ in number of days >35°C from 3% to 15%	Very High	- Programs to improve maternal and pediatric healthcare, including child immunization programs - Improve access to safe water and sanitation, including

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
		- Very High exposure; High Sensitivity. - Very poor health and poverty levels in the province as a whole, but upland areas have better access to health services and markets		groundwater bores, rainwater, and water treatment technology - Improve food security through agricultural extension programs and investments in irrigation infrastructure - Development of forecasting and early warning systems - Education programs regarding the dangers of heat stress
	Change and shift in events			
	Drought	- Incidence of drought projected to increase at the end of the dry season, a rise from 56% to 80% during April	High	- Improve access to safe water, including water storage infrastructure, rainwater tanks, and groundwater bores - Protected forest resources by developing stronger land tenure systems - Education programs regarding water-borne disease and personal hygiene - Irrigation programs to improve crop yields
	Flash floods	↑ rainfall and more intense rainfall events -> ↑ flash floods - Very High exposure due to climate events and deforestation - High sensitivity due to poverty, poor health access	High	- Afforestation, reforestation, and activities to prevent deforestation in riparian and sloping areas - Relocation of living quarters away from vulnerable areas - Improve the capacity of local and national disaster response systems - Construction of protective infrastructure, such as dams and flood diversion channels
	Landslides	↑ rainfall and more intense rainfall events -> ↑ landslides - Very High exposure due to climate events and existing erosion due to deforestation -Very High sensitivity due to poverty, poor health access	High	- Afforestation, reforestation, and activities to prevent deforestation on sloping land - Regular monitoring of slope stability in vulnerable areas - Improve the capacity of local and national disaster response systems - Construction of infrastructure reducing surface water flow, such as upstream dams and flood diversion channels

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
Mondulkiri - LPP	**Change and shift in regular climate**			
	Temperature	- Temperature ↑ of 3°C to 4°C leading to ↑ in number of days >35°C from 3% to 15% - Very High exposure; Very High Sensitivity - Very poor health and poverty levels - High proportion of the population is young or old and therefore very sensitive to high temperatures	Very High	- Programs to improve maternal and pediatric healthcare, including child immunization programs - Improve access to safe water, including water storage infrastructure, rainwater tanks, and groundwater bores - Improve food security by increasing the availability of credit in remote areas - Development of forecasting and early warning systems - Education programs regarding the dangers of heat stress
	Change and shift in events			
	Drought	- Incidence of drought projected to increase at the beginning and end of the dry season, e.g., a rise from 68% to 84% during April, 4% to 12% in May	Very High	- Improve access to safe water, including water storage infrastructure, rainwater tanks, and groundwater bores - Improve the capacity of local and national disaster response systems - Sustainable management of river and forest resources - Education programs regarding water-borne disease and personal hygiene
	Flooding	↑ rainfall and more intense rainfall events -> ↑ floods - Very High exposure due to climate events and deforestation - Very High sensitivity due to poverty, poor health access, poor food security	Very High	- Protection of forest resources that act as emergency food sources by enhancing the capacity of protected area management and formal land tenure institutions - Education regarding water-borne disease and personal hygiene - Installation of rainwater tanks in higher elevation areas to provide emergency water supply during floods - Improve distribution of mosquito nets by developing local supply chains - Reporting systems and surveillance programs for water-borne and vector-borne disease

