USAID Mekong Adaptation and Resilience to Climate Change (USAID Mekong ARCC)

Vulnerability Assessment Report

IUCN Thailand

Kok Klang Village, Sakon Nakhon © IUCN/Tawatchai Rattanasorn

June 2014

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EXECUTIVE SUMMARY

The aim of this Vulnerability and Capacity Assessment (VCA) has been to understand climate and non-climate vulnerabilities in the USAID Mekong ARCC target villages in Chiang Rai and Sakon Nakhon provinces in Thailand, and to propose potential adaptation options. Both provinces will experience an increase in rainfall and temperature, and more frequent flash floods and large rainfall events. Water shortage in dry season may become more severe.

In terms of climate vulnerabilities, the USAID Mekong ARCC climate study indicates that in Chiang Rai lowland rice, litchi and maize are vulnerable to temperature increase. In Sakon Nakhon, rainfall may affect yields of rice, maize and soybean, and increased temperatures will be a threat to rubber plantations. In both provinces, livestock is vulnerable to heat stress and floods, and fisheries will be affected by increased temperatures and changes in rainfall patterns. Productivity and fertility of non-timber forest products (NTFPs) may be affected by increased temperatures. In terms of health, the most prominent climate threats are flash floods, landslides, increased temperature, and flooding. Roads, water supply and building infrastructure are likely to be at high risk of flash floods and landslides.

Based on the USAID Mekong ARCC climate study and local vulnerability assessments conducted by IUCN, this assessment has identified the following major vulnerabilities in terms of livelihoods, ecosystems, health, and infrastructure for each target community:

Huai Kang Pla, Chiang Rai

- Flooding, landslides and heavy rain could threaten infrastructure and upland rice, the main food crop (climate factors)
- Heat stress, flash floods and storms could threaten chicken and pigs (climate factors)
- Overharvesting and habitat loss could affect availability of NTFPs (non-climate factors)
- Water shortage in dry season (climate and non-climate factors)
- Lack of access to markets, new varieties and extension services (non-climate factors)

Loh Yo and Hae Ko, Chiang Rai

- Landslides and flash floods could threaten infrastructure and upland rice, the main food crop (climate factors)
- Heat stress, flash floods and storms could threaten pigs, chicken and fish (climate factors)
- Overharvesting and habitat loss could affect availability of NTFPs (non-climate factors)
- Vulnerable to watershed degradation, water shortages and water pollution (climate and non-climate factors)
- Lack of access to markets, new varieties and extension services (non-climate factors). Maize, the main cash crop, is vulnerable to market price fluctuations.

Kok Klang, Sakon Nakhon

- Water shortage in dry season (climate and non-climate factors)
- Heavy reliance on rubber and cassava monocultures, which are vulnerable to climate change, but also to price shocks (climate and non-climate factors)
- Heat stress for pigs and chicken and climate vulnerability of fish (climate factors)
- Soil and ecosystem degradation (non-climate factors)
- Overharvesting and habitat loss could affect availability of NTFPs (non-climate factors)

Based on this assessment, this report recommends adaptation options that focus on 'no-regrets' strategies to reduce existing vulnerabilities and increase adaptive capacity of the target communities. The following options, as well as other potential options, will be

analysed with the communities in the next step of the project, taking into account specific implications of adaptation options for women and vulnerable groups.

Crop and livestock diversification

- Introduce local varieties of rice, chicken, pigs, and possibly introduce rabbits and ducks.
- Explore options for more productive (and heat-tolerant) rice production, especially in Kok Klang.
- Introduce new crops (e.g. organic vegetables, fruit trees) to diversify income generation, decrease vulnerability to climate change and price fluctuations, and reduce reliance on monocrops.
- Improve access to markets.
- Create small on-farm fish ponds.

This project presents an opportunity to diversify the livelihoods of the communities and identify more stable income generation opportunities. This can be done by using existing knowledge and networks, for instance through the District Offices of Agriculture, HRDI, and the Royal Initiative Projects.

Introduce mixed cropping and agroforestry

- Establish demonstration plots to demonstrate the long-term benefits of mixed cropping and agroforestry to the villagers.

Enrich community forest areas and protect the integrity of forest ecosystems

- Enrich community forest areas with bamboo species, trees, herbs and edible species, especially in Kok Klang and Huai Kang Pla, to reduce pressure on NTFPs and ecosystems.
- Restore deforested areas.

Strengthen infrastructure

- Where appropriate, improve housing for livestock and fish pond infrastructure, to protect them from storms and floods.
- Building of check dams might be considered as an option to create fish conservation zones and increase fish population, and to create water retention areas for small-scale irrigation.
- Other options to improve water management should be considered.

Increase awareness

- Increase awareness on climate variability and change, to improve preparedness to changes and extreme weather events.

Although the duration of this project is limited, it is hoped that the project will be able to ensure the sustainability of its activities through sustainability plans. It is also hoped that the project will be able to demonstrate successful approaches that will be replicated in other villages, districts, or provinces.

In addition, the project will try to reach out to provincial (and possibly national) government agencies and other organizations, as well as the media, to increase understanding of climate change vulnerability at the local, provincial and national levels.

Particularly, the project will try to demonstrate alternatives to rubber and other monocultures that are less vulnerable to climate change, less vulnerable to price shocks, less harmful to ecosystems, and potentially more productive, and eventually foster discussion on policies and market mechanisms that promote monocultures.

The project will also continue its collaboration with ISOC and the Royal Initiative Projects, which through their principle of ‘sufficiency economy’ present an excellent opportunity of scaling up resilience building activities.

ACKNOWLEDGEMENTS

We would like to express our thanks to all community members, government agencies and partner organizations that have provided their support and assistance for this assessment. In particular, we would like to thank:

Mr Saksiam Sakulpon (Kok Klang village headman), Mr Suphachai Saephu (Pa Tueng sub-district headman), Mr Atit Chaijumloernsakul (Pa Tueng deputy sub-district headman), Mr ASo Choemuekoo (Loh Yo village headman), Mr Suchard Yangja (Hae Ko village headman), Mr Kamron Nguaya (leader of Hae Ko village), Mr Prasong Uraiworn (Mae Chan Chief District Officer), Mr Sangphon Cheewinmahachai (Chief of Pa Tueng TAO), Ms Bampen Chaiyarak (IUCN field coordinator, Sakon Nakhon), Mr Ratkawee Boonmake (IUCN field coordinator, Chiang Rai), Ms Sujaree Bureekul (IUCN intern), Ms Shelley Gustafson (USAID Mekong ARCC Climate Study Scientific Editor), Mr Wichian Thong-Aram (Highland Research and Development Institute), Mr Thongchai Booruang (Land Development Office, Chiang Rai), and all the volunteers and partners who have helped collect data.

ACRONYMS

BCR	Building Resilience to Climate Change Impacts in Coastal Southeast Asia
CWR	Crop Wild Relative
DNP	Department of National Parks, Wildlife and Plant Conservation
FORRU	Chiang Mai University Forest Restoration Research Unit
HADF	Hill Area Development Foundation
HRDI	Highland Research and Development Institute
IPs	Implementing Partners
ISOC	Internal Security Operations Command
IUCN	International Union for Conservation of Nature
LDD	Land Development Department
LLS	Livelihoods and Landscapes Strategy
Mekong ARCC	Mekong Adaptation and Resilience to Climate Change Project
MWD	Mekong Water Dialogues
NTFP	Non-Timber Forest Products
PTTEP	PTT Exploration and Production Public Company Limited
TAO	Tambon Administration Organization (sub-district government)
Thai PBS	Thai Public Broadcasting Service
VCA	Vulnerability and Capacity Assessment

INTRODUCTION

Under the USAID Mekong ARCC project, IUCN Thailand is implementing ecosystem and community-based climate adaptation and resilience building initiatives in Loh Yo, Hae Ko and Huai Kang Pla villages of Pa Tueng sub-district in Chiang Rai, and in Kok Klang village of Chan Pen sub-district in Sakon Nakhon. The project activities are being carried out from November 2013 until December 2015.

This project is centred on establishing a nexus between climate science and on-the-ground community-led responses to changing climate in certain economic sectors and ecosystems. USAID Mekong ARCC supports adaptation initiatives that develop the capacity of local communities, while assisting them to combine their knowledge with USAID Mekong ARCC generated climate science information in order to:
a) *understand* climate risks
b) *identify* and *prioritise* adaptive responses to those risks
c) *implement* adaptation activities (technical and behavioural)
d) *monitor, measure,* and *recalibrate* adaptive responses based on experience gained and the best available weather and climate information.

IUCN Thailand is implementing the project in two 'hotspot' provinces – Chiang Rai and Sakon Nakhon – to work with communities in design and implementation of adaptation initiatives which address specific climate threats to livelihoods and natural systems, with the greatest potential to impact community well-being. USAID Mekong ARCC will use the experience gained through these adaptation initiatives to extract replicable and scalable approaches and lessons learned that national governments and donors can adopt and incorporate into projects and investments across the Lower Mekong Basin.

As part of the first step of "Understanding Vulnerability", the project conducted a Vulnerability and Capacity Assessment (VCA) at the community level.

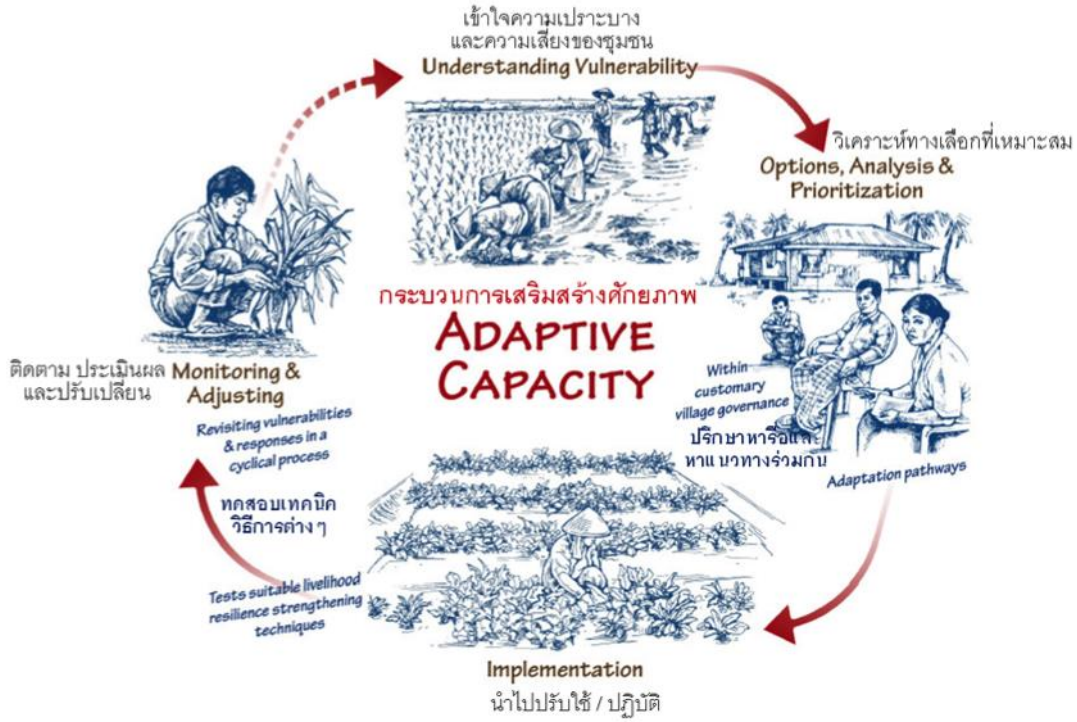

Figure 1: Project Approach (*Source:* USAID Mekong ARCC)

The aim of this assessment was to understand the communities' vulnerabilities to current climate variability and future climate change, as well as their capacity to address both climate-related and non-climate related stressors affecting their livelihoods, food and water security, and health and infrastructure.

The first part of this VCA report summarizes the findings of the USAID Mekong ARCC Climate Change Impact and Adaptation Study to describe the climate projections and the sectoral vulnerabilities at the provincial and – where available – at the site-specific level. The sectoral vulnerabilities are based on the USAID Mekong ARCC study and include the main livelihood sectors (agriculture, fisheries, livestock, and NTFPs) as well as natural systems and socio-economics (health and infrastructure). Note that this section does not include the relative importance of the different crops and livelihood options for the villages, as this will be addressed in the second part of the report.

The second part presents the results of the local vulnerability assessment. This section includes an analysis of the climate hazards that have historically occurred in the villages (historical timeline), a seasonal calendar and village map, as well as a vulnerability matrix for each village to gain a better understanding of the vulnerabilities at the village level. The information from the baseline study was then combined with the USAID Mekong ARCC projections to include the livelihood options that are relevant for each site, and thus get a clearer picture of the climate vulnerabilities in each village.

Finally, this report provides recommendations for the next step of the project, in which the communities will analyse and prioritize adaptation options. The project will encourage the adoption of 'no-regrets' adaptation strategies that reduce existing vulnerabilities and increase adaptive capacity, focussing on the most vulnerable groups identified by this assessment, including women.

VCA METHODOLOGY

The VCA methodology applied in this project is a combination of the approaches developed by IUCN's Building Resilience to Climate Change Impacts in Coastal Southeast Asia (BCR) project (Morgan 2011, and IUCN/SDF 2012), and the USAID Mekong ARCC project. In the USAID Mekong ARCC approach, the vulnerability analysis is followed by a "Climate Story" part, which combines local knowledge and priorities with the scientific climate vulnerability assessment, and eventually leads to the "Adaptation Decision Making", as shown below.

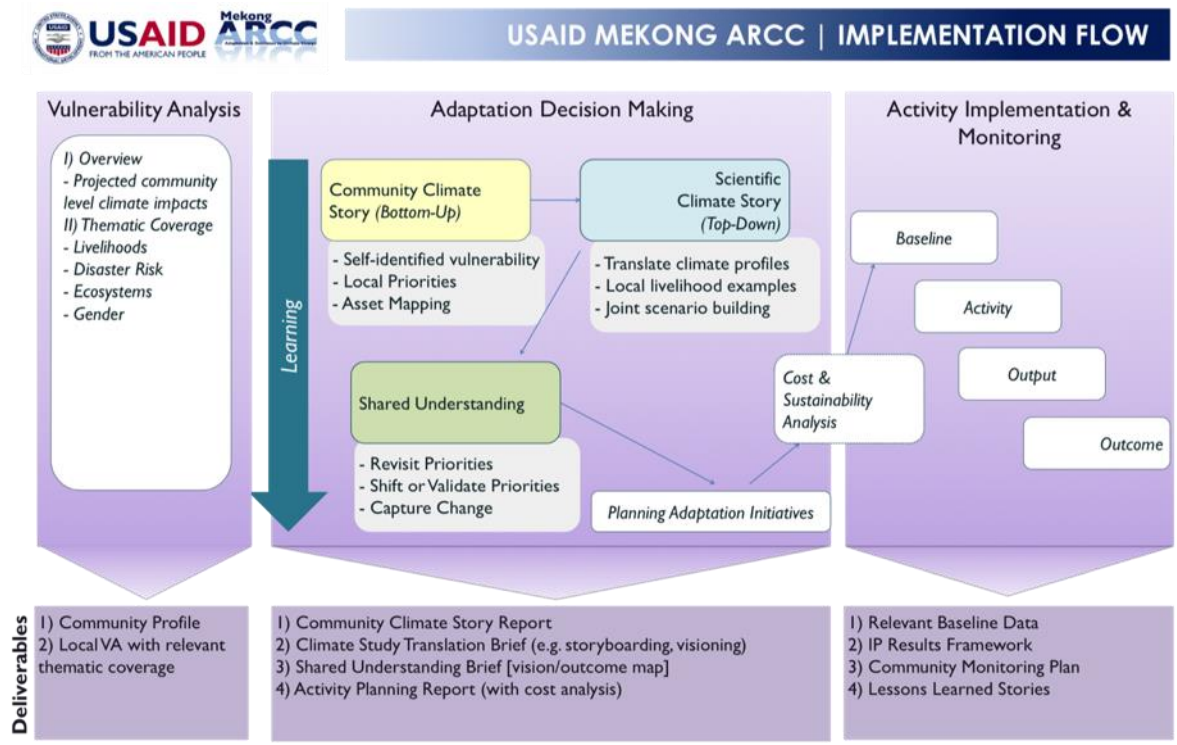

Figure 2: USAID Mekong ARCC Implementation Flow (*Source:* USAID Mekong ARCC)

Climate Vulnerability is commonly defined as a function of Exposure, Sensitivity, and Adaptive Capacity (IPPC 2007). In BCR's "CREATE" methodology, Exposure is external to a system and can be further broken down into Climate Factors and Non-climate Factors. Likewise, Sensitivity, which is internal, can be broken down into Ways-of-Life, Natural Resources and Ecosystems, and Land Use, Infrastructure and Utilities. Capacity is a function of Internal Strengths and Weaknesses and External Opportunities and Threats. (IUCN/SDF 2012)

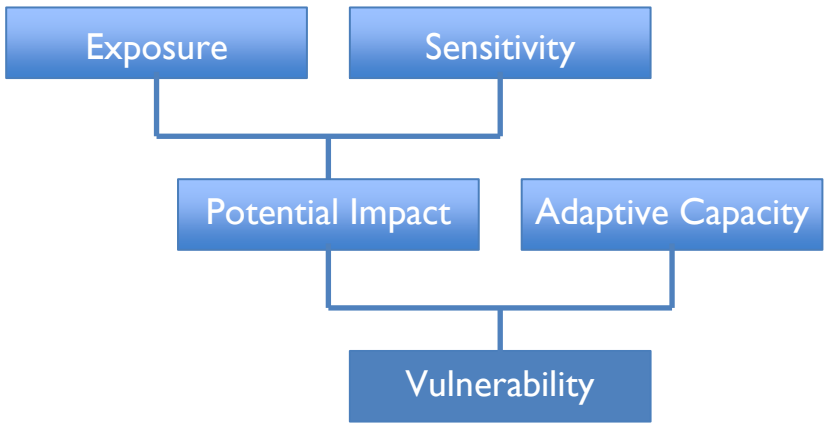

Figure 3: Vulnerability Linkages (adapted from IPCC (2007))

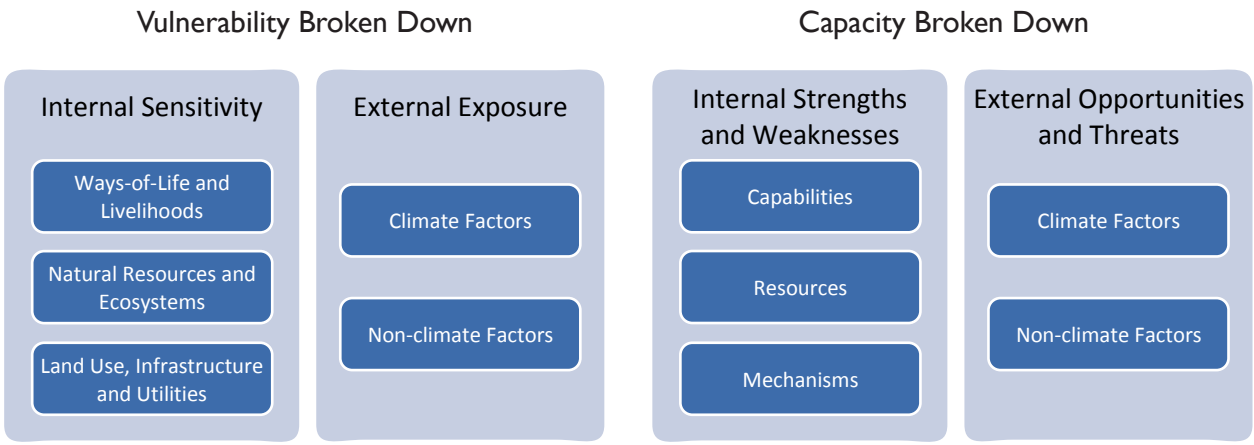

Figure 4: Vulnerability and Capacity broken down (from CREATE)

The USAID Mekong ARCC Climate Change Impact and Adaptation Study provides relevant information to assess exposure, sensitivity and adaptive capacity at the provincial and partly at the site-specific level, for both ecosystems and livelihoods. Hence, the first part of this VCA report summarizes the findings of the climate study.

To assess exposure, sensitivity and adaptive capacity at the community level, the project conducted baseline surveys, focus group discussions and key informant interviews. The baseline surveys provided important information on the community level climate vulnerabilities, and on the sensitivity and adaptive capacity of different groups.

Moreover, the following participatory tools were used to capture seasonal distribution of livelihood activities, past climate events, and to assess the vulnerability of major livelihoods, natural resources and land use to climate and non-climate hazards. These tools also enabled the project team to assess specific vulnerabilities of different groups, including women.

- *Seasonal Calendar*: To review the annual distribution of livelihoods, natural resources and land use for men and women.
- *Historical Timeline*: To explore prior climate events and/or issues within the community and, where available, mechanisms implemented to cope with them.
- *Village Mapping*: To map relevant areas, assets and natural resources/ecosystems within the community.
- *Community Vulnerability Matrix*: To score/rank climate and non-climate hazards and impacts against relevant livelihoods, natural resources and land use. (adapted from Bobenrieth et al. 2012)

Around 30-60 villagers in each village participated in the Vulnerability Assessment workshops and related focus group discussions. In addition, the activities were conducted with the involvement of community leaders and partner organizations, both to build their capacity for climate change adaptation planning and resilience building, and to engage them in the next steps of the project. Local governments were also informed about the project activities.

USAID MEKONG ARCC PROVINCIAL CLIMATE IMPACT PROJECTIONS

The aim of the USAID Mekong ARCC Climate Change Impact and Adaptation Study was to undertake a climate change vulnerability and adaptation study on the water resources, food security, livelihoods, and biodiversity of the Lower Mekong Basin (LMB). The study provides the scientific evidence base for identifying highly vulnerable and valuable agricultural and natural systems assets in the LMB. It also defines broad adaptation options and priorities, and guides the selection of focal areas for enhancing existing approaches and demonstrating and testing new adaptation strategies. The study focused on five themes: i) agriculture, ii) capture fisheries and aquaculture, iii) livestock, iv) natural systems, and v) socio-economics. (USAID 2013, *Main Report*)

Chiang Rai and Sakon Nakhon Provinces were selected as 'hotspot' provinces in Thailand, for which a more detailed analysis was carried out[1]. By determining the ranges where temperature, rainfall, and soil characteristics at specific geographic locations create conditions that transform ecosystems and alter productivity of crops, livestock, and aquatic systems, a better understanding was gained of how climate change will impact community livelihood and subsistence options.

The detailed findings of the USAID Mekong ARCC Climate Study for the two 'hotspot' provinces in Thailand, and specific information for the project sites, are summarized below. It should be noted, though, that these are projections based on models and assumptions, and that they might not materialize in the exact form presented in the analysis in the micro-locations of the project sites. In addition, other, non-climate factors such as market price and ecosystem degradation might overshadow the effects of climate change (see also *Main Report*). Thus, adaptation options should focus on 'no-regrets' strategies that reduce existing vulnerabilities and increase adaptive capacity. Monitoring and learning will also be an important component of this project.

1. Chiang Rai

1.1. Overview of Climate Projections for 2050[2]

Rainfall

The results of the USAID Mekong ARCC Climate Study indicate that Chiang Rai Province in Thailand will experience some of the largest relative increases in precipitation within the LMB with annual precipitation increasing by 9 to 18%. In absolute terms, annual rainfall will increase from 1,600 mm/year to 1,740 mm/year (+140 mm/year). The greatest percentage increase in precipitation is projected to occur in December with a close to 50% increase in precipitation from 11 to 16 mm/month. In the wet season the largest increase will be up to 30 mm in September (11% increase). Percentage change in precipitation will be higher in the south.

[1] "Hotspots" according to the USAID Mekong ARCC Climate Study are representative of the ecosystems found across the LMB; contain a mix of staple and commercial crops, fisheries, and livestock that are common throughout the basin; are projected to experience the greatest relative increase in average temperature, rainfall, or sea level rise; and where such shifts would significantly impact a number of important livelihood/subsistence options for communities.

[2] *Source:* USAID Mekong ARCC Chiang Rai Priority Province Profile and Thailand Climate Change Vulnerability Profile (*www.mekongarcc.net*), and USAID Mekong ARCC data.