3.2 INFRASTRUCTURE ADAPTATION OPTIONS MATRIX

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
From CAM table		***Summarise from CAM***	***From CAM table***	
Chiang Rai - IUU	**Change and shift in events**			
	Flash floods	↑ rainfall and more intense rainfall events -> ↑ flash floods - High exposure; High sensitivity due to poorer roads and higher levels of poverty -> weaker infrastructure overall	High	- Afforestation, reforestation, and activities to prevent deforestation in riparian and sloping areas - Incentive schemes for land-owners to improve management of sloping land - Relocation of key existing or planned infrastructure away from highly vulnerable areas - Research into protective infrastructure needs (such as dams and embankments) at the local level - Replace unsealed road surfaces with sealed surfaces
	Landslides	↑ rainfall and more intense rainfall events -> ↑ landslides - High exposure; High sensitivity due to poorer roads and higher levels of poverty -> weaker infrastructure overall	Very High	- Afforestation, reforestation, and activities to prevent deforestation on sloping land - Incentive schemes for landowners to improve management of sloping land - Regular monitoring of vulnerable slopes - Relocation of key existing or planned infrastructure away from highly vulnerable areas
Chiang Rai - LPP	**Change and shift in events**			
	Flooding	↑ rainfall and more intense rainfall events -> ↑ flood severity and frequency - High exposure; Medium sensitivity due to well-developed roads and higher levels of income -> relatively stronger infrastructure	High	- Install or increase capacity of drainage systems on road surfaces and in surrounding areas - Afforestation and reforestation activities on riparian and sloping areas - Review or introduction of design standards - Raise bridge levels to accommodate higher floods
Chiang Rai - F	**Change and**			

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
	shift in events			
	Flooding	↑ rainfall and more intense rainfall events -> ↑ flood severity and frequency - Very High exposure; Medium sensitivity due to well-developed roads and higher levels of income -> relatively stronger infrastructure	Very High	- Install or increase capacity of drainage systems on road surfaces and in surrounding areas - Afforestation, reforestation, and activities to prevent deforestation in riparian areas - Review or introduction of design standards - Raise bridge levels to accommodate higher floods and/or build bridges and embankments over floodways
Gia Lai - IUU	**Change and shift in events**			
	Flash floods	↑ rainfall and more intense rainfall events -> ↑ flash floods - Very High exposure due to climate events and deforestation and intensive land use practices.	Very High	- Afforestation, reforestation, and activities to prevent deforestation in riparian and sloping areas - Incentive schemes for landowners, particularly farmers, to improve management of sloping land - Relocation of key existing or planned infrastructure away from highly vulnerable areas - Detailed research into protective infrastructure needs (such as dams and embankments) at the local level - Replace unsealed road surfaces with sealed surfaces - Raise bridge levels to accommodate higher floods
	Landslides	↑ rainfall and more intense rainfall events -> ↑ landslides - Very High exposure due to climate events and existing erosion due to deforestation and intensive land use practices.	Very High	- Afforestation, reforestation, and activities to prevent deforestation on sloping land - Incentive schemes for landowners to improve management of sloping land - Regular monitoring of vulnerable slopes - Relocation of key existing or planned infrastructure away from highly vulnerable areas
Gia Lai - LPP	**Change and shift in events**			
	Flooding	↑ rainfall and more intense	High	- Install or increase capacity of drainage systems on

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
		rainfall events -> ↑ flood severity and frequency		road surfaces and in surrounding areas - Afforestation, reforestation, and activities to prevent deforestation in riparian areas - Replace unsealed road surfaces with sealed surfaces - Raise bridge levels to accommodate higher floods
	Flash floods	↑ rainfall and more intense rainfall events -> ↑ flash floods - Very High exposure due to climate events and deforestation and intensive land use practices.	High	- Afforestation, reforestation, and activities to prevent deforestation in riparian areas - Relocation of key existing or planned infrastructure away from highly vulnerable areas - Replace unsealed road surfaces with sealed surfaces - Raise bridge levels to accommodate higher floods
Khammouan - FU	**Change and shift in events**			
	Flash floods	↑ rainfall and more intense rainfall events -> ↑ flash floods	Very High	- Afforestation, reforestation, and activities to prevent deforestation in riparian and sloping areas - Relocation of key existing or planned infrastructure away from highly vulnerable areas - Review or introduction of design standards - Replace unsealed road surfaces with sealed surfaces
	Landslides	↑ rainfall and more intense rainfall events -> ↑ landslides	Very High	- Afforestation, reforestation, and activities to prevent deforestation on sloping land - Government actions to prevent deforestation on sloping land - Regular monitoring of vulnerable slopes - Relocation of key existing or planned infrastructure away from highly vulnerable areas
Khammouan - LPP	**Change and shift in events**			
	Flooding	↑ rainfall and more intense rainfall events -> ↑ flood severity and frequency	Very High	- Afforestation, reforestation, and activities to prevent deforestation in riparian areas - Review or introduction of design standards - Replace unsealed road surfaces with sealed surfaces and add embankments to roads

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
				- Raise bridge levels to accommodate higher floods
	Landslides	↑ rainfall and more intense rainfall events -> ↑ landslides	High	- Afforestation, reforestation, and activities to prevent deforestation in riparian areas - Incentive schemes for landowners to improve management of sloping land - Regular monitoring of vulnerable slopes - Relocation of key existing or planned infrastructure away from highly vulnerable areas
Khammouan - F	**Change and shift in events**			
	Flooding	↑ rainfall and more intense rainfall events -> ↑ flood severity and frequency	Very High	- Install or increase capacity of drainage systems on road surfaces and in surrounding areas - Assess the vulnerability of current infrastructure to future climate change - Replace unsealed road surfaces with sealed surfaces - Raise bridge levels to accommodate higher floods and/or build bridges and embankments over floodways
Kien Giang - D	**Change and shift in events**			
	Sea level rise/Storm surges	- Higher sea levels and stronger storms over prolonged periods likely to undermine natural coastal protection and coastal infrastructure.	High	- Strengthen natural coastal protection, such as mangroves - Strengthen and add to existing sea walls and dykes - Relocation of vulnerable infrastructure where efficient to do so
	Flooding/Sea level rise	- Increased precipitation, wet season flows in the Mekong and sea level rise likely to ↑severity and frequency of floods	High	- Review infrastructure capacity and required improvements in waterway network - Review and upgrade drainage capacity of fields and waterways - Install or increase capacity of drainage systems on road surfaces and in surrounding areas - Review of design standards - Replace unsealed road surfaces with sealed surfaces - Raise bridge levels to accommodate higher floods

Province – *Livelihood zone*	Threat	Impact summary	Vulnerability	Adaptation options
Mondulkiri - FU	**Change and shift in events**			
	Flash floods	↑ rainfall and more intense rainfall events -> ↑ flash floods	High	- Incorporate climate change into planned infrastructure development - Afforestation, reforestation, and activities to prevent deforestation in riparian and sloping areas - Relocation of key existing or planned infrastructure away from highly vulnerable areas - Replace unsealed road surfaces with sealed surfaces
	Landslides	↑ rainfall and more intense rainfall events -> ↑ landslides	Very High	- Afforestation, reforestation, and activities to prevent deforestation in sloping areas - Public awareness campaigns regarding deforestation - Government actions to prevent deforestation on sloping land - Incentive schemes for landowners to improve management of sloping land - Regular monitoring of vulnerable slopes - Relocation of key existing or planned infrastructure away from highly vulnerable areas
Mondulkiri - LPP	**Change and shift in events**			
	Flooding	↑ rainfall and more intense rainfall events -> ↑ flood severity and frequency	Very High	- Incorporate climate change into planned infrastructure development, particularly the siting of health centers and other important buildings during flood emergencies - Afforestation, reforestation, and activities to prevent deforestation in riparian areas - Replace unsealed road surfaces with sealed surfaces - Raise bridge levels to accommodate higher floods and/or build bridges and embankments over floodways

3.3 EXAMPLE ADAPTATION PLANNING TABLE

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Address the adaptation deficit (within existing government plans – things which need to be done irrespective of CC but which build resilience to the projected threats)	▪ Low investment ▪ Local government and community driven ▪ Community managed ▪ On farm initiatives ▪ Protected areas management board initiatives	Low to medium investment	High investment
Additional adaptation (strategies that require additional investment and change within existing farming ecosystems which may not be envisaged in development plans)	Low/medium investment	High investment	High investment
Adaptation to induce system shift	High investment Temporary shifts	Very high investment Temporary shifts and permanent system change	Very high investment Permanent system change

The contents of the table provide an indication of the size and time period of the investment associated with each adaptation strategy. Further details regarding the table and the broader adaptation planning process can be found in ICEM (2013a). In some cases the process of collating the various adaptation strategies required some amalgamation and the strategies presented in the table may not exactly correspond to those identified in the Adaption Options Matrices in Sections 3.1 and 3.2 of this Annex 3.