The figure below indicates annual average precipitation for Chiang Rai Province, showing the location of the target villages (Hae Ko and Loh Yo to the left, and Huai Kang Pla, including the five satellite villages, to the right):

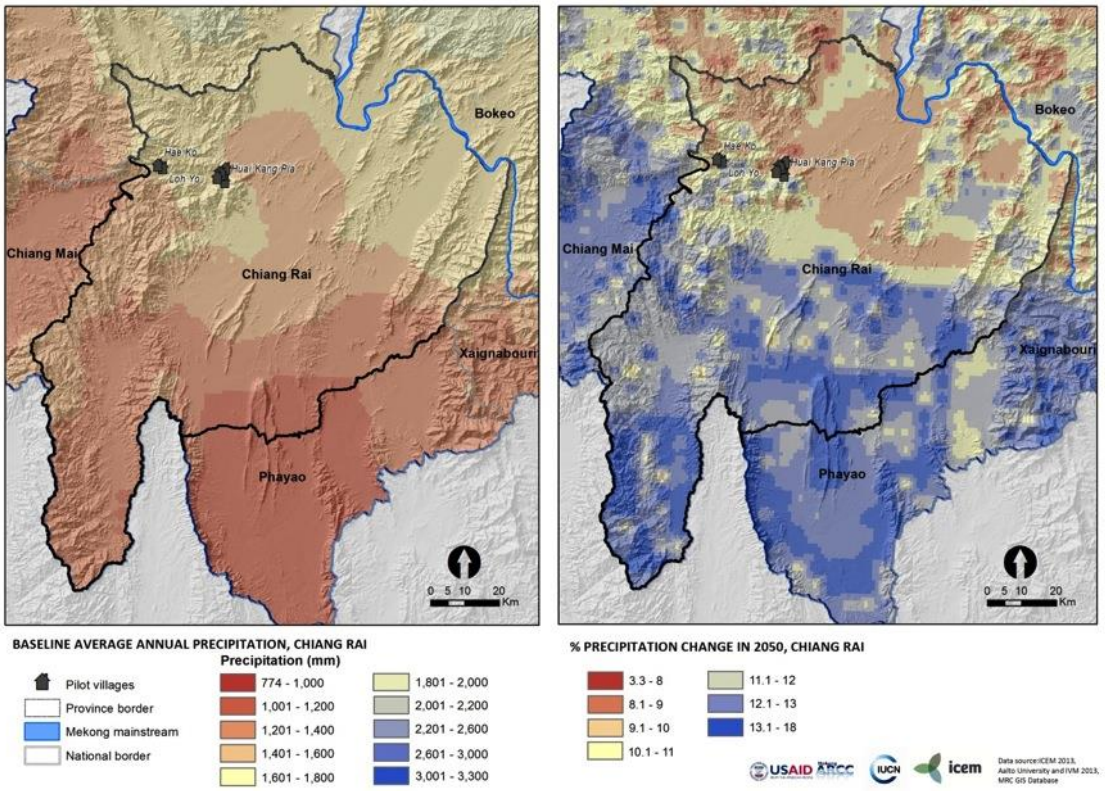

Figure 5: Annual average precipitation in Chiang Rai, Thailand (*published for USAID Mekong ARCC Project*)

For the three target villages, the site-specific data (derived from the USAID Mekong ARCC maps) indicates that precipitation will increase by around 11.3-13.6% in dry season (Dec-May), and by around 8.5% in wet season (June-Nov). Both baseline and increase in average annual precipitation are higher in the upland villages Loh Yo and Hae Ko.

	Dry season		Wet season		Average Annual	
	Baseline[3]	2050	Baseline	2050	Baseline	2050
Huai Kang Pla (460-600 masl)	270.0	+11.29% +30.5 mm	1,474.33	+8.55% +126.1 mm	1,643.29	+9.92% +163.0 mm
Loh Yo (950-1,000 masl)	273.41	+13.58% +37.1 mm	1,544.08	+8.47% +130.8 mm	1,696.92	+11.02% +187.0 mm
Hae Ko (920-950 masl)	273.95	+12.96% +35.5 mm	1,538.5	+8.47% +130.3 mm	1,662.58	+10.39% +172.7 mm

Table 1: Precipitation change for target villages in Chiang Rai (*Source: USAID Mekong ARCC data*)

The following graph also shows that, while total precipitation in dry season increases, January and February will experience a decrease in rainfall (on average). Note that this data applies to a lowland area in Chiang Rai, while the pilot villages are located in upland areas (460-1,000 masl). No specific data was available to the project team for the project

[3] The baseline represents the average rainfall per year in the period 1980-2005.

sites at the time of writing of this report. However, it is assumed that the distribution of rainfall is applicable to the upland areas too.

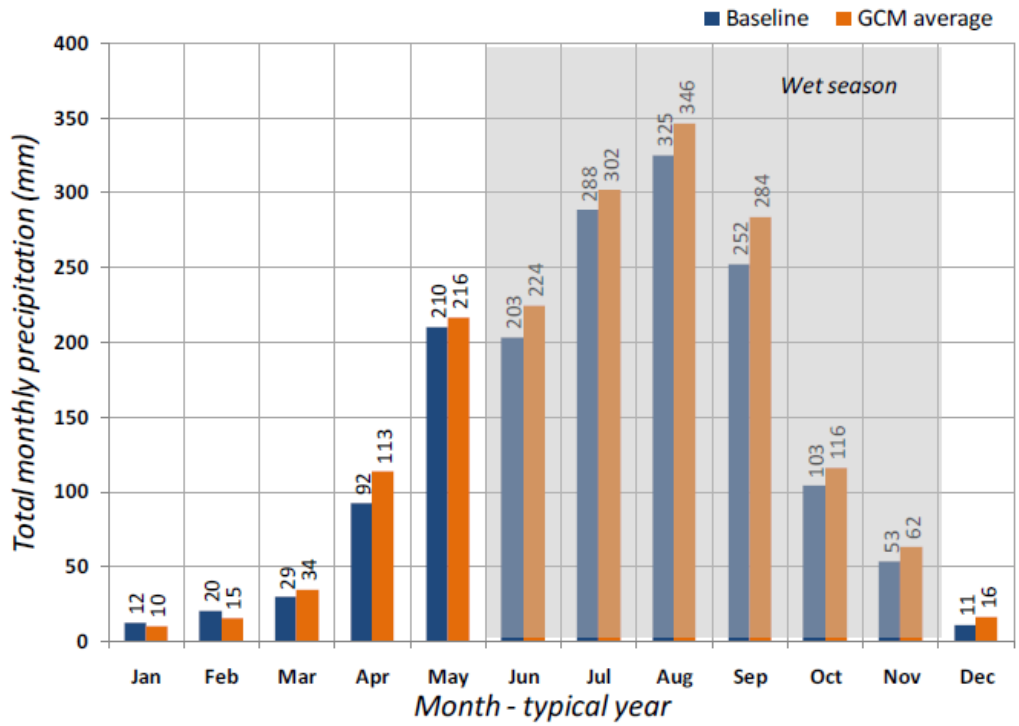

Figure 6: Monthly precipitation for a typical year in lowland area in Chiang Rai, Thailand (*GCM = General Circulation Model, i.e. climate projections for 2050*) (*Source: USAID Mekong ARCC*)

In addition, it is expected that there will be greater variability in daily, monthly and annual rainfall. The following data, although limited, from the Doi Mae Salong HRDI weather station (closest to the project site, at 1,136 metres above sea level) gives an idea of the variability in precipitation. This weather station is operating since 2012; it may be a good source for weather monitoring activities to be implemented under this project.

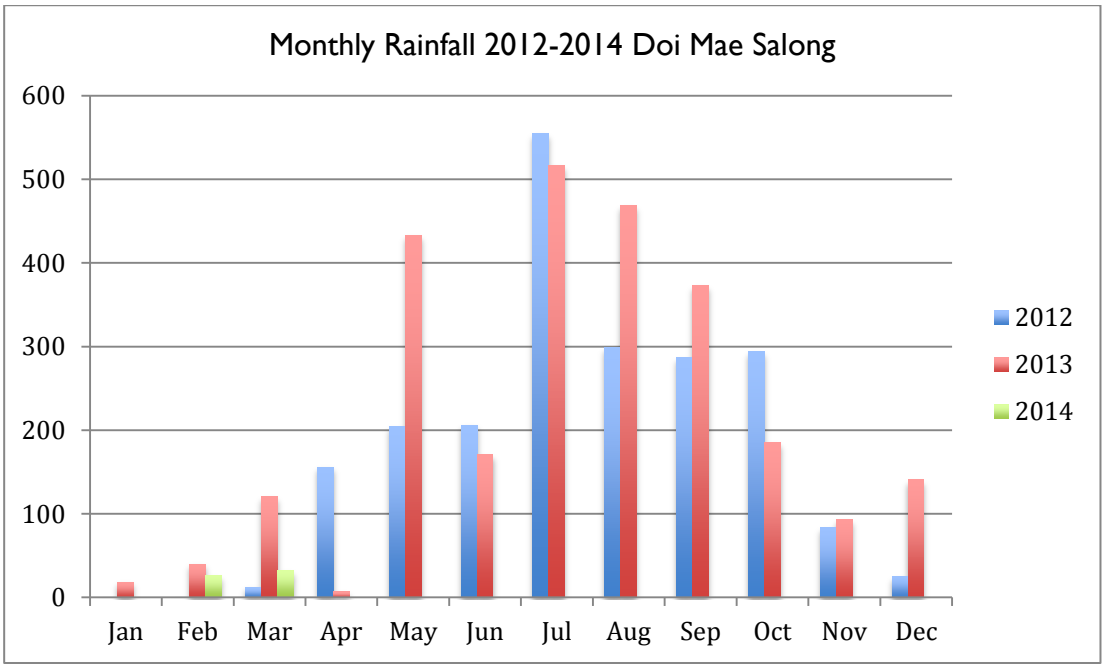

Figure 7: Monthly rainfall 2012-2014 in Doi Mae Salong in mm (*Source*: Highland Research and Development Institute, http://meteo.hrdi.or.th/Report/)

Temperature

Temperature increases are moderate across the province (between 5-8%) although still significant in terms of the potential effects on crop production and livelihoods. Chiang Rai Province has a large variation in elevation between the lowlands running north to south through the centre of the province and the higher elevations to the east and west. These differences in elevation drive some natural variation in temperature and rainfall patterns. (USAID 2013, *Main Report*)

The figure below shows that the baseline average maximum temperature is lower in the highland areas where the target villages are located. It also shows that percentage increase will be higher in Hae Ko and Loh Yo.

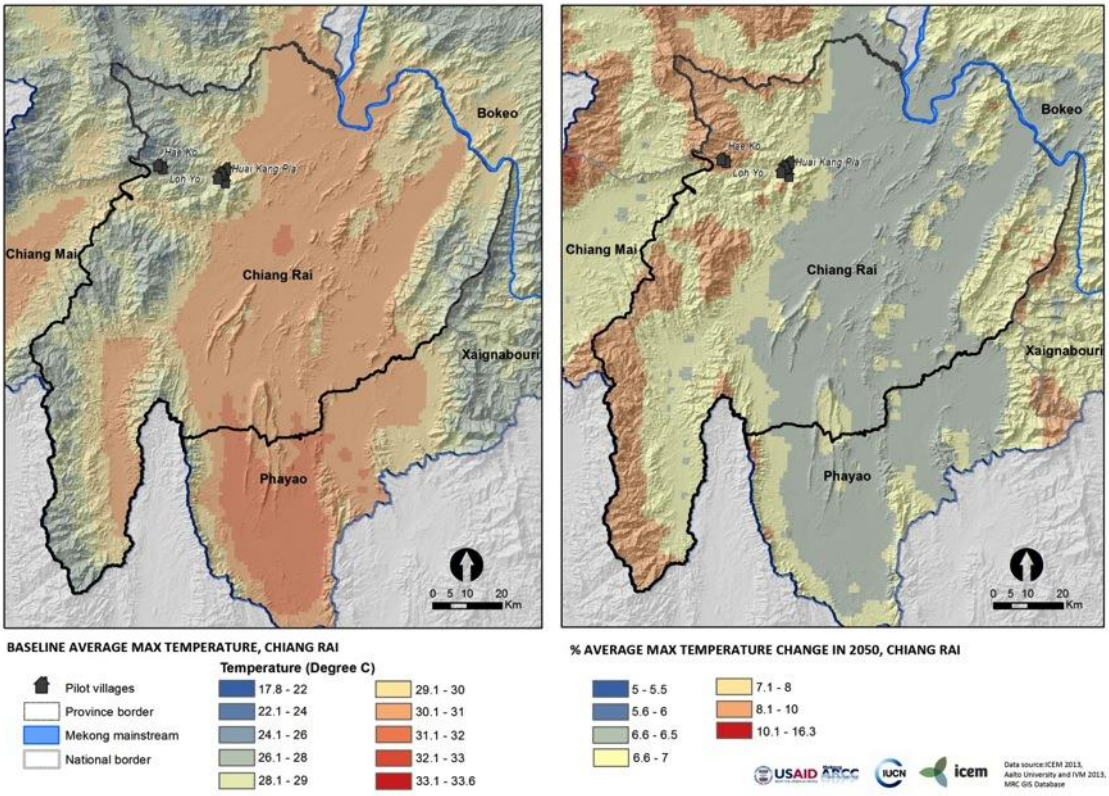

Figure 8: Annual average maximum temperature in Chiang Rai, Thailand (*published for USAID Mekong ARCC Project*)

The site-specific data (derived from the USAID Mekong ARCC maps) indicates that the average maximum temperature will increase by around 6.5-7% in dry season (Dec-May), and by around 7.2-7.5% in wet season (June-Nov). Baseline temperature is higher in Huai Kang Pla, while percentage increases are slightly higher in the upland villages Loh Yo and Hae Ko. In absolute terms, the increase in average maximum temperature will be around 2°C.

	Dry Season Average Maximum Temperature		Wet Season Average Maximum Temperature		Annual Average Maximum Temperature	
	Baseline	2050	Baseline	2050	Baseline	2050
Huai Kang Pla (460-600 masl)	29.0	+6.48% +1.88°C	29.0	+7.17% +2.08°C	28.77	+6.82% +1.96°C
Loh Yo (950-1,000 masl)	27.51	+6.87% +1.89°C	27.54	+7.49% +2.06°C	27.53	+7.18% +1.98°C

Hae Ko (920-950 masl)	27.31	+7.04% +1.92°C	27.05	+7.55% +2.04°C	27.24	+7.24% +1.97°C

Table 2: Temperature change for target villages in Chiang Rai (*Source*: USAID Mekong ARCC data)

However, these are average maximum temperatures over several months (Dec-May for dry season and June-Nov for wet season). From the USAID Mekong ARCC data, no site-specific data was available to the project team for monthly average and absolute maximum temperatures. Data from the HRDI Doi Mae Salong weather station, although limited, suggests that maximum temperature peaks at around 34.4°C in April in the highland area (1,136 metres above sea level).

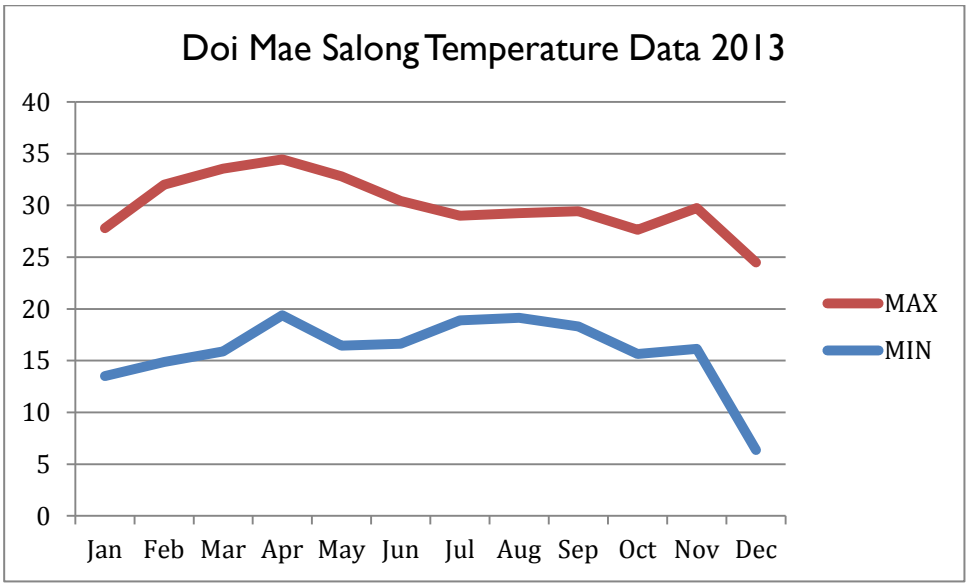

Figure 9: Monthly temperatures 2013 in Doi Mae Salong (*Source*: Highland Research and Development Institute, http://meteo.hrdi.or.th/Report/)

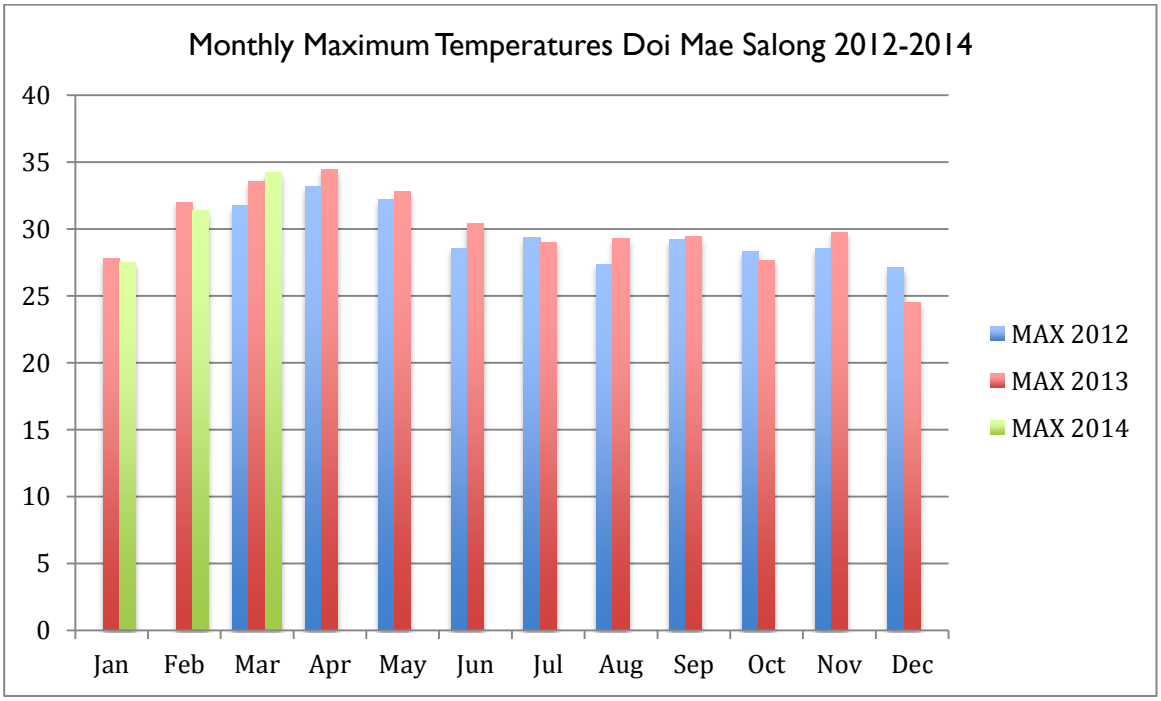

Figure 10: Monthly maximum temperatures 2009-2014 in Doi Mae Salong (*Source*: Highland Research and Development Institute, http://meteo.hrdi.or.th/Report/)

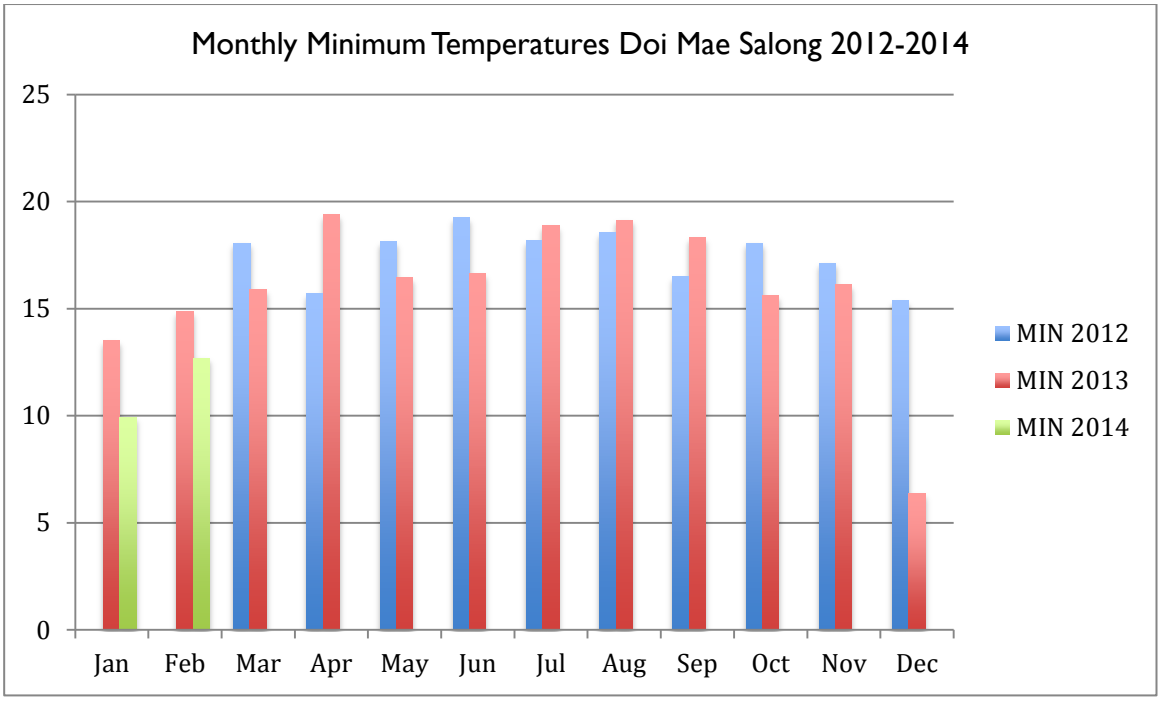

Figure 11: Monthly minimum temperatures 2009-2014 in Doi Mae Salong (*Source*: Highland Research and Development Institute, http://meteo.hrdi.or.th/Report/)

Large rainfall events

Large rainfall events (i.e., greater than 100 mm/day) will occur more frequently in Thailand and throughout the LMB. In Chiang Rai, they will occur twice as often compared to the baseline conditions (once every 12 years as opposed to once every 25 years), resulting in more frequent flash floods and higher incidence of landslides on steeply sloped terrain throughout the province. It is assumed that this information is also valid for the pilot villages.

Drought

Historical patterns of drought will remain similar under climate change, i.e., the drought period is typically limited to November-April in Chiang Rai with some years' drought also occurring in May and/or October. It is assumed that this information is also valid for the pilot villages.

Soil Moisture

Soil moisture change will be minor with a maximum increase of 0.6% to a maximum decrease of 1.4% throughout the year. It is assumed that this information is also valid for the pilot villages.

1.2. Climate Change Threats and Sectoral Vulnerabilities[4]

The USAID Mekong ARCC Climate Study indicates that increased precipitation during the traditional growing season will impact crops through increased flooding, waterlogging of soils, and higher incidence of fungal disease and pests. The increase in both average and extreme temperatures will have potentially serious impacts on crops, livestock, and human health. Specific crops that are likely to be negatively affected by climate change include lowland rice, litchi, and rubber due to an increase in temperature. Flash floods will affect mostly lowland culture such as rice, maize, and soybean. This section describes the

[4] *Source:* USAID Mekong ARCC Chiang Rai Priority Province Profile, Thailand Climate Change Vulnerability Profile, and Key Final Results (*www.mekongarcc.net*), and USAID Mekong ARCC data.

vulnerabilities of different livelihood sectors and selected crops in Chiang Rai Province and – where available – for the specific target sites. A detailed analysis of the vulnerabilities for each target village can be found in the next section.

Agriculture

Lowland rainfed rice: Temperatures exceeding 35°C during October delays ripening and reduces number and quality of grains. The climate study predicts a reduction in rice yields of 4.8% for Chiang Rai Province. *However, temperatures in the project sites are lower due to the high elevation, and temperatures exceeding 35°C will be less frequent than in the lowland area. The detailed projections for the project sites indicate that there is no shift in suitability for lowland rainfed rice, and that the suitability is high*[5]*.*

	Rice Suitability Index		Suitability Shift
	Baseline	2050	
Huai Kang Pla	84.83 (High)	84.55 (High)	No
Loh Yo	84.85 (High)	84.79 (High)	No
Hae Ko	84.68 (High)	84.81 (High)	No

Table 3: Rice Suitability Index for target villages in Chiang Rai (*Source:* USAID Mekong ARCC data; see also map in Annex 1)

Maize will be negatively affected by the expected increase in temperature, as will other crops such as soybean, coffee, and pineapple. The climate study predicts a decrease in maize yields of 3.13% for Chiang Rai. The table below shows a negative shift in maize suitability for the project sites. *However, this needs to be interpreted with caution, as both values are close to the value 60, which represents the limit of 'good' and 'moderate'. In addition, a 3.13% decrease in 2050 might not be relevant for the farmers today. Other factors such as market price, soil management, and available crop varieties are probably more important.*

	Maize Suitability Index		Suitability Shift
	Baseline	2050	
Huai Kang Pla	61.94 (Good)	59.71 (Moderate)	Negative
Loh Yo	61.83 (Good)	59.56 (Moderate)	Negative
Hae Ko	61.48 (Good)	58.71 (Moderate)	Negative

Table 4: Maize Suitability Index for target villages in Chiang Rai (*Source:* USAID Mekong ARCC data; see also map in Annex 1)

Rubber: Increased occurrence of temperatures in both the wet and dry seasons above the optimum level of 29°C might decrease yields. On the other hand, areas in higher altitudes will become more suitable for rubber plantations as a result of increasing temperatures. However, no detailed data on rubber suitability is available for the project sites from the USAID Mekong ARCC maps, and rubber is only a minor crop in the 3 villages.

[5] According to discussions with the USAID Mekong ARCC team, the results of Lowland rice can be applied to the paddy rice in upland communities (unless the main vulnerability concern is drought stress, which is not the case here).