3.4 LIVELIHOOD ZONE ADAPTATION TABLES

Note that the equivalent table for the *Delta* zone corresponds to the phasing table for Kien Giang Province in Section 3.

3.4.1 FORESTED UPLANDS

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Address the adaptation deficit	▪ Enhance food security and flood protection by strengthening sustainable management of forest resources by developing stronger land tenure systems and enhancing capacity of protected area management ▪ Programs to improve maternal and pediatric healthcare, including child immunization programs ▪ Afforestation, reforestation, and other local bioengineering programs in riparian and sloping areas ▪ Improve access to safe water and sanitation, including groundwater bores, rainwater tanks, water treatment technology, and covered latrines ▪ Strengthen community food security through agricultural extension programs and investments in irrigation infrastructure ▪ Education programs regarding water-borne disease ▪ Agricultural extension programs to improve crop yields ▪ Public awareness campaigns regarding deforestation and the impact on flood vulnerability	▪ Strengthen/develop the capacity of local and national disaster response systems ▪ Extensive monitoring system for slope stability in landslide prone areas ▪ Develop and/or strengthen reporting systems and surveillance programs for water-borne and vector-borne disease ▪ Improve road access to remote communities, including extension of the road network, and construction of embankments and bridges ▪ Government programs to prevent illegal deforestation	▪ Development and/or strengthening of national weather forecasting and extreme weather warning systems, particularly for heat stress conditions
Additional adaptation	▪ Review and/or introduction of design standards for new infrastructure that accommodate climate change	▪ Relocation of health centers and other key community infrastructure away from vulnerable areas ▪ Construction of infrastructure to protect riparian communities from flooding and flash flooding, such as flood control dams, flood diversion channels, and drainage systems	▪ Relocation of household dwellings away from areas vulnerable to floods, flash floods, and landslides
Adaptation to induce system shift	-	▪ Replace unsealed road surfaces with sealed surfaces	▪ Relocation of communities away from vulnerable areas

3.4.2 INTENSIVELY USED UPLANDS

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Address the adaptation deficit	▪ Afforestation, reforestation, and other local bioengineering programs in riparian and sloping areas, particularly in highly eroded sloping land ▪ Improved access to healthcare for ethnic minority groups, including assistance to use available but under-utilized health insurance ▪ Child nutrition programs ▪ Agricultural extension programs to raise yields on existing agricultural land ▪ Community level programs to reduce land clearing on and improve management of sloping land	▪ Strengthen the capacity of local and national disaster response systems ▪ Extensive monitoring system for slope stability in landslide prone areas	▪ Development and/or strengthening of national and weather forecasting and extreme weather warning systems
Additional adaptation	▪ Community-based incentive programs to improve management of erosion-prone slopes, i.e., payments for ecosystem services (PES) programs for reforestation ▪ Government enforcement of land-clearing restrictions in forested areas ▪ Research into protective infrastructure needs (such as dams and embankments) at the local level ▪ Relocation of planned major infrastructure away from areas highly vulnerable to extreme weather related events	▪ Construction of community level infrastructure to protect riparian communities from flooding, flash flooding, and landslides, such as flood control dams, flood diversion channels, and drainage systems ▪ Relocation of health centers away from areas vulnerable to floods, flash floods, and landslides ▪ Strengthen and raise bridges to accommodate more intense flash flooding	▪ Relocation of household dwellings away from areas vulnerable to flash floods and landslides
Adaptation to induce system shift	▪ Strengthen access to broad social security for ethnic minority groups, including provision of additional rights to stateless groups	▪ Replace all high-usage unsealed road surfaces with sealed surfaces	▪ Relocation of entire communities away from areas vulnerable to flash floods and landslides