Litchi: Increases of minimum temperatures during December flowering decrease litchi tree yields. Litchi trees require a chilling period (generally 20-22°C), and temperature below 15°C for at least 100 hours to flower during the winter months from November to December. Relative minimum temperature will increase by 20% in December. *Although in upland areas, where the pilot villages are located, temperatures are lower, in extreme years the required chilling period may not be given. However, litchi is not a main crop in any of the 3 villages.*

The climate study also indicates that the suitability of industrial crops like Robusta coffee and cassava will shift to areas of higher altitude. High-elevation areas of Chiang Rai will experience increased suitability for Robusta coffee due to projected changes in temperature and rainfall. This can be explored especially for the 2 highland villages Loh Yo and Hae Ko.

Livestock

The climate study predicts that changes in rainfall will affect livestock units through feed and animal health issues. Increasing flood events will accelerate the spread of disease and herd loss. Projected impacts to systems include small-scale commercial chicken and pig operations as well as smallholder cattle/buffalo systems. Added heat stress reduces reproduction and immunity of chicken and pigs. Wild species in the LMB – which are important genetic resources – will be threatened by climate change directly and indirectly through loss of habitat, hunting, and the threat of infectious diseases[6]. The following figure shows the climate and non-climate vulnerabilities for livestock in Chiang Rai. It shows that small commercial poultry and pig systems are more vulnerable to both non-climate drivers and climate change than smallholder cattle and buffalo.

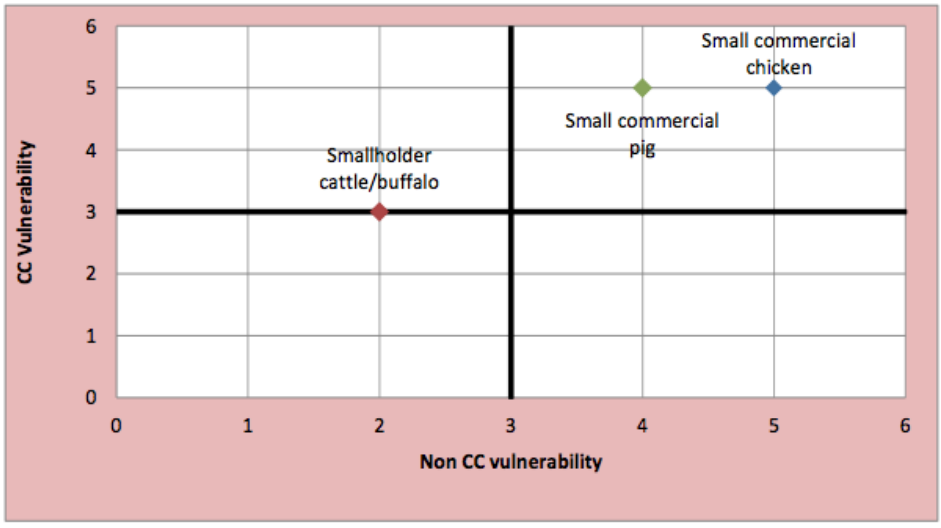

Figure 12: Climate and non-climate vulnerabilities for livestock in Chiang Rai (USAID 2013, *Detailed Report on Livestock*, p. 145)

Fisheries

Fisheries in northern Thailand will be affected by increased temperatures and changes in rainfall patterns. Upland forest stream fish will be impacted by higher temperatures in the spawning season (Nov-Dec), reducing reproduction and limiting habitat suitability. Migratory white fish may be impacted by the loss of suitable refuge pools due to higher temperatures and decreased precipitation during a portion of the dry season. Higher temperatures will

[6] A detailed vulnerability assessment for Livestock in Chiang Rai can be found in the *USAID Mekong ARCC Detailed Theme Report on Livestock*, p. 95-107.

affect the water quality of aquaculture ponds while increased flash flood events will decrease stocks and impact pond infrastructure.

For Clarias catfish (monoculture), the study indicates that more flash flood events will decrease stocks in ponds built in stream valleys. For tilapia, silver barb, and carp (polyculture), temperature increase and drier dry season means reduced oxygen levels, higher ammonia, and reduced survival. Tilapias are generally more tolerant of high temperatures and low dissolved oxygen levels.[7]

Non-Timber Forest Products (NTFPs)
Productivity and fertility of NTFPs may be affected by increased temperatures, with dry season spikes impacting flowering, fruiting, and seed dispersal. Flash floods will impact young seedlings of NTFPs and crop wild species.

Rattan: Heat stress and decrease in dry season rainfall will affect productivity; flash floods will impact young seedlings.

Giant Honeybee: Increased frequency of strong storms is likely to damage bee combs and cause migration, impacting pollination.

Wild Rice (*O. granulata, O. nivara, O. officinalis, O. rufipogon*) will be affected by some heat stress as well as potential for water logging with increase in precipitation in rainy season.

Natural Systems – Protected Areas
Climate change in the LMB will accelerate the loss of populations and species due to extreme temperatures, particularly during dry periods, and will be a significant driver of biodiversity loss. A reorganization of plant and animal communities will likely occur as a result of climate change, and new "problem" species will enter communities affecting overall structure and function. Geographic ranges for both species and ecosystems will shift, and there will be an overall loss in habitat extent.

The resin tree species, *Dipterocarpus alatus*, is highly vulnerable in most of the hotspot provinces. It is a long-lived species of great importance to local communities, with low reproductive rate and is vulnerable to forest fire, which can kill seedlings and saplings. Increases in temperature at the crucial flowering period are likely to reduce the reproductive rate further. (USAID 2013, *Summary*)

Socio-Economics (Health and Infrastructure)
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 for Chiang Rai Province were flash flooding and landslides. The following table shows the vulnerability assessments for health by threat for the *Intensively used uplands* livelihood zone in Chiang Rai Province. (USAID 2013, *Main Report*)

Health						
Livelihood Zone	Temperature	Precipitation	Drought	Flooding	Flash floods	Landslides
Intensively used uplands	Medium	Medium	Low	Medium	High	High

[7] *USAID Mekong ARCC Summary*, page 48.

Table 5: Vulnerability assessments for health by threat for the *Intensively used uplands* livelihood zone in Chiang Rai Province

The climate study identified two key areas of the rural infrastructure sector in Chiang Rai as highly vulnerable to climate change: roads and water supply infrastructure. In the intensively used upland zones of Chiang Rai, road and building infrastructure is likely to be at very high risk of flash floods and landslides. Aside from adverse climate shifts, this vulnerability reflects the prevalence of land clearing for agricultural use on sloping land that has caused instability and reduced the capacity of soil to retain water. (USAID 2013, *Summary*)

Infrastructure				
Livelihood Zone	Precipitation	Flooding	Flash floods	Landslides
Intensively used uplands	Medium	Medium	High	High

Table 6: Vulnerability assessments for infrastructure by threat for the *Intensively used uplands* livelihood zone in Chiang Rai Province

2. Sakon Nakhon

2.1. Overview of Climate Projections for 2050[8]

Rainfall

For a representative point in the centre of Sakon Nakhon, the annual rainfall for a typical year will increase from around 1,300 mm/year under baseline conditions to 1470 mm/year with climate change (+170 mm/year), an increase of 13%. The east of the province will experience higher increases in annual precipitation (12-18% increase) compared to the west of the province (6-10% increase). Wet season rainfall will increase significantly, as shown in the figure below. The location of Kok Klang village is shown in the lower right corner of the map.

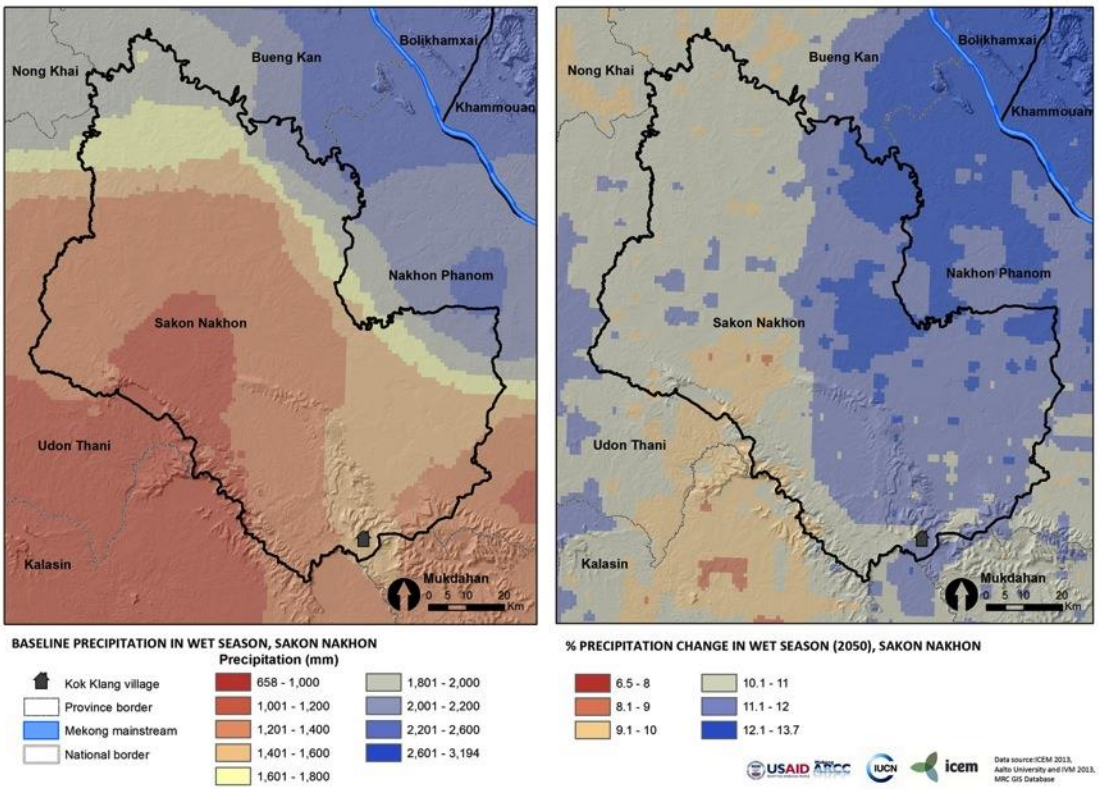

Figure 13: Wet season precipitation (June-Nov) in Sakon Nakhon (*published for USAID Mekong ARCC Project*)

[8] *Source:* USAID Mekong ARCC Sakon Nakhon Priority Province Profile, Thailand Climate Change Vulnerability Profile, and Key Final Results (*www.mekongarcc.net*), and USAID Mekong ARCC data.

For the target village Kok Klang, the site-specific data (derived from the USAID Mekong ARCC maps) indicates that precipitation will increase by 16.88% in dry season (Dec-May), and by 11.0% in wet season (June-Nov). Annual precipitation for a typical year will increase from 1,538.86 mm to 1739.53 mm (+200.67 mm/year).

	Dry season		Wet season		Average Annual	
	Baseline	2050	Baseline	2050	Baseline	2050
Kok Klang (300 masl)	261.0	+16.88% +44.06 mm	1,426.9	+11.0% +156.96 mm	1,538.86	+13.04% +200.67 mm

Table 7: Precipitation change for target village in Sakon Nakhon (*Source*: USAID Mekong ARCC data)

Data from the USAID Mekong ARCC study also suggests that, while overall precipitation in dry season increases, January and February will experience a decrease in rainfall (on average).

In addition, it is expected that there will be greater variability in daily, monthly and annual rainfall. The following data from the Tao Ngoi weather station (closest to project site) gives an idea of the variability in precipitation. The table shows monthly and annual rainfall in mm of Tao Ngoi district from 1999 to 2013.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
January	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	26.4	0.0	37.9	0.0
February	0.0	24.0	0.0	0.0	74.4	78.6	0.0	12.4	58.7	6.2	0.0	30.3	11.8	4.4	0.0
March	68.0	6.1	64.3	29.5	73.4	8.7	2.7	65.4	46.4	102.0	73.7	0.0	25.2	14.6	14.9
April	50.3	248.8	22.3	58.1	111.6	90.8	124.1	154.8	9.6	169.8	119.1	91.1	30.9	260.1	113.9
May	436.1	326.8	205.9	285.4	106.7	168.4	344.0	146.1	168.5	97.7	154.7	94.1	241.9	190.8	254.6
June	204.8	158.2	292.6	240.0	128.6	147.0	294.6	108.0	178.0	298.2	150.4	194.9	168.4	176.0	191.0
July	285.0	237.2	212.9	240.5	152.6	437.7	323.3	396.9	119.1	403.0	240.9	161.3	467.8	221.3	385.8
August	120.4	175.4	338.9	194.3	318.4	231.7	302.6	329.4	360.7	249.8	260.5	556.4	453.7	254.1	313.8
September	277.3	235.4	188.4	219.6	296.0	265.6	360.8	97.6	254.1	371.2	163.0	282.4	242.2	105.9	320.6
October	44.7	20.8	41.3	46.5	4.2	0.0	21.0	218.4	234.8	61.5	15.6	102.5	125.1	0.0	36.3
November	14.0	0.0	34.1	0.0	0.0	0.4	17.1	32.0	2.5	41.2	0.0	0.0	0.0	6.2	0.0
December	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	18.1
Whole year	**1,512.50**	**1,432.70**	**1,404.70**	**1,313.90**	**1,265.90**	**1,428.90**	**1,790.20**	**1,561.00**	**1,432.40**	**1,812.90**	**1,177.90**	**1,539.40**	**1,767.00**	**1,271.30**	**1,649.00**
Raining days	95	108	84	98	85	76	86	77	94	85	72	ND	ND	ND	ND

Table 8: Annual rainfall of Tao Ngoi district in mm/year, 1999-2013 (Tao Ngoi weather station)

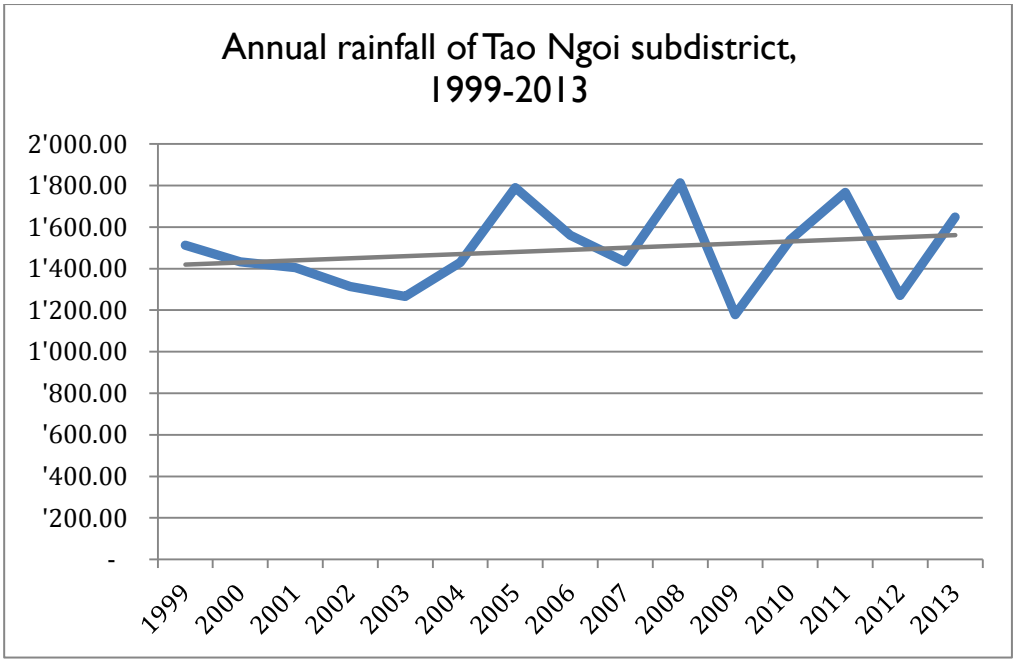

Figure 14: Annual rainfall of Tao Ngoi district in mm/year; 1999-2013 (Tao Ngoi weather station)

This data shows that the annual average over the last 10 years period 2004-2013 (1,543 mm/year) is only slightly higher than the USAID Mekong ARCC baseline (1,538.86 mm/year for the period 1980-2005) for Kok Klang, but that the trend is increasing.

Temperature

The northeastern region of Thailand historically experiences high temperatures; the dry season average maximum temperature in Sakon Nakhon, for example, ranges from roughly 30°C in the south to roughly 34°C in the north under baseline conditions. As a result, a relatively moderate temperature increase of 5 to 6% within this province translates to about a 2°C increase in temperatures for this area, which will result in significant stress on agricultural crops and other livelihood systems.

The figure below shows the baseline average maximum temperatures and projected changes for Sakon Nakhon.

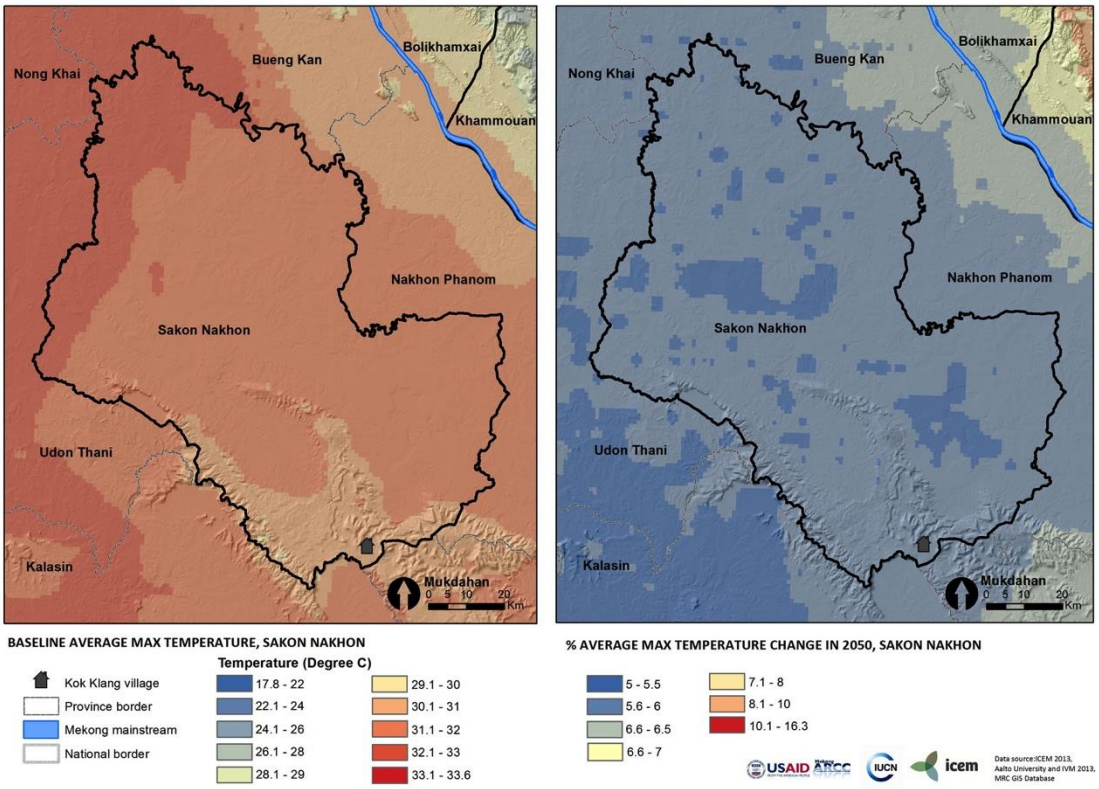

Figure 15: Annual average maximum temperature in Sakon Nakhon, Thailand (*published for USAID Mekong ARCC Project*)

The site-specific data (derived from the USAID Mekong ARCC maps) indicates that the average maximum temperature will increase by 6.0% in dry season (December-May), and by 5.9% in wet season (June-November). In absolute terms, the increase in average maximum temperature will be around 1.76°C.

	Dry Season Average Maximum Temperature		Wet Season Average Maximum Temperature		Annual Average Maximum Temperature	
	Baseline	2050	Baseline	2050	Baseline	2050
Kok Klang (300 masl)	30.66	+6.0% +1.84°C	30.65	+5.92% +1.81°C	30.65	+5.75% +1.76°C

Table 9: Temperature change for target village in Sakon Nakhon (*Source*: USAID Mekong ARCC data)

However, like in Chiang Rai, these are average maximum temperatures over several months. From the USAID Mekong ARCC data, no site-specific data was available to the project team for monthly average and absolute maximum temperatures. Data from the Thai

Meteorological Department suggests that maximum temperature peaks at around 37.7-41°C in April. Maximum temperatures during the growing months of July and August are around 34.1-36.1°C.

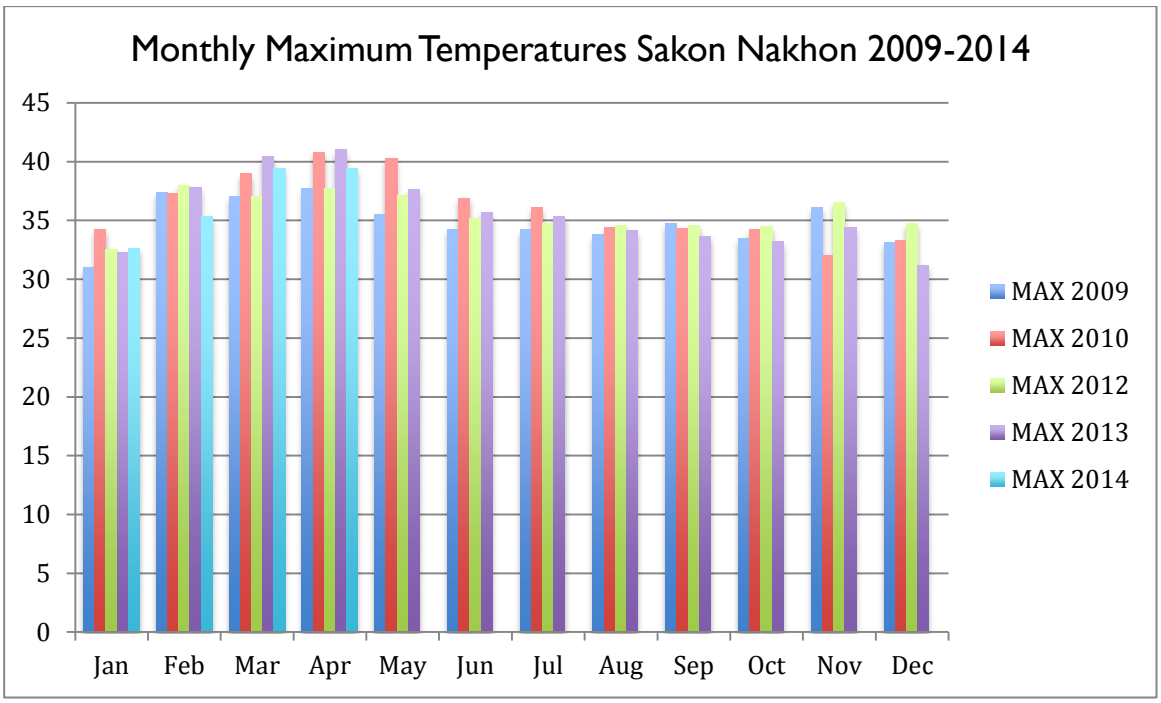

Figure 16: Monthly maximum temperatures 2009-2014 of Sakon Nakhon Province (*Source*: Thai Meteorological Department) (without 2011 as data is incomplete)

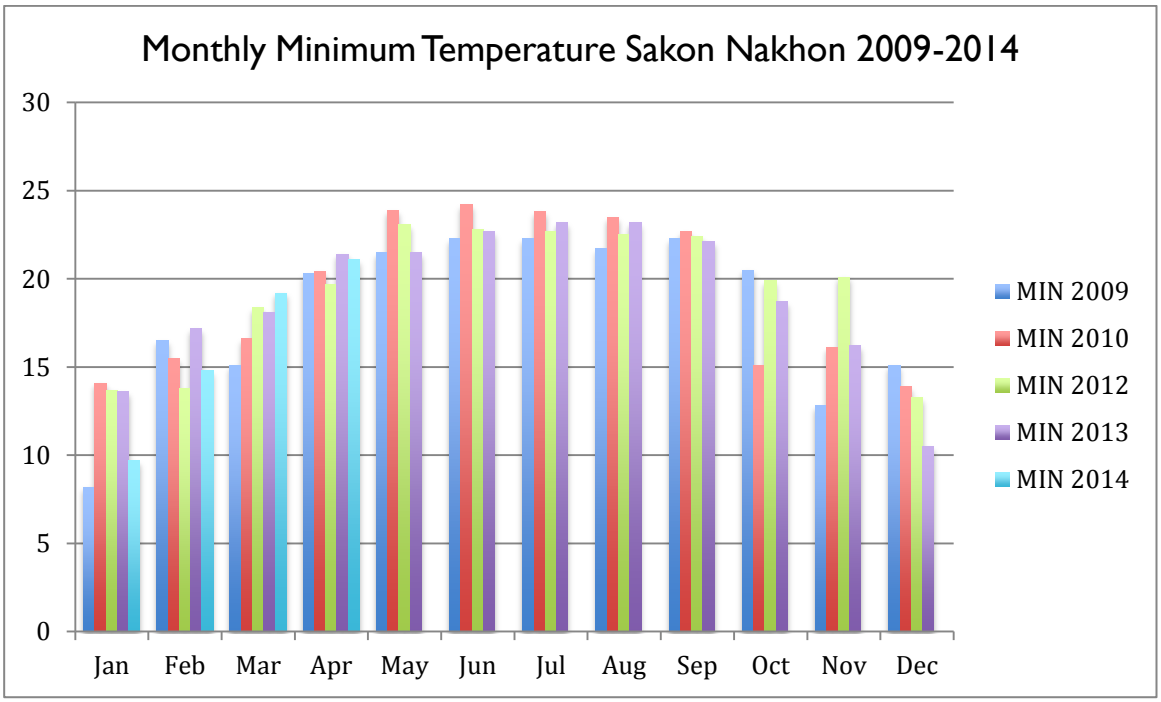

Figure 17: Monthly minimum temperatures 2009-2014 of Sakon Nakhon Province (*Source*: Thai Meteorological Department) (without 2011 as data is incomplete)

Large rainfall events

Large rainfall events (i.e., greater than 100 mm/day) will increase in frequency and intensity, resulting in increased flash flooding. It is assumed that this information is also valid for the pilot village.

2.2. Climate Change Threats and Sectoral Vulnerabilities[9]

According to the USAID Mekong ARCC Climate Study, increased precipitation during the traditional growing season will impact crops through increased flooding, waterlogging of soils, and higher incidence of fungal disease and pests. The increase in both average and extreme temperatures will have potentially serious impacts on crops, livestock, and human health. Increased temperature and rainfall will affect lowland rainfed rice, cassava, and rubber[10]. This section describes the vulnerabilities of different livelihood sectors and selected crops in Sakon Nakhon Province and – where available – for the target site. A detailed analysis of the vulnerabilities for each target village can be found in the next section.

Agriculture

Lowland rainfed rice: While increased precipitation may result in higher rainfed rice yield in this province (e.g., the crop yield modelling performed by USAID Mekong ARCC shows an increase in rice yield by 4.6%), specific changes in the timing and extent of rainfall could be detrimental. For example, increased precipitation during the typically wettest month of August in Sakon Nakhon may negatively impact rice culture if it reaches above the crop's upper limit of tolerance[11].

In addition, heat stress in wet season could decrease yields. Lowland rainfed rice is the second largest crop in the province after sugarcane with more than 280,000 ha cultivated. A decrease in productivity has the potential to significantly affect the food security of farmers throughout the province.

Rainfed crops in general are expected to be subjected to an increasing number of days with abundant precipitation. Rainfall, especially at the harvest time of rice, maize, or soybean, may affect yields and the occurrence of pests and diseases.

Cassava: An increase in rainfall is projected to reduce the suitability of cassava. Increased precipitation during the growing season is likely to result in flooding, waterlogging, and increased incidence of fungal disease and pests. Increased rainfall from May to November may increase flood intensity and frequency. The vulnerability of the crop will depend on the location of the plots (lowlands, plains, or hills) and the soil type present because these factors will determine waterlogging duration.

Rubber: Increased temperatures will be a threat to rubber plantations in northeastern Thailand with the average maximum temperature expected to be above the optimum growing conditions for a significant period of the year. Heat stress will cause widespread crop failure.

Sugarcane is relatively resistant to high temperatures and is considered a less vulnerable crop compared to rice or cassava. Sugarcane can endure waterlogging. However, since the exposure level for both threats will be high, productivity may be affected. Flooding incidence may lead to crop loss. Increased water consumption due to higher temperatures in the late

[9] *Source:* USAID Mekong ARCC Sakon Nakhon Priority Province Profile, Thailand Climate Change Vulnerability Profile, and Key Final Results (*www.mekongarcc.net*), and USAID Mekong ARCC data.
[10] On the other hand, an increase of rainfall may increase suitability for certain crops in Northeast Thailand.
[11] The rainfall data from Tao Ngoi district indeed indicates an increasing trend in precipitation in August (see Annex 2).

dry season or during droughts may be an issue that generates conflict between different water users.

In terms of crop suitability, the detailed projections for the project site indicate that there is no shift in suitability for lowland rainfed rice, cassava, and rubber, although the numbers decrease slightly, especially for cassava and rubber.

Kok Klang	Suitability Index		Suitability Shift
	Baseline	2050	
Rice	86.50 (Very high)	85.61 (Very high)	No
Cassava	95.20 (Very high)	90.16 (Very high)	No
Rubber	70.25 (Good)	65.35 (Good)	No

Table 10: Baseline and projection crop suitability for Kok Klang (*Source:* USAID Mekong ARCC data; see also map in Annex 2)

Livestock

The climate study indicates that changes in rainfall will affect livestock units through feed and animal health issues. Livestock impacts include reduced reproduction and immunity due to heat stress, and secondary impacts related to decreased fodder availability. Increasing flood events will accelerate the spread of disease and herd loss for smallholder cattle/buffalo. The system for small-scale commercial chicken is already outside the ideal temperature range; added heat stress will reduce reproduction and immunity. Wild species in the LMB – which are important genetic resources – will be threatened by climate change directly and indirectly through loss of habitat, hunting, and the threat of infectious diseases. No detailed study of the livestock vulnerabilities in Sakon Nakhon was carried out by the USAID Mekong ARCC Climate Study.

Fisheries

Black fish, which have limited migrations, appear more "climate-proof" than migratory white fish and upland fish and may be expected to increase in the proportion of fish catches as temperatures increase. Aquaculture infrastructure will be increasingly vulnerable to damage resulting from extreme events such as flash floods. Increasing temperatures throughout the LMB will result in greater eutrophication of aquaculture ponds and associated negative water quality effects on adjacent streams and river systems. No detailed study of the fisheries vulnerabilities in Sakon Nakhon was carried out by the USAID Mekong ARCC Climate Study.

Non-Timber Forest Products (NTFPs)

Productivity and fertility of NTFPs may be affected by increased temperatures, with dry season spikes impacting flowering, fruiting, and seed dispersal. No detailed study of the NTFPs vulnerabilities in Sakon Nakhon was carried out by the USAID Mekong ARCC Climate Study.

Natural Systems – Protected Areas

Climate change in the LMB will accelerate the loss of populations and species due to extreme temperatures, particularly during dry periods, and will be a significant driver of biodiversity loss. A reorganization of plant and animal communities will likely occur as a result of climate change, and new "problem" species will enter communities affecting overall structure and function. Geographic ranges for both species and ecosystems will shift, and there will be an overall loss in habitat extent.

VULNERABILITY AND CAPACITY ASSESSMENT OF TARGET COMMUNITIES

1. Huai Kang Pla, Chiang Rai

Huai Kang Pla is one of the three selected target villages in Pa Tueng sub-district, Mae Chan district, Chiang Rai Province. Huai Kang Pla is connected to the other two villages, Loh Yo and Hae Ko, through the Mae Chan watershed, a sub-basin of the Mae Kok River Basin. The three villages have been selected after discussions with partner organizations and the Pa Tueng Tambon Administration Organization[12]. The main idea was to have different ethnic groups and communities of Pa Tueng sub-district, and different scales, represented in the study.

Pa Tueng is part of the high-elevation moist broadleaf forest ecozone as outlined by the USAID Mekong ARCC Climate Study. Huai Kang Pla is situated in the lower reaches of the watershed.

There is no specific soil characteristics identified around Huai Kang Pla village because it is a slope complex area according to the classification of Thailand's Land Development Department (LDD). Some problems regarding acidic soil can be found.

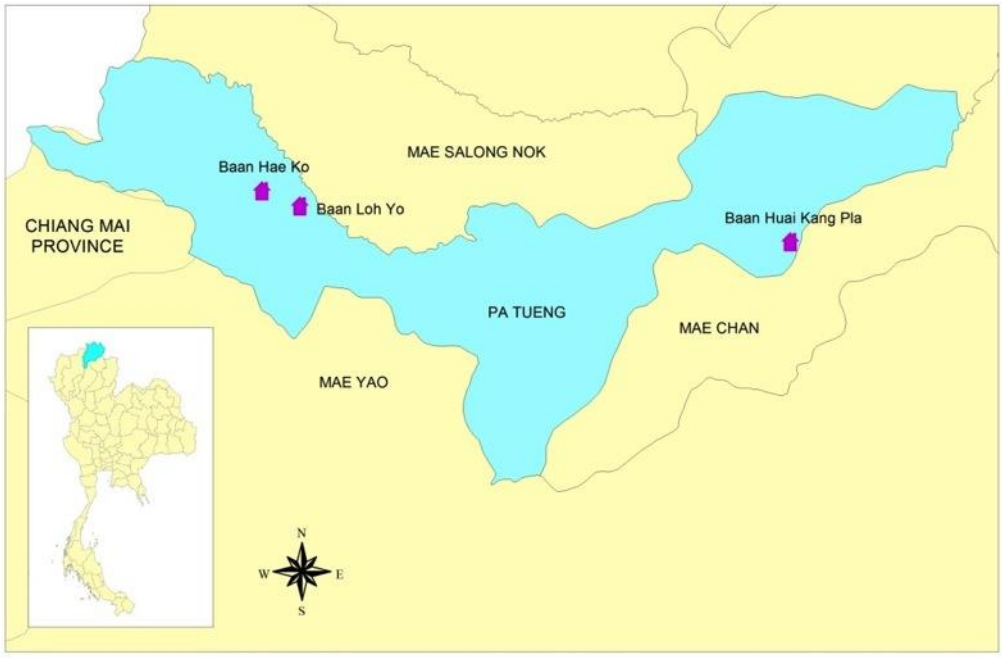

Figure 18: Location of three target villages in Pa Tueng Sub-district, Chiang Rai

Huai Kang Pla is composed of Huai Kang Pla village (480-500 metres above sea level) and five satellite villages: Huai Pu (460 masl), Lua Pattana (460 masl), Pa Bong Ngam Lang (460-480 masl), Pa Bong Ngam Bon (600 masl), and Huai Ya No (580-600 masl).

Huai Kang Pla (including satellite villages) is inhabited by the Akha, Lahu, Lawa, Yao, and local Thai ethnic groups and comprises 326 households and 2,177 individuals. Apart from growing rice, the villagers also practice fishery activities, raise pigs, cattle and buffalo, and grow litchi, maize, and rubber.

[12] Sub-district government.

Huai Kang Pla village has approximately 176 hectares agricultural land area; Huai Pu 88 hectares, Lua Pattana 8.8 hectares, Pa Bong Ngam Lang 6.4 hectares, Pa Bong Ngam Bon 27.2 hectares, and Huai Ya No 4.8 hectares. Total agricultural land area for all villages is approximately 311 hectares.

Results from VCA tools

- *Village Mapping*

The following village map shows the location of Huai Kang Pla and the five satellite villages. Some villages are located next to a river or stream, which makes them more vulnerable to flooding. Other villages are more vulnerable to landslides.

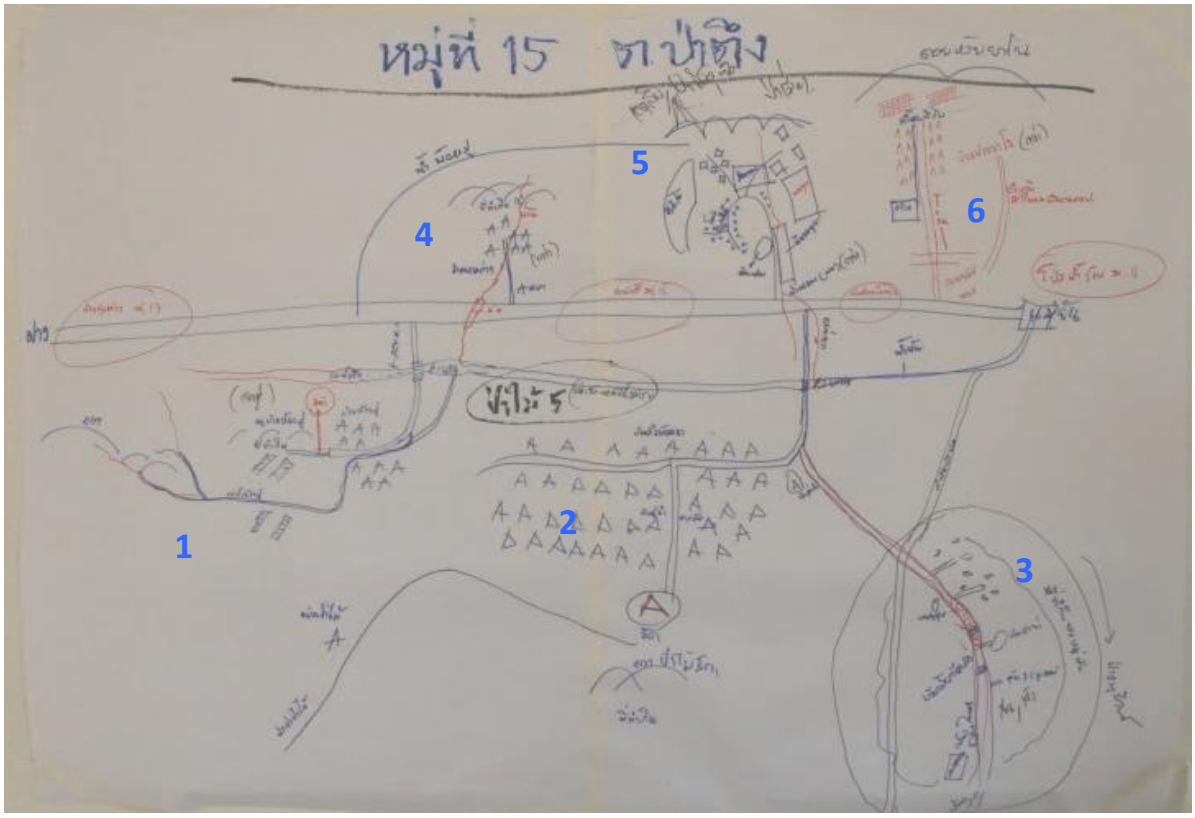

Figure 19: Huai Kang Pla Village Mapping

Description

To the south of the road, from left to right:
1. Huai Pu (settlement, paddy fields, Huai Pu creek, forest and watershed area)
2. Lua Pattana (settlement, temple, agricultural land, preserved forest area (incl. teak trees))
3. Huai Kang Pla (settlement, Huai Kang Pla creek, agricultural area, upland rice, forest)

To the north of the road, from left to right:
4. Pa Bong Ngam Lang (settlement, agricultural area, mountainous area)
5. Pa Bong Ngam Bon (settlement, forest, landslide area, agricultural land and mountainous area, agricultural land owned by outsider)
6. Huai Ya No (settlement, upland rice fields, forest, Huai Ya No mountain, Huai Ya No creek, abandoned golf course)

Mae Chan River is parallel to the main road, to the south.

Huai Kang Pla Forest Park and Lam Nam Kok National Park are situated further south.

- *Seasonal Calendar*

The following seasonal calendar shows the main livelihood activities in Huai Kang Pla throughout the year. The calendar is applicable to men and women. Men are mainly involved in land preparation, spraying pesticide and herbicide, applying fertilizer, weeding, and harvesting, while women are involved in planting, weeding, and harvesting. Women are more involved in NTFP collection than men; but honey collection is done only by men.

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Remarks
Maize			land preparation and weed elimination		grow		fertilizer and herbicide		harvest				for sale (grown mostly in Huai Kang Pla village)
Upland rice			land preparation and weed elimination		grow		fertilizer and herbicide				harvest		for consumption but not enough for the whole year (grown mostly in Pa Bong Ngam Bon village)
Ginger	harvest mature		land preparation	grow		fertilizer and herbicide		harvest young ginger				harvest mature	for sale
Rice (paddy)						sowing, ploughing, herbicide	plant		fertilizer		harvest		for consumption and sale (for Huai Pu village)
Soybean	grow			harvest								grow	for sale (grown after harvesting rice)
Rambutan							harvest						for sale
Litchi						harvest							for sale
Passion fruit (sour)		stand preparation	grow						harvest				for sale to Doi Kham project
Pineapple			grow								harvest		for sale
Bitter rattan, galangal, lemongrass, banana flower	harvest												for consumption and sale
Bamboo shoot, mushroom							harvest						for sale

Edible fern			harvest									
Honey			harvest									only by men

- *Historical Timeline*

Year	Important and climate-related events
1954	Huai Hia village (which became Huai Kang Pla village in 1966) was established by Yao people who migrated from Lao.
1958	Huai Ya No village was established.
1968	Huai Pu village was established.
1971	Lua Pattana village was established (separated from Huai Pu village).
1974	Pa Bong Ngam Bon village was established. Started to grow upland rice in Huai Pu village (other villages grew upland rice since settling down).
1977	Hill tribe development and aid organization started to provide some assistance in Huai Pu village.
1980	Road access to Pa Bong Ngam Bon village. Granite mining concession in Pa Bong Ngam Bon village.
1982	Mountain water supply in Pa Bong Ngam Bon village.
1984	Epidemic of malaria especially in Pa Bong Ngam Bon village.
1986	Electricity access in Huai Pu village. Asphalt road and electricity access in Huai Kang Pla village. Huai Kang Pla Waterfall Park was established.
1987	Asphalt road and electricity access to Lua Pattana village. Asphalt road and bridge were built in Huai Pu village.
1989	Mountain water supply pipe were destroyed by mining, then moved to use water from Huai Pu Kho until now.
1991	Massive migration of teenage labour to other provinces for employment.
1993	Hailstorm damaged houses in Huai Pu village.
1994	Public health centre established in Lua Pattana village. Mountain water supply in Huai Ya No village.
1995	Electricity access and reforestation by the Royal Forest Department in Pa Bong Ngam Bon village.
1997	Started to grow maize.
1998	Hail storm damaged houses in Huai Kang Pla village.
1999	Short period of very cold weather and heavy storm destroyed houses in Lua Pattana village.
2000	Outside investors came to buy land from the villagers in Pa Bong Ngam Bon village. Electricity access in Huai Ya No village.
2002	Asphalt road and electricity access to Huai Ya No village.
2003	Stopped rice cultivation in the reforested area, shortage of water supply and severe flooding in Lua Pattana village.
2005	Granite mining concession was expired but still operating. The Pa Bong Ngam Bon villagers then protested and succeeded.
2007	Severe flooding destroyed a few houses and bird flu spread in Lua Pattana village.
2009	TAO supported water supply; chemical contamination found in water resource leading to disappearance of aquatic organisms; NTFPs were also difficult to find in Lua Pattana village.
2011	Flooding at the entrance of the village and very heavy rain severely damaged rice yield in Huai Ya No village.

2013	Flooding at the entrance to the village and very cold weather in Huai Ya No village.
2014	Shortage of water during March-May in Lua Pattana village.

Since the establishment of the village 60 years ago, villagers can remember climate-related events mostly since 1998. This is mainly because recent events are more present in their minds. Nevertheless, it may be that climate-related events have increased in frequency and intensity over the last 20 years.

- *Community Vulnerability Matrix*

Vulnerability ranking: 0-no impact, 1-low impact, 2-medium impact, 3-high impact.

Livelihoods/Resources	Disasters and Climate hazards					Total score
	Unusual rain	Drought	Hail storm	Storm	Disease Epidemic	
Upland rice yield	3	3	3	3	3	15
Livestock (chicken, pig, duck)	3	3	1	1	3	11
Maize yield	3	3	3	3	3	15
Water for consumption	3	3	1	0	0	7
Total score	12	12	8	7	9	

Main climate threats identified by the Huai Kang Pla villagers are related to unusual rain, drought, hail storms, storms, and diseases. Unusual rain and drought are identified as the most important threats to livelihoods and resources of Huai Kang Pla village. The most vulnerable livelihoods identified by the community are upland rice and maize yield. Temperature increase is not mentioned as a main threat by the villagers; awareness around increasing temperature will be built up during the scientific climate story part.

Scientific vulnerability assessment

The following table summarizes the main climate threats and vulnerabilities for the major livelihood areas for Huai Kang Pla village, based primarily on the USAID Mekong ARCC reports. The potential adaptation options are a first selection of options; however, these will be further explored in the next step of the project. Note: The items below are listed by theme (agriculture, livestock, fishery, natural systems, health and infrastructure). Within each theme, they are listed in order of importance for the community. However, in this table, the importance of each item for the community is not taken into account in the vulnerability assessment. This will be taken into account in the next section.

Livelihood Area	Threat	Impact and Vulnerability Summary	Exposure	Sensitivity	Adaptive Capacity	Vulnera-bility	Potential Adaptation Options (selection)
Upland rice (food and cash crop)	Increased temperature	Although upland rice will generally be less affected by changes in climate than lowland rice, an increase in temperatures might decrease yields. Vulnerability to mentioned threats is assessed as medium in the USAID Mekong ARCC Climate Study[13].	Medium	Medium	High	Medium	• Monitor changes in yield and, if relevant, try new varieties and diversify
	Increased precipitation		Low	Low	High	Medium	
	Water stress		Low	High	Low	Medium	
Paddy rice[14] (food crop)	Increased temperature	Temperature above 35°C induces sterility and reduces the number of grains. High temperatures in October will affect the ripening stage when the crop has a lower temperature tolerance.	Medium	High	Low	High[15]	• Shifting calendar • Heat-tolerant varieties; local varieties
	Increased precipitation	Although exposure to high temperature will be lower in the upland area, this assessment is still considered valid for Huai Kang Pla (exposure 'medium').	Low	Low	Medium	Medium	• Early maturation rice and using residual water for a short crop
	Water stress		Low	High	Low	Medium	
	Flash floods		Medium	Medium	Low	Medium	

[13] *Detailed Report on Agriculture*, page 108 ff.
[14] According to discussions with the USAID Mekong ARCC team, the results of Lowland rice can be applied to the paddy rice in upland communities (unless the main vulnerability concern is drought stress, which is not the case here).
[15] Note: External adaptive capacity is low, with lack of access to new varieties and extension services. Internal adaptive capacity is high, with capacity to grow in warm temperatures, critical temperature is 45°C at some growth stages, but with negative impact on yield. (*Detailed Report on Agriculture*, page 110)

Maize (cash crop)	Increased temperature	Slight decrease in maize suitability due to temperature increase.	Medium	Low	Low	Medium [16]	• Diversification, alternative crops • Intercropping with legume species
	Increased precipitation		Medium	Medium	Low	Medium	
Vegetables (food crop)	Increased temperature, precipitation	Vulnerability has not been assessed.				N/A	• N/A
Ginger (cash crop)	Increased temperature, precipitation	Vulnerability has not been assessed. Optimal temperature is between 19-29°C, absolute temperature between 13-35°C; and optimal rainfall between 1,400 and 3,000 mm/year.[17] Thus, vulnerability appears to be moderate.				N/A	• N/A
Litchi (cash crop)	Increased temperature	Predicted decrease in yields. However, this is only a minor crop in Huai Kang Pla.	Medium	Medium	Low	Medium	• Altitude shift • Heat-tolerant variety
	Increased precipitation		Medium	Low	High	Medium	• Shifting agro-forestry system to less heat vulnerable trees
Local chicken (consumption)	Increased temperature	The system for small-scale chicken is already outside the ideal temperature range; added heat stress will reduce reproduction and immunity. Feed and animal health issues. Local variety might be more heat-tolerant [18] . As exposure to high	Medium	High	Very Low	High	• Ensure adequate vaccination • Alternative feeding • Housing, shade trees • Introduce local varieties
	Flash floods,	temperature will be lower in the upland	Medium	High	Low	High	• Locate housing,

[16] Internal capacity is low. Shift in cropping calendar to avoid high temperature (and high precipitation period) is possible. (*Detailed Report on Agriculture*, p. 113)
[17] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=2177 (*Zingiber officinale*)
[18] *Detailed Report on Livestock*, page 95 ff.

	storms	area, exposure has been adjusted to 'medium' compared to 'high' in the initial assessment.		run, and feed storage away from high-risk areas

Pig (consumption)	Increased temperature	The system for small-scale pig operations is already outside the ideal temperature range; added heat stress will reduce reproduction and immunity. Feed and animal health issues.	High	High	Low	High	• Ensure adequate vaccination • Housing, shade trees • Introduce local varieties and alternative feeding • Locate housing, run, and feed storage away from high-risk areas
	Flash floods, storms	As exposure to high temperature will be lower in the upland area, exposure has been adjusted to 'high' compared to 'very high' in the initial assessment.	Low	Very High	Very Low	High	
Cattle (small-scale commercial)	Increased temperature	Reduced fodder availability affects already under-nourished stock; increased risk of disease, reduced productivity and value.	Medium	Low	Medium	Medium	• Planned destocking, forage development, improve access and quality of animal health services. • Improve infrastructure and reproduction management.
	Decrease in precipitation		Medium	Medium	Medium	Medium	
	Flash floods, storms		Medium	High	Low	High	
NTFPs: bamboo shoots, broom flower, galangal, banana flower, honey (sale and	Increased temperature, precipitation	Vulnerability not assessed in detail, but estimated relatively moderate[19]. Non-climate threats such as habitat loss and overharvesting.				Medium	• Protect the integrity of forest and wetland ecosystems

[19] The USAID Mekong ARCC Climate Study analysed selected NTFP species. For instance, the climate vulnerability of the rattan species *Calamus caesius* was assessed as moderate, while its non-climate vulnerability is very high. For the Giant Honeybee, climate vulnerability is moderate, non-climate vulnerability high. According to the study, species such as "*Calamus* (rattan), Red ants, Honeybees, Earthworms, and wild rice need attention to protect the species and its habitat and encourage more sustainable harvesting, rather than specific climate change adaptation measures" (*Detailed Report on NTFPs*, p. 102).

consumption)

Ecosystems (agricultural land, community forest, watersheds)	Increased temperature	Vulnerability not assessed in detail, but expected loss of biodiversity with impacts on NTFPs. Non-climate threats such as watershed degradation, soil degradation due to intensive land use and use of chemicals, and deforestation.				High	• Protect the integrity of forest and wetland ecosystems • Afforestation and reforestation to prevent soil erosion and preserve watershed • Agroforestry, mixed cropping • Reduce use of chemicals, use organic fertilizers
Health	Flash floods, landslides	Main vulnerabilities in the highland area are linked to flash floods and landslides. Assessed as 'high' in the USAID Mekong ARCC Climate Study.[20]	High	High	Medium	High	• Afforestation and reforestation to prevent soil erosion • Development of forecasting and early warning systems • Improve access to health services for all villagers
	Temperature	Flooding and high temperature	Medium	High	Medium	Medium	
	Flooding		Medium	High	Medium	Medium	
Infrastructure	Flash floods, landslides	Risk of infrastructure damage, including water supply.[21]	High	High	Medium	High	• Improve water system • Protect most vulnerable assets
	Flooding	Assessed as medium, but estimated high for certain households situated along the creeks (where exposure is medium to high).	Low	High	Low	Medium	

[20] *USAID Mekong ARCC Socio-Economic Assessment*, p. 94 ff. Assessment for *Intensively used uplands* in Chiang Rai.
[21] *USAID Mekong ARCC Socio-Economic Assessment*, p. 102 ff. Assessment for *Intensively used uplands* in Chiang Rai.