3.4.3 LOWLAND PLAINS AND PLATEAUS

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Address the adaptation deficit	▪ Education programs regarding water-borne disease and heat stress ▪ Improve access to safe water and sanitation, including groundwater bores, rainwater tanks, water treatment technology, and covered latrines ▪ Installation of rainwater tanks in higher elevation areas adjacent to lowland areas to provide emergency water supplies to lowland communities ▪ Increase access to safe water through improved groundwater sources outside flood events and rainwater tanks during flood events ▪ Strengthen sustainable management of forest and river resources by developing stronger land tenure systems and enhancing capacity of protected area management ▪ Afforestation, reforestation, and other local bioengineering programs in riparian and sloping areas ▪ Programs to improve maternal and pediatric healthcare, including child immunization programs ▪ Strengthen community food security through agricultural extension programs and investments in irrigation infrastructure ▪ Strengthen distribution of mosquito nets by developing local supply chains	▪ Development and/or strengthening of reporting systems and surveillance programs for water-borne and vector-borne disease ▪ Extension of electricity network to remote areas and/or development of off-grid renewable energy and associated supply chains ▪ Improve road access to remote communities, including extension of the road network, and construction of embankments and bridges ▪ Strengthen/develop the capacity of local and national disaster response systems	▪ Development and/or strengthening of national weather forecasting and extreme weather warning systems, particularly for heat stress conditions
Additional adaptation	▪ Review or introduction of design standards that incorporate climate change ▪ Relocation of planned major infrastructure away from areas highly vulnerable to extreme weather events, particularly health centers	▪ Relocation of health centers away from areas vulnerable to floods ▪ Construction of community level infrastructure to protect riparian communities from flooding, such as flood control dams, flood diversion channels, and drainage systems ▪ Construction of air-conditioned heat respite community centers for the benefit of young, elderly, and other vulnerable groups ▪ Install or increase capacity of drainage systems on road surfaces and in surrounding	▪ Relocation of household dwellings away from areas vulnerable to floods

		areas	
Adaptation to induce system shift	▪ Introduction of building design standards to improve the capacity of dwellings to provide relief from heat stress	▪ Replace all high-usage unsealed roads in the province with sealed roads	▪ Relocation of communities away from vulnerable areas

3.4.4 FLOODPLAIN

Level of response	Short period (< 5 years)	Medium period (5 to 10 years)	Long period (> 10 years)
Address the adaptation deficit	▪ Afforestation, reforestation, and other local bioengineering programs in riparian areas ▪ Installation of rainwater tanks in higher elevation areas to provide emergency water supply during floods ▪ Education programs regarding water-borne disease	▪ Develop reporting systems and surveillance programs for water-borne and vector-borne disease ▪ Strengthen/develop the capacity of local and national disaster response systems ▪ Development of forecasting and early warning systems for flooding and vector-borne disease	▪ Development and/or strengthening of national weather forecasting and extreme weather warning systems, particularly for heat stress conditions and flooding
Additional adaptation	▪ Community-based incentive programs to provide watershed protection, i.e., payments for ecosystem services (PES) programs ▪ Research into protective infrastructure needs (such as dams and embankments) at the local level ▪ Detailed assessment of the vulnerability of current public infrastructure to climate change	▪ Construction of infrastructure to protect riparian communities from flooding, such as flood control dams, flood diversion channels, and drainage systems ▪ Install or increase capacity of drainage systems on road surfaces and in surrounding areas ▪ Bridge construction, road elevation, and other civil engineering programs to secure road access to flood-prone communities ▪ Raise bridge levels to accommodate higher flooding and/or build bridges and embankments over floodways where appropriate	▪ Relocation of household dwellings away from areas vulnerable to floods
Adaptation to induce system shift	-	• Replace unsealed road surfaces with sealed surfaces, in conjunction with construction of embankments and bridges in floodways	▪ Relocation of entire communities away from areas vulnerable to floods