Scientific vulnerability matrix

The following matrix, based on the scientific vulnerability assessment, aims to provide an overview and ranking of the major threats and livelihood resources of Huai Kang Pla in order to identify the most vulnerable assets and livelihoods. This ranking has been undertaken by IUCN Thailand as part of the expert assessment, and includes the importance of each item for the community. Note that ecosystems are not explicitly represented in this table, but they are linked with and underlying the other livelihood resources.

Vulnerability ranking: 1-low, 2-medium, 3-high, 4-very high (based on USAID Mekong ARCC data where available; otherwise estimate based on FAO data and information from baseline surveys).

		Climate and non-climate hazards							
Livelihood resources	Importance weighting (4-critical to 1-slightly important)[22]	Increase in temp.	Increase in rainfall	Drought	Flash floods, landslides	Storms	Non-climate threats	Minus community adaptive capacity (3-high to 1-low)[23]	Total
Upland rice	4	2	2	2	2	1	1	-1	13
Bamboo shoots and other NTFPs[24]	3	2	2	2	2	2	3[25]	-1	15
Ginger[26]	3	2	1	2	2	2	1	-1	12
Maize	2	2	2	2	2	2	2[27]	-1	13
Vegetables[28]	2	2	2	2	2	2	1	-1	12
Chicken	2	3	2	1	3	3	1	-1	14
Pigs	2	3	2	1	3	3	1	-1	14
Cattle	2	2	1	1	3	3	1	-1	12
Litchi	1	2	2	2	2	2	1	-1	11
Paddy rice	1	3	2	2	2	2	1	-1	12
Health	3	2	2	1	3	3	1	-3	12
Infrastructure	3	1	2	1	3	3	1	-3	11
Total	28	27	22	19	29	28	15	-16	

From this vulnerability ranking, NTFPs, chicken, pigs, upland rice and maize are the most vulnerable livelihoods for Huai Kang Pla village. Chicken and pigs are most vulnerable to increased temperature while NTFPs are more vulnerable to non-climate threats. Increased temperature, flash floods, landslides and storms are the most important hazards.

[22] The importance weighting is based on information from the community profiles (assessment by the community), except for health and infrastructure, which are weighted '3-very important' (IUCN assumption).
[23] The adaptive capacity has been assessed based on IUCN's knowledge of the village. More details are included under 'Community adaptive capacity'.
[24] Detailed vulnerability has not been assessed. Estimate based on *Detailed Report on NTFPs*.
[25] Vulnerable to habitat loss and overharvesting.
[26] Detailed vulnerability has not been assessed. Estimate based on FAO data.
[27] Vulnerable to market price fluctuations.
[28] Vulnerability has not been assessed. IUCN estimate.

Community adaptive capacity

Community adaptive capacity generally is moderate. For paddy rice, for instance, the USAID Mekong ARCC study indicates that external adaptive capacity is low, with lack of access to new varieties and extension services[29]. This also applies to other crops and livestock in Huai Kang Pla. Adaptive capacity can be increased through this project by improving access to new varieties and extension services. Some of the satellite villages are rather remote, with greater difficulty to access markets. On the other hand, an important strength of Huai Kang Pla village is that the village headman is also sub-district headman, which ensures that they have the support of the sub-district government. Also, Huai Kang Pla has existing loan groups, such as the 'Million Baht' fund group, which provides loan for the members to be used for their living and investment. Women are very actively participating in the project activities. In terms of health and infrastructure, adaptive capacity of the community is assessed as high due to the support of the sub-district government.

Information from the baseline survey also indicates that the community sometimes accesses and integrates climate information and forecasts into decision-making, but only a few times a year. The main sources of weather/climate information are TV, radio, newspapers, and the Internet. The community does not solidly plan for or practice adaptation strategies to mitigate climatic effects or manage seasonal variability. However, the villagers undertake some climate change resilience-related activities, i.e. building firebreaks and check dams.

Specific vulnerabilities of women or vulnerable groups

Households situated along rivers appear to be more vulnerable to floods. For instance, Lua Pattana village is located close to the Mae Chan River, and thus will be more vulnerable to heavy rain. The higher villages Pa Bong Ngam Bon and Huai Ya No are more vulnerable to landslides. Note that this project will be able to account for the specific conditions in the satellite villages only partially. Although the satellite villages are invited to participate in the activities, a detailed analysis of each village is not possible due to restrictions in time and resources. However, the satellite villages will certainly benefit from the lessons learned of this project.

Villagers who largely depend on NTFP collection, especially women, will be particularly vulnerable to climate and non-climate threats such as a decrease in yield, loss of habitat or overharvesting. Women who depend on NTFPs will have to spend more time in the forest to collect sufficient NTFPs for sale or consumption. This will be taken into consideration when selecting the adaptation options.

No difference in vulnerability has been identified between the different ethnic groups.

[29] While internal adaptive capacity is high. *Detailed Report on Agriculture*, page 110.

Villager from Huai Kang Pla preparing NTFPs for sale

Conclusions

The major vulnerabilities for Huai Kang Pla village identified by this assessment are:
- Flooding, landslides and heavy rain could threaten infrastructure and upland rice, the main food crop (climate factors)
- Heat stress, flash floods and storms could threaten chicken and pigs (climate factors)
- Overharvesting and habitat loss could affect availability of NTFPs (non-climate factors)
- Water shortage in dry season (climate and non-climate factors)
- Lack of access to markets, new varieties and extension services (non-climate factors)

2. Loh Yo, Chiang Rai

Loh Yo village is inhabited by the Akha hill tribe community comprising 60 households and 600 individuals. Loh Yo is located in the upper reaches of the Mae Chan watershed, at around 950-1,000 metres above sea level (see Figure **18**).

Loh Yo is located about 31 km away from central Mae Chan district and was established in 1966 by an Akha community that migrated from the nearby area to find agricultural land and to flee from border conflicts. Most households in Loh Yo occupy agricultural land of about 1-5 rai (0.16-0.8 ha).

In this village, under IUCN's Poverty Reduction Project, three demonstration plots were established for indigenous tree species and other species identified by the Chiang Mai University Forest Restoration Research Unit (FORRU). In addition, farmers have been encouraged to plant different species in this forest, such as rattan, Burmese grape, and other fast-growing species (i.e. *Fraxinus griffithii*, *Liqudambar formosana*, and *Cinnamomum camphora*). Farmers in this village also have terraced paddy fields, and they apply integrated farming practices with perennial and cash crops and fruit crops such as strawberries, mulberries etc. Some villagers raise chicken and conduct off-farming activities such as woodcarving.

There are homestays and several shops in Loh Yo for tourists who want to visit the hill tribes of Doi Mae Salong. A museum on Akha culture is being built by a young villager who works as a tourist guide.

Loh Yo village is surrounded by community forest, with an estimated area of 144 hectares. Total agricultural land area is approximately 160 hectares.

Loh Yo is a satellite village of Santisuk village. Currently, none of Loh Yo villagers are represented as council members of Pa Tueng Tambon Administration Organization.

Almost 70% of households have temporary housing structures. Access by the non-asphalt road can be difficult during rainy season. Although none of the households live below the poverty line, the villagers are relatively poor, and 87.5% of the villagers do not have any school education. In the village, there is only the kindergarten available. For further education, children go to Baan Ruam Jai School (nowadays all children go to school). Many villagers, especially women and elderly, are unable to communicate in Thai language. 90% of the villagers are Christian.

Results from VCA tools

- *Village Mapping*

The diagram below represents a map of Loh Yo village. There are two churches and a kindergarten in the village. The main water source is Saen Mai River, located outside the village. Most of the village area is on a steep slope.

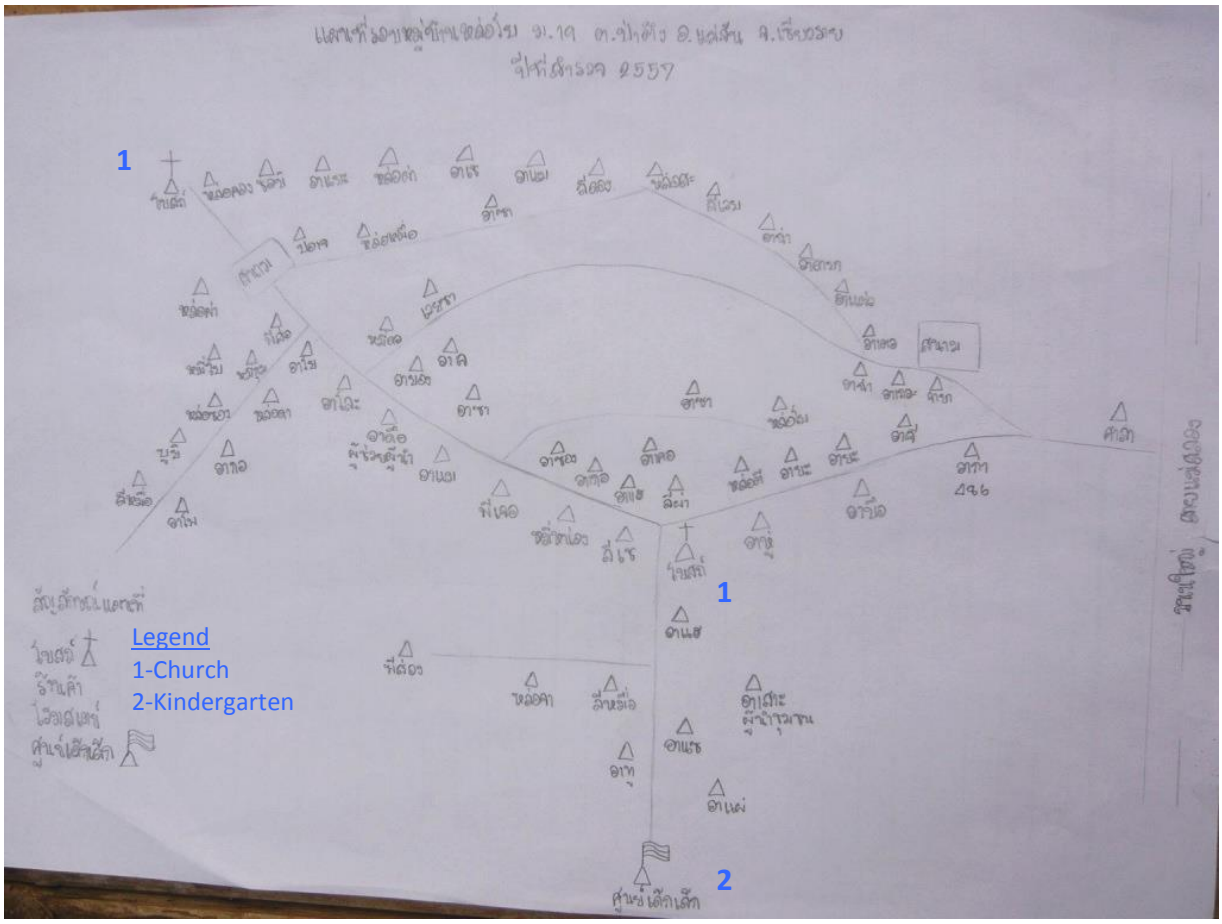

Figure 20: Loh Yo Village Mapping

- *Seasonal Calendar*

The following seasonal calendar shows the main livelihood activities in Loh Yo throughout the year. The calendar is applicable to men and women. Men are mainly involved in land preparation, spraying pesticide and herbicide, applying fertilizer, weeding, and harvesting, while women are involved in planting, weeding, and harvesting. Women are more involved in NTFP collection than men; but honey collection is done only by men. In addition, woodcarving is done only by men throughout the year.

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
For consumption												
Upland rice			*land preparation and weed elimination (chemical spraying)*		grow	*weed elimination (chemical spraying)*	*weed elimination (by hand)*			harvest		
Rice (field)					*land preparation*	*sowing*	*grow*		fertilizer			harvest
Vegetables (coriander, chilli, cabbage)	Grow and harvest				Grow and harvest							
White and black sesame					Sow/spray herbicide	grow					harvest	
For sale												
Maize			*land preparation and weed elimination (chemical spraying)*		grow	*weed elimination (chemical spraying)*				harvest		
Plums[30] (can be harvested after 3 years)				harvest								
Chinese apricot (can be harvested after 3 years)				harvest								
Livestock												

[30] Referred to as 'cherries' by the villagers.

Chicken	Feeding											
Pig	Feeding											
Duck	Feeding											
NTFPs for consumption												
Edible fern	Harvest (along the stream)											
Vegetables	Harvest											
Fish	Catch (in Mae Chan river)											
NTFPs for sell												
Bamboo shoot								Harvest				
Bamboo worm										Harvest		
Phyllanthus emblica (Indian gooseberry)	Harvest											
Ant's eggs				Harvest								
Honey				Harvest								

- *Historical Timeline*

Year	Important and climate-related events
1966	Loh Yo village was established under the lead of Lao Oe old man. 5 households migrated from Hua Mae Kham.
1971	Loh Yo old man led more migration from Hua Mae Kham and Mae Chan Luang.
1984	First church was established.
1987	More migration from Mae Sai.
1994	Children development centre was established.
2005	Road and electricity access to the village.
2014	Hail storm (5-6 April 2014) and earthquake (5 May 2014)

Since the establishment of the village almost 50 years ago, villagers of Loh Yo do not remember any climate-relevant events except for the recent hail storm (and earthquake, although not climate-related) in 2014.

- *Community Vulnerability Matrix*

Vulnerability ranking: 0-no impact, 1-low impact, 2-medium impact, 3-high impact.

Livelihood/Resources	Disaster and Climate hazards					Total score
	Unusual rain	Drought	Hail storm	Forest fire	Earthquake**	
Upland Rice yield	3	3	3	0*	3	12
Maize yield	3	3	3	0*	3	12
Water for consumption and use	3	3	0	3	3	12
NTFPs	3	3	2	3	3	14
Fruits (plums, litchi)	3	3	3	0*	3	12
Total score	15	15	11	6	15	

* There are forest fire protections around agricultural area.
** The vulnerability matrix discussion with the villagers took place in the week after a 6.0 magnitude earthquake struck Northern Thailand (5 May 2014). Villagers were very scared of the earthquake and aftershocks, and they did not go to the field in the days following the earthquake.

Main climate threats identified by the Loh Yo villagers are related to unusual rain, drought, hail storms, and forest fire. Unusual rain and drought are identified as the most important threats to livelihoods and resources of Loh Yo village. The most vulnerable livelihoods identified by the community vulnerability matrix are NTFPs, but also upland rice and maize yield, water availability and fruit trees. Temperature increase is not mentioned as a main

threat by the villagers; awareness around increasing temperature will be built up during the scientific climate story part.

Some villagers mentioned pollution and soil degradation as an issue, but there is a lack of data on soil and water quality.

Scientific vulnerability assessment

The following table summarizes the main climate threats and vulnerabilities for the major livelihood areas for Loh Yo village, based primarily on the USAID Mekong ARCC reports. The potential adaptation options are a first selection of options; however, these will be further explored in the next step of the project.

Livelihood Area	Threat	Impact and Vulnerability Summary	Exposure	Sensitivity	Adaptive Capacity	Vulnera-bility	Potential Adaptation Options (selection)
Upland rice (food crop)	Increased temperature	Although upland rice will generally be less affected by changes in climate than lowland rice, an increase in temperatures might decrease yields. Vulnerability is assessed as medium by the USAID Mekong ARCC Climate Study (applicable to Loh Yo village)[31].	Medium	Medium	High	Medium	• Monitor changes in yield and, if relevant, try new varieties and diversify
	Increased precipitation		Low	Low	High	Medium	
	Water stress		Low	High	Low	Medium	
Paddy rice (food crop)	Increased temperature	Temperature above 35°C induces sterility and reduces the number of grains. High temperatures in October will affect the ripening stage when the crop has a lower temperature tolerance. As exposure to high temperature will be lower in the upland area, exposure has been adjusted to 'low' compared to 'medium' in the initial assessment.	Low	High	Low	High[32]	• Shifting calendar • Heat-tolerant varieties; local varieties
	Increased precipitation		Low	Low	Medium	Medium	
	Water stress		Low	High	Low	Medium	
	Flash floods		Medium	Medium	Low	Medium	• Early maturation rice and using residual water for a short crop

[31] *Detailed Report on Agriculture*, page 108 ff.

[32] Note: External adaptive capacity is low, with lack of access to new varieties and extension services. Internal adaptive capacity is high, with capacity to grow in warm temperatures, critical temperature is 45°C at some growth stages, but with negative impact on yield. (*Detailed Report on Agriculture*, page 110)

Maize (cash crop)	Increased temperature	Slight decrease in maize suitability due to temperature increase.	Medium	Low	Low	Medium [33]	• Diversification, alternative crops
	Increased precipitation		Medium	Medium	Low	Medium	
Vegetables, sesame (food crops)	Increased temperature, flooding	Vulnerability has not been assessed. Sesame: Optimal temperature is between 20-30°C, absolute temperature between 10-40°C; and optimal rainfall between 500 and 1,000 mm/year. [34] Thus, while vulnerability to temperature increase appears to be moderate, vulnerability to increased rainfall appears to be high.				N/A	• Monitor changes in rainfall and yield and, if relevant, change location of plots or try new varieties
Litchi (cash crop)	Increased temperature	Predicted decrease in yields.	Medium	Medium	Low	Medium	• Altitude shift • Shifting agro-forestry system to less heat vulnerable trees
	Increased precipitation		Medium	Low	High	Medium	
Other fruit trees (plums, Japanese apricot) (cash crops)	Increased temperature	Vulnerability has not been assessed. *Prunus domestica*: Optimal temperature between 18-33°C, absolute temperature between 6-36°C; and optimal rainfall between 900 and 1,500 mm/year. *Prunus salicina*: Optimal temperature between 18-34°C, absolute temperature between 6-38°C; and optimal rainfall between 750 and 900 mm/year. Japanese apricot: Optimal temperature between 18-34°C, absolute temperature				N/A	• Monitor changes in rainfall and yield and, if relevant, change location of plots or try new varieties

[33] Internal capacity is low. Shift in cropping calendar to avoid high temperature (and high precipitation period) is possible. (*Detailed Report on Agriculture*, p. 113)

[34] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=1937 (*Sesamum indicum*)

		between 6-38°C; and optimal rainfall between 800 and 1,000 mm/year.[35] Thus, while vulnerability to temperature increase appears to be moderate, vulnerability to increased rainfall appears to be high.					
Arabica coffee (cash crop)	Increased temperature	Vulnerability has not been assessed. Might be negatively affected by increase in temperature. Optimal temperature is between 14-28°C, absolute temperature between 10-34°C; and optimal rainfall between 1,400 and 2,300 mm/year.[36] Thus, coffee may be vulnerable to increased temperature.[37] High-elevation areas of Chiang Rai will experience increased suitability for Robusta coffee due to projected changes in temperature and rainfall. Optimal temperature for Robusta coffee is between 20-30°C, absolute temperature between 12-36°C, and optimal rainfall between 1,700 and 3,000.[38]				N/A	• Monitor changes in temperature and yield and, if relevant, diversify and try Robusta variety
Local chicken (consumption)	Increased temperature	The system for small-scale commercial chicken is already outside the ideal temperature range; added heat stress will reduce reproduction and immunity.	Medium	High	Very Low	High	• Ensure adequate vaccination • Housing, shade trees

[35] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=16203 (*Prunus domestica*)
http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=8992 (*Prunus salicina*)
http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=8983 (*Prunus mume*)
[36] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=749 (*Coffea arabica*)
[37] In addition, certain studies indicate that "Arabica crops grown in the world's coffee plantations are from very limited genetic stock and are thought to lack the flexibility to cope with climate change and other threats such as pests and diseases." *Source:* http://www.bbc.co.uk/news/science-environment-20252472 (8 November 2012).
[38] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=750 (*Coffea canephora*)

	Flash floods, storms	Feed and animal health issues. Local variety might be more heat-tolerant [39] . As exposure to high temperature will be lower in the upland area, exposure has been adjusted to 'medium' compared to 'high' in the initial assessment.	Medium	High	Low	High	• Locate housing, run, and feed storage away from high-risk areas
Pig (consumption)	Increased temperature	The system for small-scale pig operations is already outside the ideal temperature range; added heat stress will reduce reproduction and immunity. Feed and animal health issues.	High	High	Low	High	• Ensure adequate vaccination • Housing, shade trees
	Flash floods, storms	Climate threats from flash floods and storms assessed as high. As exposure to high temperature will be lower in the upland area, exposure has been adjusted to 'high' compared to 'very high' in the initial assessment. However, pigs are not a major livestock product in Loh Yo.	Low	Very High	Very Low	High	• Locate housing, run, and feed storage away from high-risk areas
Duck (consumption)	Increased temperature, flash floods, storms	The vulnerability of ducks has not been assessed in detail for Chiang Rai. The overall climate vulnerability of field running layer duck in the LMB assessed as low.[40] Ducks are not a major livestock product in Loh Yo.	Very Low	Very Low	Low	Low	• N/A
Wild fish (consumption)	Increased temperature	Upland forest stream fish will be impacted by higher temperatures in the	High	Very High	Low	Very High[42]	• Preserve or restore forest

[39] *Detailed Report on Livestock*, page 95 ff.
[40] *Detailed Report on Livestock*, page iv.

	Decrease in precipitation	spawning season (Nov-Dec), reducing reproduction and limiting habitat suitability.[41]	High	Medium	Low	High	cover along upland streams
	Flash floods and storms	As exposure to high temperature will be lower in the upland area, exposure has been adjusted to 'high' compared to 'very high' in the initial assessment.	Medium	Medium	Medium	High	
NTFPs: bamboo shoots and worms, *Phyllanthus emblica* Linn.[43], ants' eggs, edible fern (sale and consumption)	Increased temperature, precipitation	Vulnerability not assessed in detail, but estimated relatively moderate.[44] Non-climate threats such as habitat loss and overharvesting.				Medium	• Protect the integrity of forest and wetland ecosystems
Ecosystems (agricultural land, community forest, watersheds)	Increased temperature	Vulnerability not assessed in detail, but expected loss of biodiversity with impacts on NTFPs. Non-climate threats such as watershed degradation, soil degradation, and deforestation.				High	• Protect the integrity of forest and wetland ecosystems • Afforestation and reforestation to prevent soil erosion and preserve watershed

[42] 'Very high' only for *Tor tambroides* upland fish and migratory white fish categories. For other categories, the temperature increase threat is assessed as 'high' or 'medium'.

[41] *Detailed Report on Fisheries*, page 116 ff.

[43] Indian gooseberry.

[44] The USAID Mekong ARCC Climate Study analysed selected NTFP species. For instance, the climate vulnerability of the rattan species *Calamus caesius* was assessed as moderate, while the non-climate vulnerability is very high. For the Red ant, climate vulnerability is low, non-climate vulnerability moderate. According to the study, species such as "*Calamus* (rattan), Red ants, Honeybees, Earthworms, and wild rice need attention to protect the species and its habitat and encourage more sustainable harvesting, rather than specific climate change adaptation measures" (*Detailed Report on NTFPs*, p. 102).

							• Agroforestry, mixed cropping • Reduce use of chemicals, use organic fertilizers
Health	Flash floods, landslides	Main vulnerabilities in the highland area are linked to flash floods and landslides. Assessed as 'high' in the USAID Mekong ARCC Climate Study.[45] In addition, Loh Yo village is remote and in rainy season it can be difficult to access.	High	High	Medium	High	• Afforestation and reforestation to prevent soil erosion • Development of forecasting and early warning systems • Improve access to health services for all villagers
Infrastructure	Flash floods, landslides	Risk of infrastructure damage, including water supply, especially for temporary housing structures.[46]	High	High	Low	High	• Improve water system • Protect most vulnerable assets

[45] *USAID Mekong ARCC Socio-Economic Assessment*, p. 94 ff. Assessment for *Intensively used uplands* in Chiang Rai.
[46] *USAID Mekong ARCC Socio-Economic Assessment*, p. 102 ff. Assessment for *Intensively used uplands* in Chiang Rai.

Scientific vulnerability matrix

The following matrix aims to provide an overview and ranking of the major threats and livelihood resources of Loh Yo in order to identify the most vulnerable assets and livelihoods. Note that ecosystems are not explicitly represented in this table, but they are linked with and underlying the other livelihood resources.
Vulnerability ranking: 1-low, 2-medium, 3-high, 4-very high (based on USAID Mekong ARCC data where available; otherwise estimate based on FAO data and information from baseline surveys).

		Climate and non-climate hazards							
Livelihood resources	Importance weighting (4-critical to 1-slightly important)[47]	Increase in temp.	Increase in rainfall	Drought	Flash floods, landslides	Storms	Non-climate threats	Minus community adaptive capacity (3-high to 1-low)[48]	Total
Upland rice	4	2	2	2	2	1	1	-1	13
Maize	4	2	2	2	2	2	2[49]	-1	15
Bamboo shoots and other NTFPs[50]	4	2	2	2	2	2	3[51]	-1	16
Sesame[52]	3	2	2	2	2	2	1	-1	13
Paddy rice	2	3	2	2	2	2	1	-1	13
Chicken	2	3	2	1	3	3	1	-1	14
Wild fish	2	3	2	2	3	3	2[53]	-1	16
Plums, Japanese apricot[54]	2	2	3	2	2	2	1	-1	13
Health	3	2	2	1	3	3	1	-2	13
Infrastructure	3	1	2	1	3	3	1	-2	12
Total	29	22	21	17	24	23	14	-12	

From this vulnerability ranking, NTFPs, maize, chicken and wild fish are the most vulnerable livelihoods for Loh Yo village. Upland rice as their main food crop also represents an important vulnerability. Wild fish and chicken are very vulnerable to increased temperature, flash floods, landslides and storms while NTFPs appear to be more vulnerable to non-climate threats. Increased temperature, flash floods, landslides and storms are the most important hazards.

[47] The importance weighting is based on information from the community profiles (assessment by the community), except for health and infrastructure, which are weighted '3-very important' (IUCN assumption).
[48] The adaptive capacity has been assessed based on IUCN's knowledge of the village. More details are included under 'Community adaptive capacity'.
[49] Vulnerable to market price fluctuations.
[50] Detailed vulnerability has not been assessed. Estimate based on *Detailed Report on NTFPs*.
[51] Vulnerable to habitat loss and overharvesting.
[52] Detailed vulnerability has not been assessed. Estimate based on FAO data.
[53] Vulnerable to habitat loss and overharvesting.
[54] Detailed vulnerability has not been assessed. Estimate based on FAO data.

Community adaptive capacity

Community adaptive capacity generally is moderate. Access to markets, new varieties and extension services is limited, although it has been strengthened by the Poverty Reduction Project. Lack of land tenure, the inability to speak Thai, lack of citizenship, and lack of school education of some villagers all increase vulnerability. Access to loans is limited, partly due to the lack of land title. Also, Loh Yo villagers are not represented in the TAO. An important strength of this village is the past interventions of the Livelihoods and Landscapes and Poverty Reduction projects, which have helped restore the watershed area and have introduced livelihood diversification through alternative crops (e.g. fruit trees) and tourism. For Arabica coffee, for instance, Loh Yo benefited from the knowledge and experience of HRDI and the Royal Initiative Projects. Villagers are willing to try new crops and livelihood activities.

Information from the baseline survey also indicates that the community sometimes accesses and integrates climate information and forecasts into decision-making (about 5-10 times a year). The main sources of weather/climate information are TV, radio, and their own observations. The community does not solidly plan for or practice adaptation strategies to mitigate climatic effects or manage seasonal variability. However, the villagers undertake some climate change resilience-related activities, i.e. building firebreaks and reforestation.

Specific vulnerabilities of women or vulnerable groups

Villagers who largely depend on NTFP collection, especially women, will be particularly vulnerable to climate and non-climate threats. Villagers with lack of citizenship, and villagers who do not speak Thai (more women than men), are also particularly vulnerable. This will be taken into consideration when selecting the adaptation options.

Conclusions

The major vulnerabilities for Loh Yo village identified by this assessment are:
- Landslides and flash floods could threaten infrastructure and upland rice, the main food crop (climate factors)
- Heat stress, flash floods and storms could threaten chicken and wild fish (climate factors)
- Overharvesting and habitat loss could affect availability of NTFPs (non-climate factors)
- Vulnerable to watershed degradation, water shortages and water pollution (climate and non-climate factors)
- Lack of access to markets, new varieties and extension services (non-climate factors). Maize, the main cash crop, is vulnerable to market price fluctuations.

3. Hae Ko, Chiang Rai

Like Loh Yo, the neighbouring Hae Ko village is located in the upper reaches of the Mae Chan watershed, at around 920-950 metres above sea level (see Figure **18**).

Hae Ko is located about 30 km away from central Mae Chan district. Like Loh Yo, Hae Ko is a satellite village of Santisuk village. Currently, none of Hae Ko villagers are represented as council members of Pa Tueng Tambon Administration Organization.

Hae Ko village is inhabited by the Lisu hill tribe community consisting of 49 households and 282 individuals. This Lisu community migrated from Mae Salong in 1975 to seek fertile land. Most households in Hae Ko occupy agricultural land of about 1-5 rai (0.16-0.8 ha). Total agricultural land area is approximately 320 hectares, and estimated community forest area is 8 hectares.

Upon recommendation of the Poverty Reduction Project, this community started planting coffee in remnant forests around the village and harvesting other forest products. In this way, they have been encouraged to conserve and look after the forest. The villagers have also started to use small-scale fish ponds for the sourcing of fish for household consumption. This village also practices multiple cropping, i.e. some villagers plant red beans one month before harvesting the maize, which helps nitrogen fixation in roots and produces better nutrients for the soil. On some plots, they plant groundnuts after harvesting the rice. In addition, the villagers grow new crops such as passion fruit, which they then sell to the Royal Project.

Mae Salong Villa, an outsider, acquired land in Hae Ko for tea gardens. Several villagers are employed in the tea gardens.

51% of households have temporary housing structures. Access by the non-asphalt road can be difficult during rainy season. Although none of the households live below the poverty line, the villagers are relatively poor, and 64% of the villagers do not have any school education. In the village, there is only the kindergarten available. For further education, children go to Baan Ruam Jai School (nowadays all children go to school). Most villagers are able to verbally communicate well in Northern Thai; but most elderly people do not speak Thai.

Results from VCA tools

- *Village Mapping*

The diagram below represents a map of Hae Ko village. There is a church and a kindergarten in the village. The main road leads from Mae Chan to Doi Mae Salong. The Hae Ko stream passes next to the village. However, the main water source is Saen Mai River, located outside the village, because it is located in a higher area, which makes it easier to bring the water to the village. Most of the village area is on a steep slope.

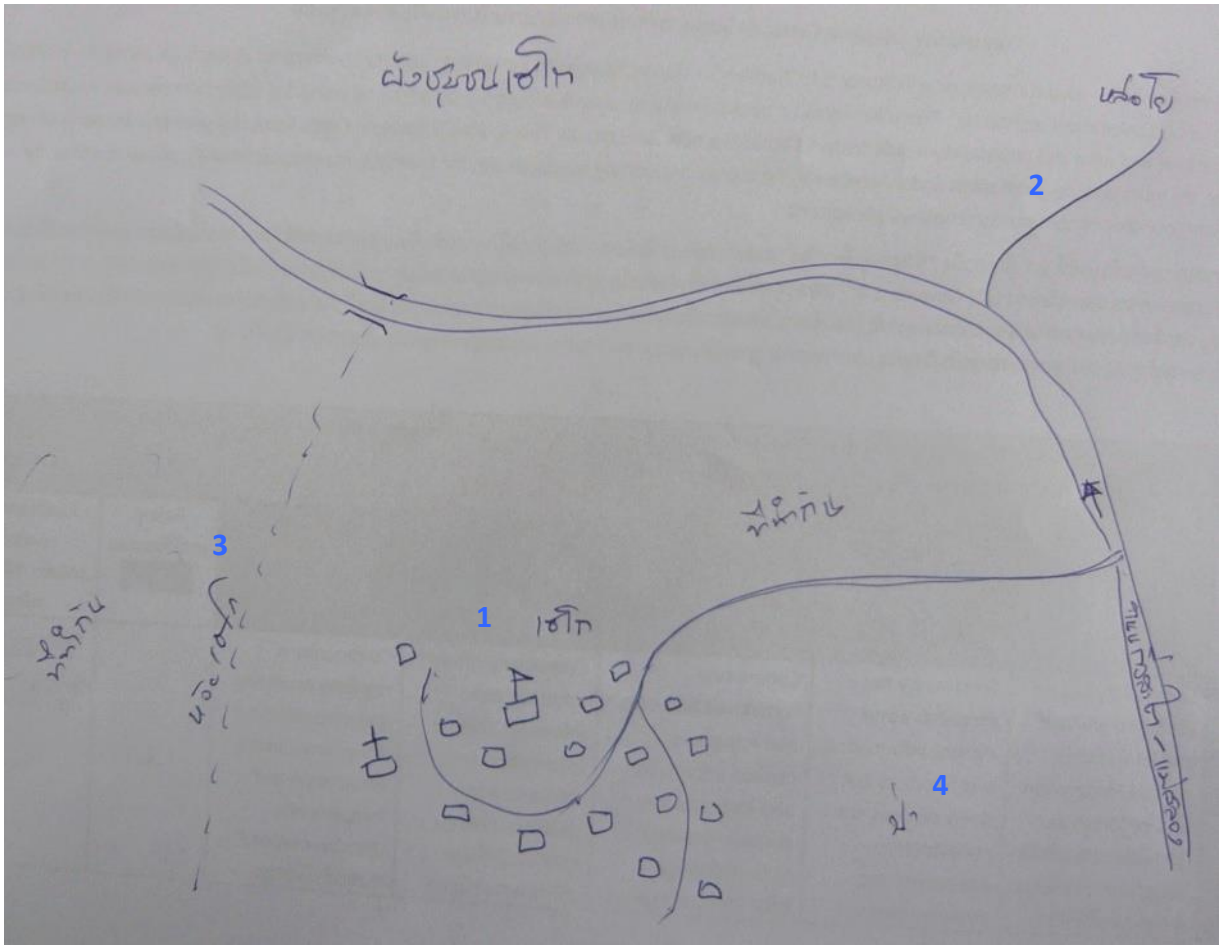

Figure 21: Hae Ko Village Mapping

Description:
1. Hae Ko village, with kindergarten and church
2. Road to neighbouring Loh Yo village
3. Hae Ko stream
4. Forest area

- *Seasonal Calendar*

The following seasonal calendar shows the main livelihood activities in Hae Ko throughout the year. The calendar is applicable to men and women. Men are mainly involved in land preparation, spraying pesticide and herbicide, applying fertilizer, weeding, and harvesting, while women are involved in planting, weeding, and harvesting. Women are more involved in NTFP collection than men; but honey collection and hunting is done only by men. In addition, women produce handicrafts (bags, bracelets).

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
For consumption												
Upland rice			*land preparation*		*weed elimination (chemical spraying)*	*grow*		*weed elimination (by hand)*			harvest	
Cabbage, coriander,			*land preparation*	*sowing*	*harvest*							
Rice (field)					*land preparation*	*sowing*	*grow*		fertilizer			harvest
For sale												
Groundnut					*land preparation and weed elimination (chemical spraying)*		grow	*weed elimination (chemical spraying)*			harvest	
Maize			*land preparation*		grow		*weed elimination (chemical spraying)*			harvest		
Red bean/Rice bean							grow				harvest	
Arabica coffee (can be harvested after 3 years)											harvest	
Plums (can be harvested after 3 years)		*flowering*		harvest								

Litchi					harvest							
Livestock												
Chicken	*Feeding*											
Pig	*Feeding*											
NTFPs for consumption												
Bamboo shoot								*Harvest*				
Mushroom										*Harvest*		
Wild mango						*Harvest*						
Wildlife (wild chicken, hedgehogs, monkey)	*Hunting*											
NTFPs for sell												
Bamboo shoot								*Harvest*				
Honey				*Harvest*								

- *Historical Timeline*

Year	Important and climate-related events
1975	Hae Ko village was established under the lead of A Hle old man. 7 households migrated from Hua Mae Kham.
1979	First church was established.
1982	Children development centre was established.
1996	Road access to the village.
2006	Electricity access to the village.
2011	Improved the road and Mr Suzuki (Japanese) helped to build school and buy tractor for the village.
2012	Landslide in the farming area (usually happens along side of the road)
2014	Hail storm (5-6 April 2014) damaged plum trees[55] and other crops; earthquake (5 May 2014).

According to the timeline, since the establishment of the village about 40 years ago, villagers of Hae Ko can remember only recent climate-related events, i.e. a landslide in 2012 and the hail storm (and earthquake, although not climate-related) in 2014.

- *Community Vulnerability Matrix*

Vulnerability ranking: 0-no impact, 1-low impact, 2-medium impact, 3-high impact.

Livelihood/Resources	Disaster and Climate hazards					Total score
	Unusual rain	Drought	Hail storm	Storm	Landslide	
Upland rice yield	3	3	3	3	3	15
Water for consumption and use	3	3	0	0	3	9
Maize yield	3	3	3	3	3	15
Groundnut	3	3	3	1	3	13
Plums[55]	3	3	3	3	1	13
Total score	15	15	12	10	13	

Main climate threats identified by the Hae Ko villagers are related to unusual rain, drought, hail storms, storms, and landslides. Unusual rain and drought are identified as the most important threats to livelihoods and resources of Hae Ko village. The most vulnerable livelihoods identified by the community are upland rice and maize yield, groundnuts and plums. Temperature increase is not mentioned as a main threat by the communities; awareness around increasing temperature will be built up during the scientific climate story part.

[55] Referred to as 'cherries' by the villagers.

Scientific vulnerability assessment

The following table summarizes the main climate threats and vulnerabilities for the major livelihood areas for Hae Ko village, based primarily on the USAID Mekong ARCC reports. The potential adaptation options are a first selection of options; however, these will be further explored in the next step of the project.

Livelihood Area	Threat	Impact and Vulnerability Summary	Exposure	Sensitivity	Adaptive Capacity	Vulnera-bility	Potential Adaptation Options (selection)
Upland rice (food crop)	Increased temperature	Although upland rice will generally be less affected by changes in climate than lowland rice, an increase in temperatures might decrease yields. Vulnerability is assessed as medium in the USAID Mekong ARCC Climate Study[56].	Medium	Medium	High	Medium	• Monitor changes in yield and, if relevant, try new varieties and diversify
	Increased precipitation		Low	Low	High	Medium	
	Water stress		Low	High	Low	Medium	
Paddy rice (food crop)	Increased temperature	Temperature above 35°C induces sterility and reduces the number of grains. High temperatures in October will affect the ripening stage when the crop has a lower temperature tolerance. As exposure to high temperature will be lower in the upland area, exposure has been adjusted to 'low' compared to 'medium' in the initial assessment.	Low	High	Low	High[57]	• Shifting calendar • Heat-tolerant varieties; local varieties
	Increased precipitation		Low	Low	Medium	Medium	
	Water stress		Low	High	Low	Medium	• Early maturation rice and using residual water for a short crop
	Flash floods		Medium	Medium	Low	Medium	
Maize (cash crop)	Increased temperature	Slight decrease in maize suitability due to temperature increase.	Medium	Low	Low	Medium[58]	• Diversification, alternative crops

[56] *Detailed Report on Agriculture*, page 108 ff.
[57] Note: External adaptive capacity is low, with lack of access to new varieties and extension services. Internal adaptive capacity is high, with capacity to grow in warm temperatures, critical temperature is 45°C at some growth stages, but with negative impact on yield. (*Detailed Report on Agriculture*, page 110)
[58] Internal capacity is low. Shift in cropping calendar to avoid high temperature (and high precipitation period) is possible. (*Detailed Report on Agriculture*, p. 113)

	Increased precipitation		Medium	Medium	Low	Medium	
Ground nuts (cash crops)	Increased temperature, precipitation	Vulnerability has not been assessed. Optimal temperature is between 22-32°C, absolute temperature between 10-45°C; and optimal rainfall between 600 and 1,500 mm/year.[59] Thus, ground nut may be vulnerable to increased rainfall.				N/A	• Monitor changes in rainfall and yield and, if relevant, change location of plots or try new varieties
Red beans (cash crops)	Increased temperature, precipitation	Vulnerability has not been assessed. *Vigna umbellata*: Optimal temperature is between 18-30°C, absolute temperature between 10-40°C; and optimal rainfall between 700 and 1,500 mm/year. *Vigna angularis*: Optimal temperature is between 15-30°C, absolute temperature between 5-36°C; and optimal rainfall between 900 and 1,300 mm/year.[60] Thus, red beans may be vulnerable to increased rainfall.				N/A	• Monitor changes in rainfall and yield and, if relevant, change location of plots or try new varieties
Cabbage (food crop)	Increased temperature, precipitation	Vulnerability has not been assessed. *Phaseolus vulgaris*: Optimal temperature is between 15-24°C, absolute temperature between 7-32°C; and optimal rainfall between 500 and 1,000 mm/year.[61] Thus, cabbage may be vulnerable to increased rainfall.				N/A	• Monitor changes in rainfall and yield and, if relevant, change location of plots or try new varieties
Plums	Increased	Vulnerability has not been assessed.				N/A	• Monitor changes in

[59] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=2199 (*Arachis hypogaea*)
[60] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=2152 (*Vigna umbellata*)
http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=2147 (*Vigna angularis*)
See also http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=1668 (*Phaseolus vulgaris*)
[61] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=554 (*Brassica oleracea var. capitata*)

(cash crops)	temperature, precipitation	*Prunus domestica*: Optimal temperature is between 18-33°C, absolute temperature between 6-36°C; and optimal rainfall between 900 and 1,500 mm/year. *Prunus salicina*: Optimal temperature between 18-34°C, absolute temperature between 6-38°C; and optimal rainfall between 750 and 900 mm/year.[62] Thus, plums may be vulnerable to increased rainfall.			rainfall and yield and, if relevant, change location of plots or try new varieties
Passion fruit (cash crop)	Increased temperature, precipitation	Vulnerability has not been assessed. Optimal temperature is between 20-30°C, absolute temperature between 18-34°C; and optimal rainfall between 900 and 2,000 mm/year.[63] Thus, vulnerability appears to be moderate. This is only a minor crop in Hae Ko.		N/A	• N/A
Arabica coffee (cash crop)	Increased temperature	Vulnerability has not been assessed. Might be negatively affected by increase in temperature. Optimal temperature is between 14-28°C, absolute temperature between 10-34°C; and optimal rainfall between 1,400 and 2,300 mm/year.[64] Thus, coffee may be vulnerable to increased temperature. High-elevation areas of Chiang Rai will experience increased suitability for Robusta coffee due to projected changes in temperature and rainfall. Optimal		N/A	• Monitor changes in temperature and yield and, if relevant, diversify and try Robusta variety

[62] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=16203 (*Prunus domestica*)
http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=8992 (*Prunus salicina*)
[63] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=1633 (*Passiflora edulis*)
[64] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=749 (*Coffea arabica*)

	temperature for Robusta coffee is between 20-30°C, absolute temperature between 12-36°C, and optimal rainfall between 1,700 and 3,000. [65]	

[65] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=750 (*Coffea canephora*)

Tea gardens (employment)	Increased temperature, precipitation	Vulnerability has not been assessed. Might be negatively affected by increase in temperature. Optimal temperature between 20-30°C, absolute temperature between 8-35°C; and optimal rainfall between 1,400 and 2,000 mm/year. [66] Thus, vulnerability appears to be moderate.				N/A	• N/A
Local chicken (consumption)	Increased temperature	The system for small-scale chicken is already outside the ideal temperature range; added heat stress will reduce reproduction and immunity. Feed and animal health issues. Local variety might be more heat-tolerant [67] . As exposure to high temperature will be lower in the upland area, exposure has been adjusted to 'medium' compared to 'high' in the initial assessment.	Medium	High	Very Low	High	• Ensure adequate vaccination • Housing, shade trees
	Flash floods, storms		Medium	High	Low	High	• Locate housing, run, and feed storage away from high-risk areas
Pig (consumption)	Increased temperature	The system for small-scale pig operations is already outside the ideal temperature range; added heat stress will reduce reproduction and immunity. Feed and animal health issues. As exposure to high temperature will be lower in the upland area, exposure has been adjusted to 'high' compared to 'very high' in the initial assessment.	High	High	Low	High	• Ensure adequate vaccination • Housing, shade trees
	Flash floods, storms		Low	Very High	Very Low	High	• Locate housing, run, and feed storage away from high-risk areas

[66] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=599 (*Camellia sinensis*)
Similar ranges for http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=4089 (*Camellia sinensis var. assamica*), although range for rainfall is higher (3,000-4,000 mm/year).
[67] *Detailed Report on Livestock*, page 95 ff.

Fish (fish ponds, mainly for sale)	Decrease in precipitation	Culture fish is vulnerable to increased water temperatures, decreased water availability, droughts, flooding, and flash flooding.[68] However, fish is not a main source of income or food in Hae Ko.	Medium	Very High	Very Low	Very High	• Improve water storage and management • Protection against flooding
	Flooding		High	Very High	Medium	Very High	
	Increase in temperature		High	High	Low	High	
	Drought, storms and flash floods		Medium	Very High	Low	High	
NTFPs: bamboo shoots, mushrooms, honey, etc. (sale and consumption)	Increased temperature, precipitation	Vulnerability not assessed in detail, but estimated relatively moderate.[69] Non-climate threats such as habitat loss and overharvesting.				Medium	• Protect the integrity of forest and wetland ecosystems
Ecosystems (agricultural land, community forest, watersheds)	Increased temperature	Vulnerability not assessed in detail, but expected loss of biodiversity with impacts on NTFPs. Non-climate threats such as watershed degradation, soil degradation, and deforestation.				High	• Protect the integrity of forest and wetland ecosystems • Afforestation and reforestation to prevent soil erosion and preserve

[68] *Detailed Report on Fisheries*, page 116 ff. The assessment applies to semi-intensive pond polyculture of tilapia, silver barb and carps. For other categories, these threats are assessed from 'medium' to 'very high'.

[69] The USAID Mekong ARCC Climate Study analysed selected NTFP species. For instance, the climate vulnerability of the rattan species *Calamus caesius* was assessed as moderate, while the non-climate vulnerability is very high. For the Giant Honeybee, climate vulnerability is moderate, non-climate vulnerability high. For Russula mushroom, climate vulnerability is moderate, non-climate vulnerability very high. According to the study, species such as "*Calamus* (rattan), Red ants, Honeybees, Earthworms, and wild rice need attention to protect the species and its habitat and encourage more sustainable harvesting, rather than specific climate change adaptation measures" (*Detailed Report on NTFPs*, p. 102).

							watershed • Agroforestry, mixed cropping • Reduce use of chemicals, use organic fertilizers
Health	Flash floods, landslides	Main vulnerabilities in the highland area are linked to flash floods and landslides. Assessed as 'high' in the USAID Mekong ARCC Climate Study.[70] In addition, Hae Ko village is remote and in rainy season it can be difficult to access.	High	High	Medium	High	• Afforestation and reforestation to prevent soil erosion • Development of forecasting and early warning systems • Improve access to health services for all villagers
Infrastructure	Flash floods, landslides	Risk of infrastructure damage, including water supply, especially for temporary housing structures.[71]	High	High	Low	High	• Improve water system • Protect most vulnerable assets

[70] *USAID Mekong ARCC Socio-Economic Assessment*, p. 94 ff. Assessment for *Intensively used uplands* in Chiang Rai.
[71] *USAID Mekong ARCC Socio-Economic Assessment*, p. 102 ff. Assessment for *Intensively used uplands* in Chiang Rai.

Scientific vulnerability matrix

The following matrix aims to provide an overview and ranking of the major threats and livelihood resources of Hae Ko in order to identify the most vulnerable assets and livelihoods. Note that ecosystems are not explicitly represented in this table, but they are linked with and underlying the other livelihood resources.
Vulnerability ranking: 1-low, 2-medium, 3-high, 4-very high (based on USAID Mekong ARCC data where available; otherwise estimate based on FAO data and information from baseline surveys).

		Climate and non-climate hazards							
Livelihood resources	Importance weighting (4-critical to 1-slightly important)[72]	Increase in temp.	Increase in rainfall	Drought	Flash floods, landslides	Storms	Non-climate threats	Minus community adaptive capacity (3-high to 1-low)[73]	Total
Upland rice	4	2	2	2	2	1	1	-1	13
Chicken	4	3	2	1	3	3	1	-1	16
Pigs	4	3	2	1	3	3	1	-1	16
Ground nuts[74]	4	1	2	2	2	2	1	-1	13
Maize	4	2	2	2	2	2	2[75]	-1	15
Paddy rice	2	3	2	2	2	2	1	-1	13
Cabbage[76]	2	2	2	2	2	2	1	-1	12
Red beans[77]	2	2	1	1	3	3	1	-1	12
Plums[78]	2	2	3	2	2	2	1	-1	11
Arabica coffee[79]	2	3	2	2	2	2	1	-1	13
Bamboo shoots and other NTFPs[80]	1	2	2	2	2	2	3[81]	-1	13
Health	3	2	2	1	3	3	1	-2	13
Infrastructure	3	1	2	1	3	3	1	-2	12
Total	37	28	26	21	31	30	16	-15	

From this vulnerability ranking, chicken, pigs and maize are the most vulnerable livelihoods for Hae Ko village. Upland rice as their main food crop also represents an important

[72] The importance weighting is based on information from the community profiles (assessment by the community), except for health and infrastructure, which are weighted '3-very important' (IUCN assumption).
[73] The adaptive capacity has been assessed based on IUCN's knowledge of the village. More details are included under 'Community adaptive capacity'.
[74] Detailed vulnerability has not been assessed. Estimate based on FAO data.
[75] Vulnerable to market price fluctuations.
[76] Detailed vulnerability has not been assessed. Estimate based on FAO data.
[77] Detailed vulnerability has not been assessed. Estimate based on FAO data.
[78] Detailed vulnerability has not been assessed. Estimate based on FAO data.
[79] Detailed vulnerability has not been assessed. Estimate based on FAO data.
[80] Detailed vulnerability has not been assessed. Estimate based on *Detailed Report on NTFPs*.
[81] Vulnerable to habitat loss and overharvesting.

vulnerability. Chicken and pigs are very vulnerable to increased temperature, flash floods, landslides and storms while maize appears to be more vulnerable to non-climate threats. Increased temperature, flash floods, landslides and storms are the most important hazards.

Community adaptive capacity

Community adaptive capacity generally is moderate. Access to markets, new varieties and extension services is limited, although it has been strengthened by the Poverty Reduction Project. Lack of land tenure, the inability to speak Thai, lack of citizenship, and lack of school education of some villagers all increase vulnerability. Also, Hae Ko villagers are not represented in the TAO. Access to loans is limited, partly due to the lack of land title. While informal agreements on land use were a successful approach of the Livelihoods and Landscapes project, villagers face new uncertainty since the area is no longer a military zone. The area now falls under the National Reserve Forest legislation. Some of the reforested area has been reclaimed by the villagers.

An important strength of this village is the past interventions of the Livelihoods and Landscapes and Poverty Reduction projects, which have helped restore the watershed area and have introduced livelihood diversification through alternative crops. For Arabica coffee and passion fruit, for instance, Hae Ko benefited from the knowledge and experience of HRDI and the Royal Initiative Projects. However, passion fruit has had limited success due to the high investment and possibly lack of knowledge and/or follow-up. Nevertheless, villagers are willing to try new crops and livelihood activities. This project presents an opportunity for Hae Ko village to diversify their livelihoods and identify more stable income generation opportunities.

Information from the baseline survey also indicates that the community sometimes accesses and integrates climate information and forecasts into decision-making, but only a few times a year. The main sources of weather/climate information are TV and radio. The community does not solidly plan for or practice adaptation strategies to mitigate climatic effects or manage seasonal variability. However, the villagers undertake some climate change resilience-related activities, i.e. building firebreaks and check dams.

Specific vulnerabilities of women or vulnerable groups

Villagers who largely depend on NTFP collection, especially women, will be particularly vulnerable to climate and non-climate threats. Villagers with lack of citizenship, and villagers who do not speak Thai (more women than men), are also particularly vulnerable. This will be taken into consideration when selecting the adaptation options.

Conclusions

The major vulnerabilities for Hae Ko village identified by this assessment are:
- Landslides and flash floods could threaten infrastructure and upland rice, the main food crop (climate factors)
- Heat stress, flash floods and storms could threaten pigs, chicken and fish ponds (climate factors)
- Overharvesting and habitat loss could affect availability of NTFPs (non-climate factors)
- Vulnerable to watershed degradation, water shortages and water pollution (climate and non-climate factors)
- Lack of access to markets, new varieties and extension services (non-climate factors). Maize, the main cash crop, is vulnerable to market price fluctuations.

4. Kok Klang, Sakon Nakhon

Kok Klang village is part of Chan Pen sub-district in Tao Ngoi district, Sakon Nakhon Province. It is adjacent to Phu Pha Yon National Park, and situated at around 300 metres above sea level.

Chan Pen sub-district is located in the highland plateau of the Phu Phan hill, in the Nam Phung River Basin. The Nam Phung River flows from the Phu Phan Mountain Range down to Nong Han Lake, which connects to the Mekong River through the Nam Kam River, an important tributary of the Mekong. Chan Pen is part of the mid-elevation dry broadleaf forest ecozone as outlined by the USAID Mekong ARCC Climate Study.[82]

Soil found in the community area is mostly in the Korat series, i.e. sandy loam soil leading to low fertility and tendency for water loss when cultivated. This type of soil is suitable for dipterocarp forest, annual crops such as cassava, maize, sugarcane and beans as well as upland rice. It is not suitable for paddy rice. Some problems regarding acidic soil can also be found.[83]

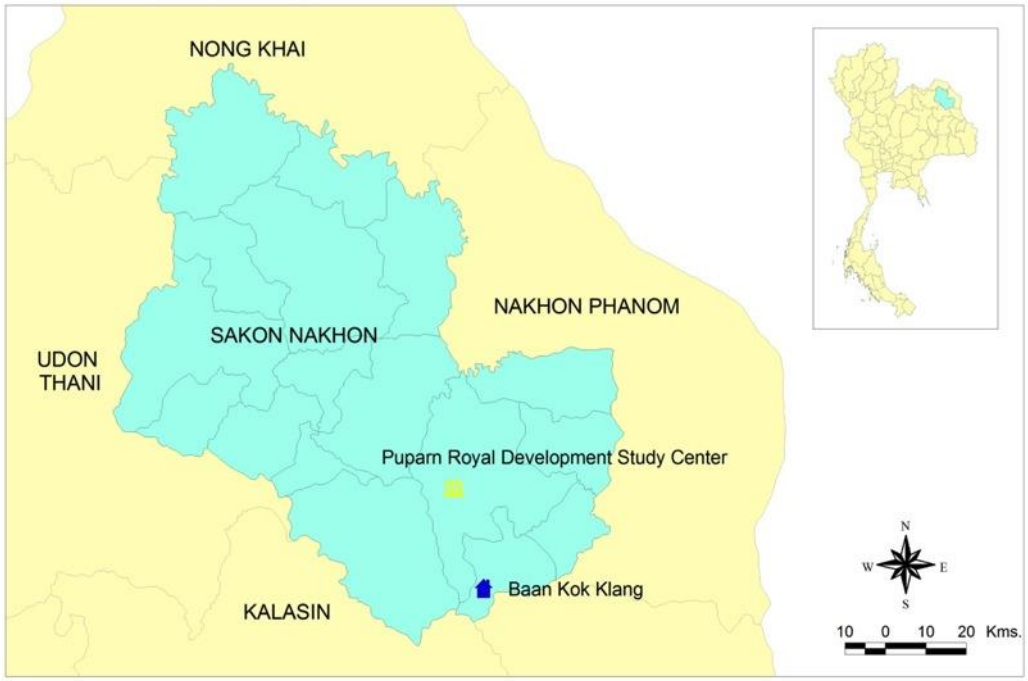

Figure 22: Location of Kok Klang village, Sakon Nakhon

Kok Klang village is a Northeastern Thai community with 70% Yor ethnic group, 10% So, 10% Kaloeng, 6% Lao, and 4% Phuthai/Thai. It is composed of 454 households or 1,143 individuals. The village was selected by IUCN after consultations with its partner ISOC and the Chan Pen Tambon Administration Organization. It is a large community with an estimated land area of 4,800 hectares (3,400 hectares agricultural land).

There are Catholics and Buddhists living in Kok Klang. The Catholics were the first major group to settle in Kok Klang; the second large group was composed of former members of the Thai Communist Party who came out of the forest to settle in Kok Klang. The third major

[82] *USAID Mekong ARCC Socio-Economic Assessment*, p. 86. Kok Klang's elevation is higher than 250m, thus it can be considered as part of *Forested uplands and Intensively used uplands*.
[83] *Source:* Land Development Department.

group is composed of newcomers who arrived recently to plant rubber at the border of the village. Some of these new plantations are on the boundary with Phu Pha Yon National Park.

Land tenure is complex in Kok Klang; most of the areas are preserved forest but some areas are under the *Sor Por Kor* and *Sor Tor Kor* legislation. *Sor Por Kor* land cannot be sold, but can be used for agriculture and transferred by inheritance. *Sor Tor Kor* land is in the zone of national reserved forest, but confers the right to reside and live on the land. The villagers make use of the nearby forest, which is part of the Phu Pha Yon National Park, for their living. Kok Klang has about 1,400 hectares of community forest; however, an official request for it to be declared as community forest under the Community Forest Act is yet to be submitted.

The villagers depend on the nearby forest, cattle husbandry and on rubber plantations for subsistence and income generation. They also grow cassava, sugarcane and rain-fed rice. Rubber plantations have recently been replacing cassava and sugarcane. This is affecting water use and the quality of soil due to the use of chemical fertilizers and herbicides.

Although the village chief and his two assistants are men, women are strongly represented in this community. 8 out of the 10 village committee members are women; most of the 25 leaders of the village sections (*Khum*) are also women. Wealth disparity seems to be rather low in Kok Klang.

Climate

Kok Klang village is located in the tropical monsoon climate zone. There are 3 seasons. Hot season starts from March and lasts until April. Rainy season, influenced by the Southwestern monsoon, begins in May and lasts until October. Winter influenced by Northeastern monsoon starts from November and lasts until February.

Results from VCA tools

- *Village Mapping*

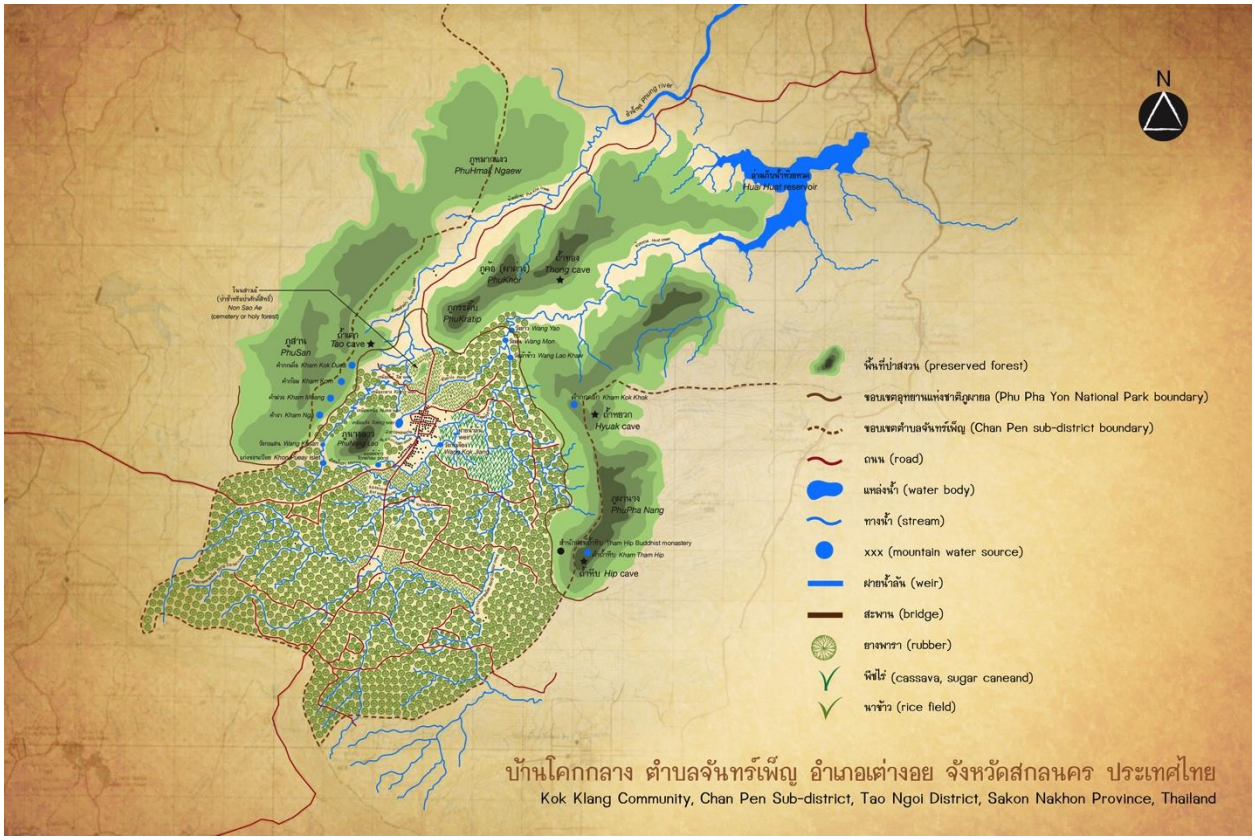

Figure 23: Kok Klang Village Resource Mapping

Figure 24: Kok Klang Village Resource Mapping (Village Details)

- *Seasonal Calendar*

The following seasonal calendar shows the main livelihood activities in Kok Klang throughout the year. Blue colour represents activities mainly for men and grey colour is for both men and women

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cultivation												
Rice (field)	store rice		plough and land preparation			sow		seeding	weed elimination		harvest	
Sugarcane	Disease and pests protection								plough and land preparation and fertilizer		Grow and weed elimination	
		Harvest (in the coming year)										
Cassava	plough and land preparation		Grow		weed elimination			Spraying herbicide and fertilizer			harvest and sell	
Rubber	resting period for rubber tapping				Spraying pesticide							
					rubber tapping and fertilizer application							
Chilli	Harvest				Grow		weed elimination and fertilizer			harvest		
	Grow			weed elimination and fertilizer			harvest					
Vegetables	Harvest								Grow		Harvest	
Vegetables harvested (NTFP)												
Melientha suavis												
Mushrooms (depending on species)												
Bamboo shoot (depending on species)												
Curcuma flowers												
Animals captured (NTFP)												
Ants' eggs												
Cicada												
Fish and shrimps												
Frog/toad												
Insects (depending on species)												

- *Historical Timeline*

Year	Important and climate-related events
1927	Kok Klang village was established by a few families who migrated from *Phu Phan* mountain for growing rice
Before 1949	12 Christian families from Chan Pen came to settle down in the village
1965	Members of Thai Communist Party settled down at *Phu Lom Khao* and *Phu Pha Yon,* east side of the village
1980-1983	Members of Thai Communist Party came out of the forest, became Thai development group and settled down in the village. Original Kok Klang villagers who escaped to other places came back to settle down.
1985	Started mountain water supply, asphalt road access and cleared the forest land for growing cassava
1986	Declaration of *Huai Huat* National Park (became *Phu Pha Yon* National Park in 2001)
1989	Land was sold for growing cassava
1993	Electricity access to the village
1998	Started to grow sugarcane (promoted by the government)
2002	Started to grow rubber (promoted by the government)
2003	Hailstorm damaged houses
2007	Massive land was sold for growing rubber to private company own by the outsider
2009	Severe drought effecting rice, sugarcane and cassava yield. Government gave some compensation.
2011	Epidemic of Brown planthoppers (*Nilaparvata lugens* (Stal)) in cassava leading to a decline of yield
2014	Established rubber-processing factory owned by private company in the village. Severe forest fire around the village.
2013	Prevalence of Dengue fever in summer. Lack of drinking water (the villagers had to buy drinking water).
2014	Prevalence of flu in hot season in every household. Severe drought. Inadequate mountain water supply. Rubber trees died.

Since the establishment of the village almost 90 years ago, villagers can remember climate-related events since 2003. This is mainly because recent events are more present in their minds. Nevertheless, it may be that climate-related events have increased in frequency and intensity over the last 10-20 years.

- *Community Vulnerability Matrix*

Vulnerability ranking: 0-no impact, 1-low impact, 2-medium impact, 3-high impact.

Livelihood/Resources	Unusual rain	Flooding	Drought	Forest fire	Total score
Rice yield	3	3	3	0	9
Cassava yield	3	3	3	2	11
Sugarcane yield	3	3	3	2	11
Rubber yield	3	2	3	3	11
NTFP harvesting	3	3	3	3	12
Water for consumption	3	3	3	3	12
Water for agriculture	3	3	3	0	9
Aquaculture	3	3	2	0	8
Livestock	3	3	3	3	12
	27	26	26	18	

Main climate threats identified by the Kok Klang villagers are related to unusual rain, flooding, drought, and forest fire. Unusual rain, flooding and drought are identified as the most important threats to livelihoods and resources of Kok Klang village. The most vulnerable livelihoods identified by the villagers are NTFPs, water for consumption, and livestock. Temperature increase is not mentioned as a main threat by the villagers; awareness around increasing temperature will be built up during the scientific climate story part.

Scientific vulnerability assessment

The following table summarizes the main climate threats and vulnerabilities for the major livelihood areas for Kok Klang village, based primarily on the USAID Mekong ARCC reports. The potential adaptation options are a first selection of options; however, these will be further explored in the next step of the project.

Livelihood Area	Threat	Impact and Vulnerability Summary	Exposure	Sensitivity	Adaptive Capacity	Vulnera-bility	Potential Adaptation Options (selection)
Lowland rice (food crop)	Increased temperature	Predicted decrease in yields due to increased temperatures.	Medium	High	Low	High	• Heat-tolerant and submergence-tolerant rice varieties; local varieties • Diversification with dry season vegetable crops • Improved soil management
	Increased precipitation	While increased precipitation may result in higher rainfed rice yield, specific changes in the timing and extent of rainfall could be detrimental. Rice yield in Kok Klang is already low due to unfavourable soil conditions (sandy soil). Villagers have to buy some of their rice for consumption.	High	Low	Medium	Medium	
Cassava (cash crop)	Increased precipitation	An increase in rainfall is projected to reduce the suitability of cassava. Risk of flooding, waterlogging, and increased incidence of fungal disease and pests, depending on the location of the plots.	High	High	Low	High	• Shifting to sugarcane or other more waterlog-tolerant crop • Shift location of plots • Diversification with mixed cropping, vegetable crops
	Flooding		Medium	Very High	Low	High	
Rubber (cash crop)	Increased temperature	Heat stress is expected to cause widespread crop failure.	High	Medium	Low	High	• Heat-tolerant variety • Intercropping with vegetables to improve water retention • Diversification, alternatives to

	rubber, agroforestry, mixed crop-livestock systems

Sugarcane (cash crop)	Increased temperature Increased precipitation Flooding	Sugarcane is relatively resistant to high temperatures and is considered a less vulnerable crop compared to rice or cassava. Sugarcane can endure waterlogging. However, since the exposure level for both threats will be high, productivity may be affected.	High Low Medium	Medium Medium Medium	High Low Medium	Medium Medium Medium	• N/A
Chili (food and cash crop)	Increased temperature, precipitation	Vulnerability has not been assessed. Optimal temperature between 18-30°C, absolute temperature between 7-40°C; and optimal rainfall between 600 and 1,500 mm/year. [84] Thus, vulnerability appears to be moderate.				N/A	• N/A
Vegetables, mushrooms, bamboo (food crops)	Increased temperature, precipitation	Vulnerability has not been assessed.				N/A	• N/A
Papaya (food crop)	Increased temperature	Vulnerability has not been assessed. Optimal temperature between 21-30°C, absolute temperature between 12-44°C; and optimal rainfall between 1,500 and 2,500 mm/year. [85] Thus, vulnerability appears to be moderate.				N/A	• N/A
Chicken (consumption, sale)	Increased temperature	The system for small-scale commercial chicken is already outside the ideal temperature range; added heat stress will	High	High	Very Low	Very High	• Ensure adequate vaccination • Housing, shade

[84] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=621 (*Capsicum frutescens*)
[85] http://ecocrop.fao.org/ecocrop/srv/en/dataSheet?id=630 (*Carica papaya*)

		reduce reproduction and immunity. Feed and animal health issues.[86] However, local variety might be more heat-tolerant.					trees • Introduce local varieties (e.g. Phu Phan black chicken) • Locate housing, run, and feed storage away from high-risk areas
	Flash floods, storms		Medium	High	Low	High	
Duck (for sale)	Increased temperature, flash floods, storms	The vulnerability of ducks has not been assessed in detail. The overall climate vulnerability of field running layer duck in the LMB assessed as low.[87]	Very Low	Very Low	Low	Low	• N/A
Cattle/buffalo (small-scale commercial)	Increased temperature, drought	Reduced fodder availability affecting already under-nourished stock; increased risk of disease, reduced productivity and value.	Medium	Low	Medium	Medium	• Planned destocking, forage development, improve access and quality of animal health services. • Improve infrastructure and reproduction management.
	Flash floods, storms	Climate threats from flash floods and storms estimated high.	Medium	High	Low	High	
Pig (consumption)	Increased temperature	The system for small-scale pig operations is already outside the ideal temperature range; added heat stress will reduce reproduction and immunity. Feed and animal health issues.	Very High	High	Low	Very High	• Ensure adequate vaccination • Housing, shade trees
	Flash floods, storms	Climate threats from flash floods and storms estimated high.	Low	Very High	Very Low	High	• Locate housing, run, and feed storage away from high-risk areas

[86] Climate vulnerability for livestock has not been assessed in detail for Sakon Nakhon. Nevertheless, inferences can be made from the general assessment. *Detailed Report on Livestock*, page 95 ff.
[87] *Detailed Report on Livestock*, page iv.

Fish (fish ponds, mainly for sale)	Decrease in precipitation	Vulnerable to increased water temperatures, decreased water availability, droughts, flooding, and flash flooding.[88] However, the main species in Kok Klang are tilapias, which are generally more tolerant of high temperatures and low dissolved oxygen levels.[89] Sensitivity to decrease in precipitation has been adjusted to 'High' compared to 'Very high' in the initial assessment. Sensitivity to high temperature has been adjusted to 'Medium' compared to 'High'.	Medium	High	Very Low	High	• Improve water storage and management • Protection against flooding
	Flooding		High	Very High	Medium	Very High	
	Increase in temperature		High	Medium	Low	High	
	Drought, storms and flash floods		Medium	Very High	Low	High	
Wild fish (consumption and sale)	Increased temperature	Upland forest stream fish will be impacted by higher temperatures in the spawning season (Nov-Dec), reducing reproduction and limiting habitat suitability.[90] Other threats include decrease in precipitation, flash floods and storms.	Very High	Very High	Low	Very High[91]	• Preserve or restore forest cover along upland streams
	Decrease in precipitation		High	Medium	Low	High	
	Flash floods and storms		Medium	Medium	Medium	High	
NTFPs: rat, chameleon (consumption)	Increased temperature, drought	Vulnerability not assessed, but estimated low. Non-climate threats such as habitat loss and overharvesting.				N/A	• Protect the integrity of forest and wetland ecosystems
NTFPs: *Meliantha*	Increased temperature,	Vulnerability not assessed in detail, but estimated relatively moderate.[92]				Medium	• Protect the integrity of forest and

[88] *Detailed Report on Fisheries*, page 116 ff. (no detailed analysis for Sakon Nakhon; based on analysis for Chiang Rai). The assessment applies to semi-intensive pond polyculture of tilapia, silver barb and carps. For other categories, these threats are assessed from 'medium' to 'very high'.
[89] *USAID Mekong ARCC Summary*, page 48.
[90] *Detailed Report on Fisheries*, page 116 ff. (no detailed analysis for Sakon Nakhon; based on analysis for Chiang Rai).
[91] 'Very high' only for *Tor tambroides* upland fish and migratory white fish categories. For other categories, the temperature increase threat is assessed as 'high' or 'medium'.

suavis, ants' eggs, cicada, mushroom, bamboo shoot (mainly for sale)	precipitation, drought	Non-climate threats such as habitat loss and overharvesting.		wetland ecosystems
Ecosystems (agricultural land, community forest, watersheds)	Increased temperature, drought	Vulnerability not assessed, but expected loss of biodiversity with impacts on NTFPs. Decreased water availability. Non-climate threats such as watershed degradation, soil degradation, and deforestation.	High	• Protect the integrity of forest and wetland ecosystems; prevent further expansion of rubber monocultures on the boundary with the National Park • Afforestation and reforestation to prevent soil erosion and preserve watershed • Alternatives to monocultures, agroforestry, mixed cropping • Reduce use of chemicals, use organic fertilizers

[92] The USAID Mekong ARCC Climate Study analysed selected NTFP species. For instance, the climate vulnerability of the rattan species *Calamus caesius* was assessed as moderate, while the non-climate vulnerability is very high. For the Giant Honeybee, climate vulnerability is moderate, non-climate vulnerability high. For Russula mushroom, climate vulnerability is moderate, non-climate vulnerability very high. According to the study, species such as "*Calamus* (rattan), Red ants, Honeybees, Earthworms, and wild rice need attention to protect the species and its habitat and encourage more sustainable harvesting, rather than specific climate change adaptation measures" (*Detailed Report on NTFPs*, p. 102).

Health	Flash floods, landslides Increased temperature and flooding	Vulnerability linked to flash floods and landslides in Kok Klang is estimated as medium by the project.[93] Other threats are increased temperature and flooding. Increased occurrence of disease. Water shortages in dry season.	Medium Medium	High High	Medium Medium	Medium Medium	• Afforestation and reforestation to prevent soil erosion and preserve watershed • Development of forecasting and early warning systems • Improve access to health services for all villagers • Improve water system
Infrastructure	Flash floods, landslides	Risk of infrastructure damage, including water supply.[93] Vulnerability estimated as medium.	Medium	High	Low	Medium	• Improve water system • Protect most vulnerable assets

[93] *USAID Mekong ARCC Socio-Economic Assessment*, p. 94 ff. No detailed socio-economic assessment has been conducted by the USAID Mekong ARCC Climate Study for Sakon Nakhon. This analysis is based on assessment for *Intensively used uplands* in Chiang Rai and information from Kok Klang village.

Scientific vulnerability matrix

The following matrix aims to provide an overview and ranking of the major threats and livelihood resources of Kok Klang in order to identify the most vulnerable assets and livelihoods. Note that ecosystems are not explicitly represented in this table, but they are linked with and underlying the other livelihood resources.
Vulnerability ranking: 1-low, 2-medium, 3-high, 4-very high (based on USAID Mekong ARCC data where available; otherwise estimate based on FAO data and information from baseline surveys).

		Climate and non-climate hazards							
Livelihood resources	Importance weighting (4-critical to 1-slightly important)[94]	Increase in temp.	Increase in rainfall	Drought	Flash floods, landslides	Storms	Non-climate threats	Minus community adaptive capacity (3-high to 1-low)[95]	Total
Paddy rice	4	3	2	2	2	2	1	-1	15
Rubber	4	3	2	2	2	2	2[96]	-1	16
Cassava	4	2	3	1	2	2	2[97]	-1	15
NTFPs: rat, chameleon[98]	4	2	2	2	2	2	3[99]	-1	16
NTFPs: *Meliantha suavis*, ants' eggs, cicada, mushroom, bamboo shoot[100]	4	2	2	2	2	2	3[101]	-1	16
Fish ponds[102]	3	3	2	3	4	3	1	-1	18
Wild fish[103]	3	4	2	2	3	3	2[104]	-1	18
Chicken[105]	3	4	2	1	3	3	1	-1	16
Chili[106]	3	2	2	2	2	2	1	-1	13
Vegetables[107]	3	2	2	2	2	2	1	-1	13

[94] The importance weighting is based on information from the community profiles (assessment by the community), except for health and infrastructure, which are weighted '3-very important' (IUCN assumption).
[95] The adaptive capacity has been assessed based on IUCN's knowledge of the village. More details are included under 'Community adaptive capacity'.
[96] Vulnerable to market price fluctuations.
[97] Vulnerable to market price fluctuations.
[98] Detailed vulnerability has not been assessed. Estimate based on *Detailed Report on NTFPs*.
[99] Vulnerable to habitat loss and overharvesting.
[100] Detailed vulnerability has not been assessed. Estimate based on *Detailed Report on NTFPs*.
[101] Vulnerable to habitat loss and overharvesting.
[102] *Detailed Report on Fisheries*, page 116 ff. (no detailed analysis for Sakon Nakhon; based on analysis for Chiang Rai).
[103] *Detailed Report on Fisheries*, page 116 ff. (no detailed analysis for Sakon Nakhon; based on analysis for Chiang Rai).
[104] Vulnerable to habitat loss and overharvesting.
[105] *Detailed Report on Livestock*, page 95 ff. (no detailed analysis for Sakon Nakhon; based on analysis for Chiang Rai).
[106] Detailed vulnerability has not been assessed. Estimate based on FAO data.

Papaya[108]	3	2	1	2	2	2	1	-1	12
Cattle/buffalo	2	2	1	1	3	3	1	-1	12
Pigs	2	4	2	1	3	3	1	-1	15
Health	3	2	2	1	2	3	1	-3	11
Infrastructure	3	1	2	1	2	3	1	-3	10
Total	48	38	29	25	36	37	22	-19	

From this vulnerability ranking, rubber, NTFPs, fish, and chicken are the most vulnerable livelihoods for Kok Klang village. Rubber, fish and chicken are most vulnerable to increased temperature while NTFPs are more vulnerable to non-climate threats. Increased temperature and storms are the most important hazards.

Community adaptive capacity

The community has several existing development groups (housewives group, women's group, village health volunteer group, civil defense volunteer group, youth group), which helps the community to adapt to future changes. Also, the sub-district government is supportive of initiatives at the village level, although interactions between the village and the sub-district government are limited for several mostly historical reasons.

Information from the baseline survey also indicates that the community accesses and integrates climate information and forecasts into decision-making several times a year. The main sources of weather/climate information are TV, radio, newspapers, and the Internet. However, the community does not solidly plan for or practice adaptation strategies to mitigate climatic effects or manage seasonal variability.

In addition, the community is highly dependent on market prices, primarily for rubber, which makes them more vulnerable.

Specific vulnerabilities of women or vulnerable groups

Due to the relatively equal wealth distribution, the low percentage of poor households and women's participation in the governance structure, including access to finance, no specific vulnerabilities have been identified for women or vulnerable groups. However, women may be affected by an increased workload related to livelihood activities and health issues. This will be taken into consideration when selecting the adaptation options.

Conclusions

The major vulnerabilities for Kok Klang village identified by this assessment are:
- Water shortage in dry season (climate and non-climate factors)
- Heavy reliance on rubber and cassava monocultures, which are vulnerable to climate change, but also to price shocks (climate and non-climate factors)
- Heat stress for pigs and chicken and climate vulnerability of fish (climate factors)
- Soil and ecosystem degradation (non-climate factors)
- Overharvesting and habitat loss could affect availability of NTFPs (non-climate factors)

[107] Vulnerability has not been assessed. IUCN estimate.
[108] Detailed vulnerability has not been assessed. Estimate based on FAO data.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

Climate projections

The USAID Mekong ARCC study indicates an increase of around 10-11% in annual rainfall for 2050 for the project sites in Chiang Rai, as well as a 2°C increase in temperatures. It also predicts more frequent flash floods and higher incidence of landslides.

For the target village in Sakon Nakhon, the study predicts a 13% increase in annual rainfall for 2050, and a 1.76°C increase in temperatures, as well as more frequent flash floods.

Climate threats and sectoral vulnerabilities

For Chiang Rai, the study indicates that lowland rice, rubber, litchi and maize are vulnerable to temperature increase. Livestock is vulnerable to heat stress and floods. Fisheries will be affected by increased temperatures and changes in rainfall patterns. Productivity and fertility of NTFPs may be affected by increased temperatures. In terms of health, the most prominent climate threats are flash floods and landslides. Roads, water supply and building infrastructure are likely to be at high risk of flash floods and landslides.

For Sakon Nakhon, the study indicates that rainfall, especially at the harvest time of rice, maize, or soybean, may affect yields and the occurrence of pests and diseases. An increase in rainfall is projected to reduce the suitability of cassava. Increased temperatures will be a threat to rubber plantations. Livestock is vulnerable to heat stress and floods. Fisheries will be affected by increased temperatures and changes in rainfall patterns. Productivity and fertility of NTFPs may be affected by increased temperatures.

Major vulnerabilities identified by this assessment

Huai Kang Pla, Chiang Rai

- Flooding, landslides and heavy rain could threaten infrastructure and upland rice, the main food crop (climate factors)
- Heat stress, flash floods and storms could threaten chicken and pigs (climate factors)
- Overharvesting and habitat loss could affect availability of NTFPs (non-climate factors)
- Water shortage in dry season (climate and non-climate factors)
- Lack of access to markets, new varieties and extension services (non-climate factors)

Loh Yo and Hae Ko, Chiang Rai

- Landslides and flash floods could threaten infrastructure and upland rice, the main food crop (climate factors)
- Heat stress, flash floods and storms could threaten pigs, chicken and fish (climate factors)
- Overharvesting and habitat loss could affect availability of NTFPs (non-climate factors)
- Vulnerable to watershed degradation, water shortages and water pollution (climate and non-climate factors)
- Lack of access to markets, new varieties and extension services (non-climate factors). Maize, the main cash crop, is vulnerable to market price fluctuations.

Kok Klang, Sakon Nakhon

- Water shortage in dry season (climate and non-climate factors)
- Heavy reliance on rubber and cassava monocultures, which are vulnerable to climate change, but also to price shocks (climate and non-climate factors)
- Heat stress for pigs and chicken and climate vulnerability of fish (climate factors)
- Soil and ecosystem degradation (non-climate factors)
- Overharvesting and habitat loss could affect availability of NTFPs (non-climate factors)

Potential adaptation options

This report recommends adaptation options that focus on 'no-regrets' strategies to reduce existing vulnerabilities and increase adaptive capacity of the target communities. Monitoring and learning will be an important component of this project, with the involvement of the District Offices of Agriculture and other relevant government agencies and organizations.

In particular, this assessment recommends adaption options in the following areas. These and other potential options will be analysed with the communities in the next step of the project. Specific implications of adaptation options for women will also be analysed.

Crop and livestock diversification

- Introduce local varieties of rice, chicken, pigs, and possibly introduce rabbits and ducks.
- Explore options for more productive (and heat-tolerant) rice production, especially in Kok Klang.
- Introduce new crops (e.g. organic vegetables, fruit trees) to diversify income generation, decrease vulnerability to climate change and price fluctuations, and reduce reliance on monocrops.
- Improve access to markets.
- Create small on-farm fish ponds.

This project presents an opportunity to diversify the livelihoods of the communities and identify more stable income generation opportunities. This can be done by using existing knowledge and networks, for instance through the District Offices of Agriculture, HRDI, and the Royal Initiative Projects. Through IUCN's partner ISOC, the project has access to the knowledge and experience of the Royal Initiative Project Learning Centres in each province. In addition, villagers will be invited to participate in trainings organized by the Huai Hong Krai and the Phu Phan Royal Development Study Centres in Chiang Mai and Sakon Nakhon.

Introduce mixed cropping and agroforestry

- Establish demonstration plots to demonstrate the long-term benefits of mixed cropping and agroforestry to the villagers.

Enrich community forest areas and protect the integrity of forest ecosystems

- Enrich community forest areas with bamboo species, trees, herbs and edible species, especially in Kok Klang and Huai Kang Pla, to reduce pressure on NTFPs and ecosystems.
- Restore deforested areas.

Strengthen infrastructure

- Where appropriate, improve housing for livestock and fish pond infrastructure, to protect them from storms and floods.
- Building of check dams might be considered as an option to create fish conservation zones and increase fish population, and to create water retention areas for small-scale irrigation.
- Other options to improve water management should be considered.

Increase awareness

- Increase awareness on climate variability and change, to improve preparedness to changes and extreme weather events.

Scaling up

Although the duration of this project is limited, it is hoped that the project will be able to ensure the sustainability of its activities through sustainability plans. It is also hoped that the project will be able to demonstrate successful approaches that will be replicated in other villages, districts, or provinces.

In addition, the project will try to reach out to provincial (and possibly national) government agencies and other organizations, as well as the media, to increase understanding of climate change vulnerability at the local, provincial and national levels, and to start the process of longer-term adaptation planning.

Particularly, the project will try to demonstrate alternatives to rubber and other monocultures that are less vulnerable to climate change, less vulnerable to price shocks, less harmful to ecosystems, and potentially more productive, and eventually foster discussion on policies and market mechanisms that promote monocultures.

The project will also continue its collaboration with ISOC and the Royal Initiative Projects, which through their principle of ‘sufficiency economy’ present an excellent opportunity of scaling up resilience building activities. It will also try to engage with local universities to develop a wider landscape approach of the ecological system and promote further research in the study area.

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ANNEX 1: WEATHER DATA, CLIMATE PROJECTIONS AND CROP SUITABILITY MAPS CHIANG RAI

Annual and monthly rainfall data for Chiang Rai

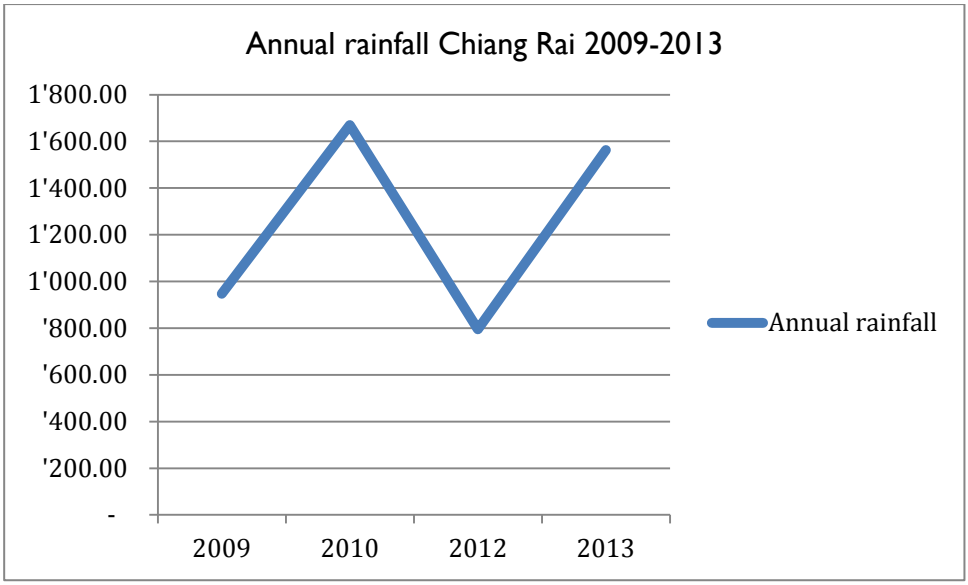


Figure 25: Annual rainfall 2012-2014 in Chiang Rai in mm/year (*Source*: Thai Meteorological Department) (without 2011 as data is incomplete)

	2009	2010	2012	2013	2014
January	0.60	1.40	30.00	20.20	1.80
February	1.00	0.00	7.40	10.20	0.20
March	31.00	47.00	56.40	137.60	65.80
April	79.20	68.00	138.20	3.40	89.80
May	437.20	130.40	411.40	124.80	
June	106.00	279.40	79.00	181.00	
July	341.80	309.80	365.40	421.60	
August	315.80	442.00	68.20	243.80	
September	163.20	534.20	140.40	347.40	
October	8.80	101.00	106.20	178.40	
November	1.80	0.20	31.80	69.20	
December	10.20	2.80	4.00	121.40	
whole year	**947.60**	**1'669.40**	**795.00**	**1'562.80**	
MAX	437.20	534.20	411.40	421.60	
MIN	0.60	0.00	4.00	3.40	

Table 11: Monthly rainfall of Chiang Rai in mm; 2009-2014 (Source: Thai Meteorological Department) (without 2011 as data is incomplete)

Climate projection maps for Chiang Rai

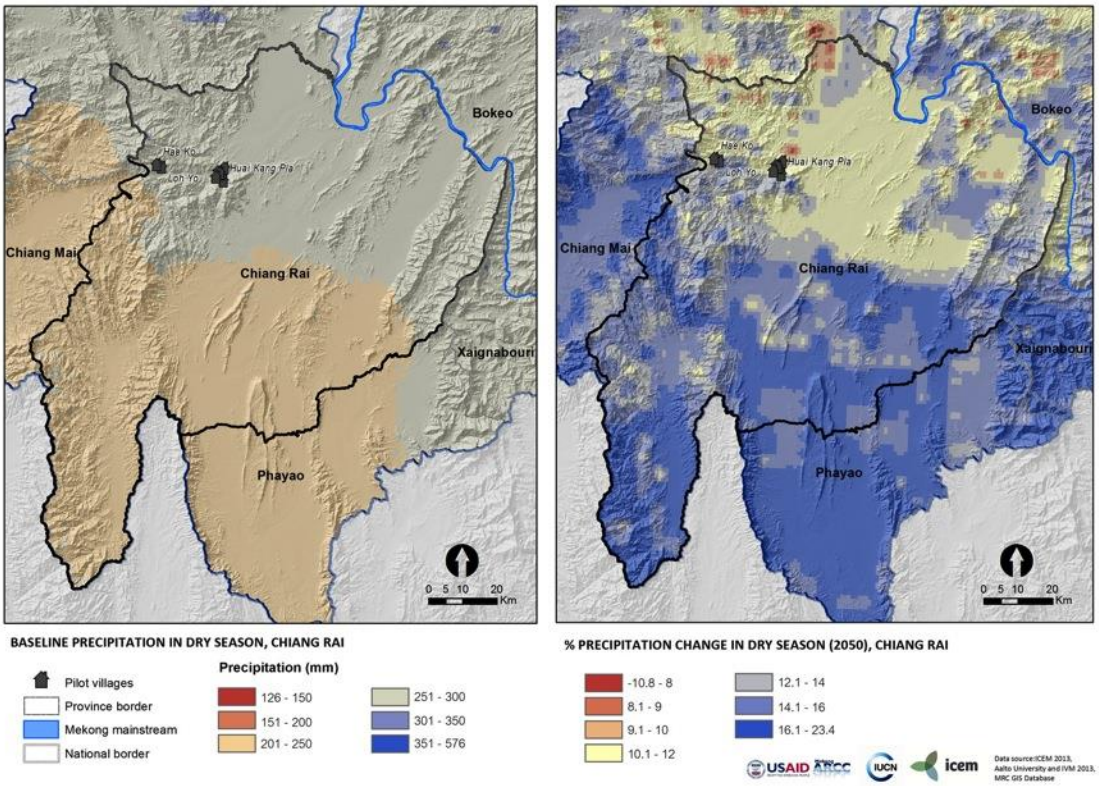


Figure 26: Dry season precipitation in Chiang Rai, Thailand (*published for USAID Mekong ARCC Project*)

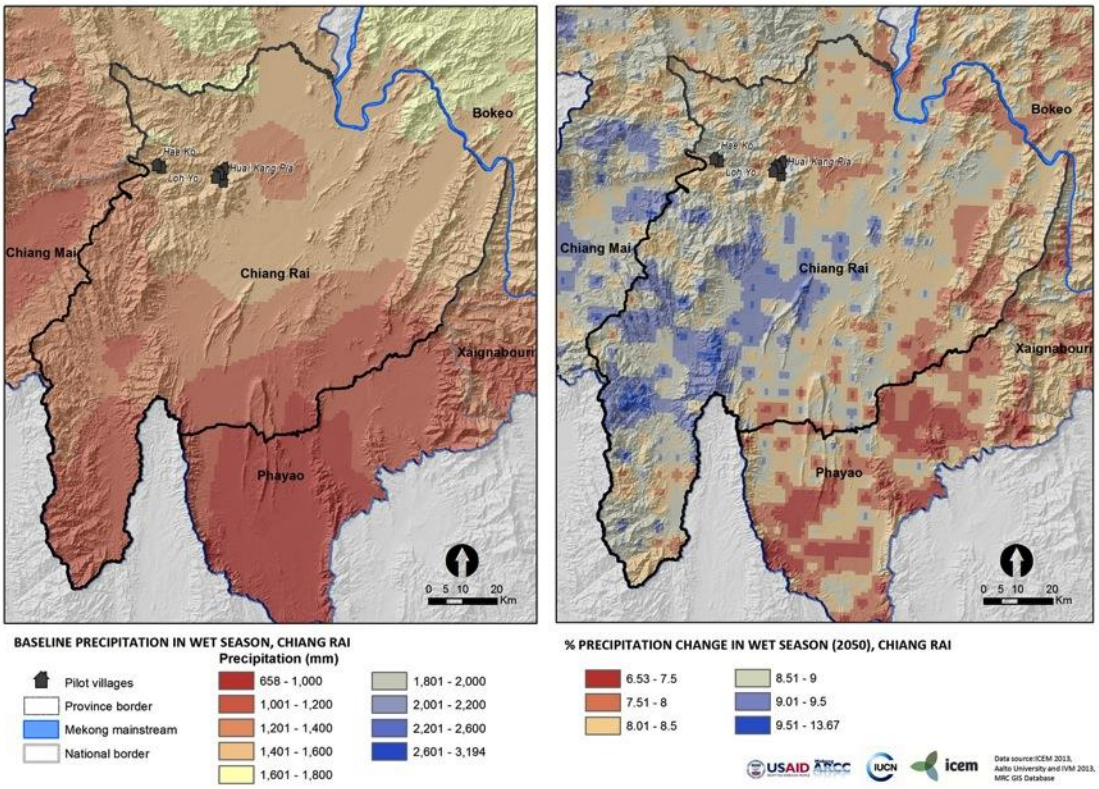


Figure 27: Wet season precipitation in Chiang Rai, Thailand (*published for USAID Mekong ARCC Project*)

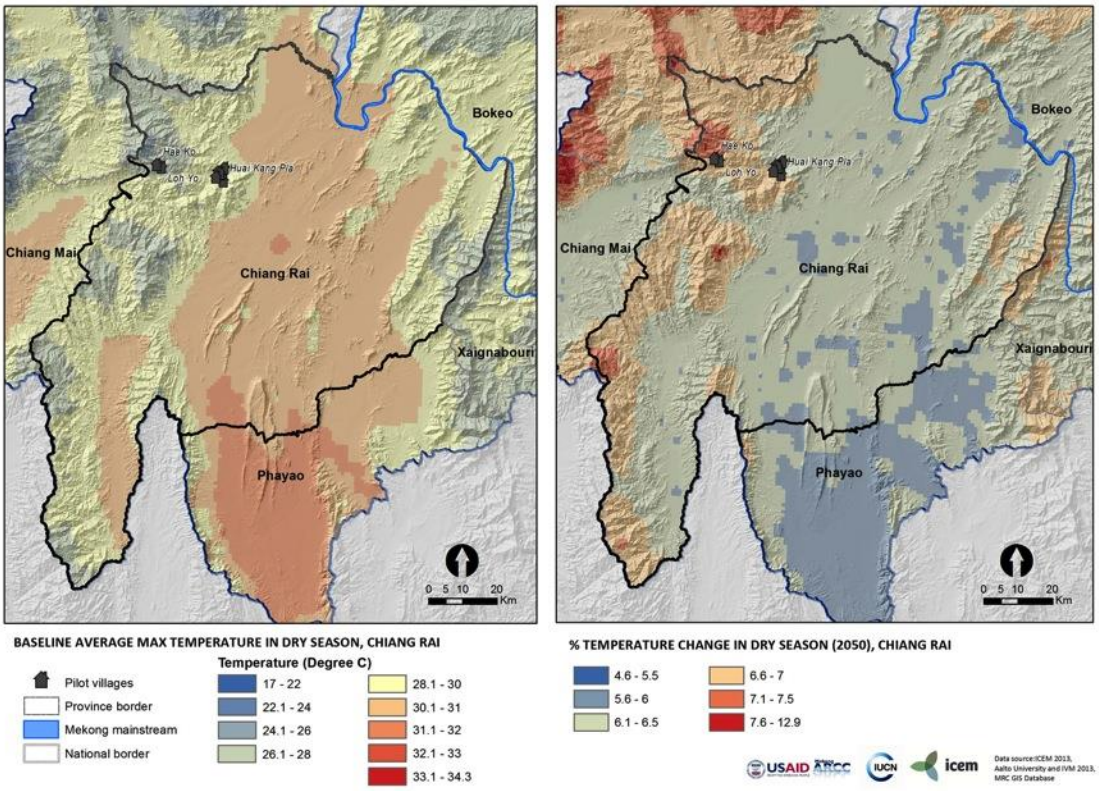


Figure 28: Dry season average maximum temperature in Chiang Rai, Thailand (*published for USAID Mekong ARCC Project*)

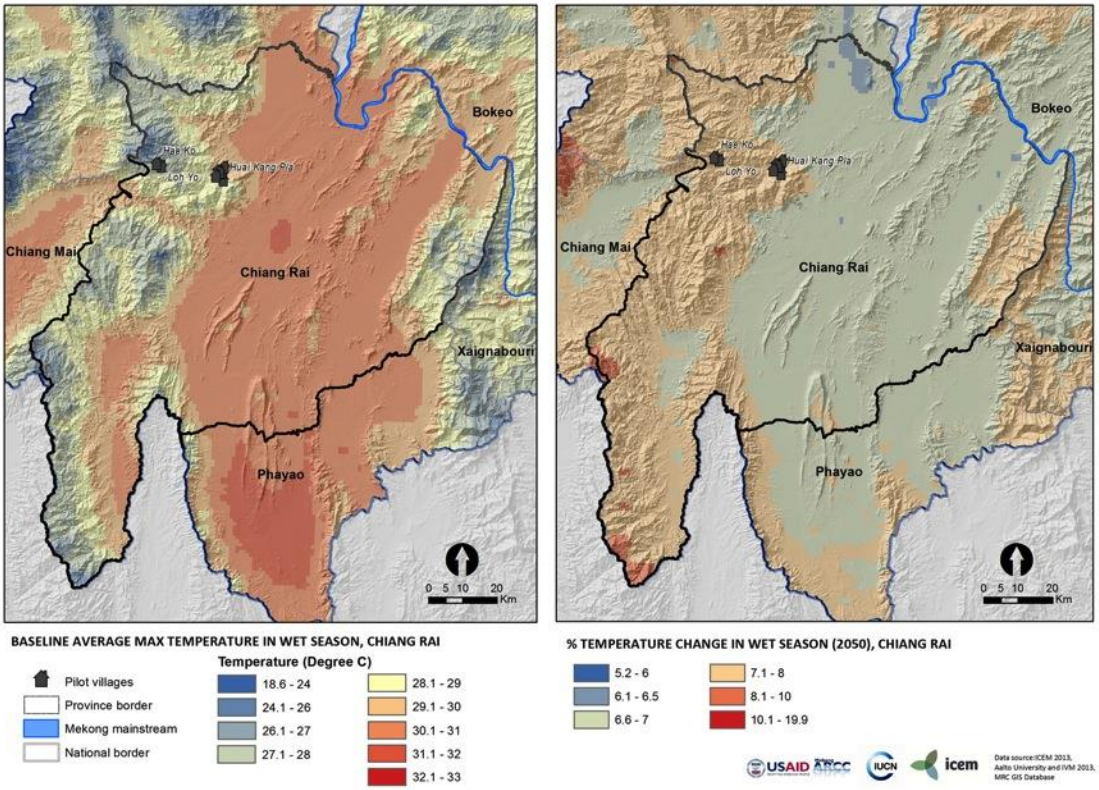
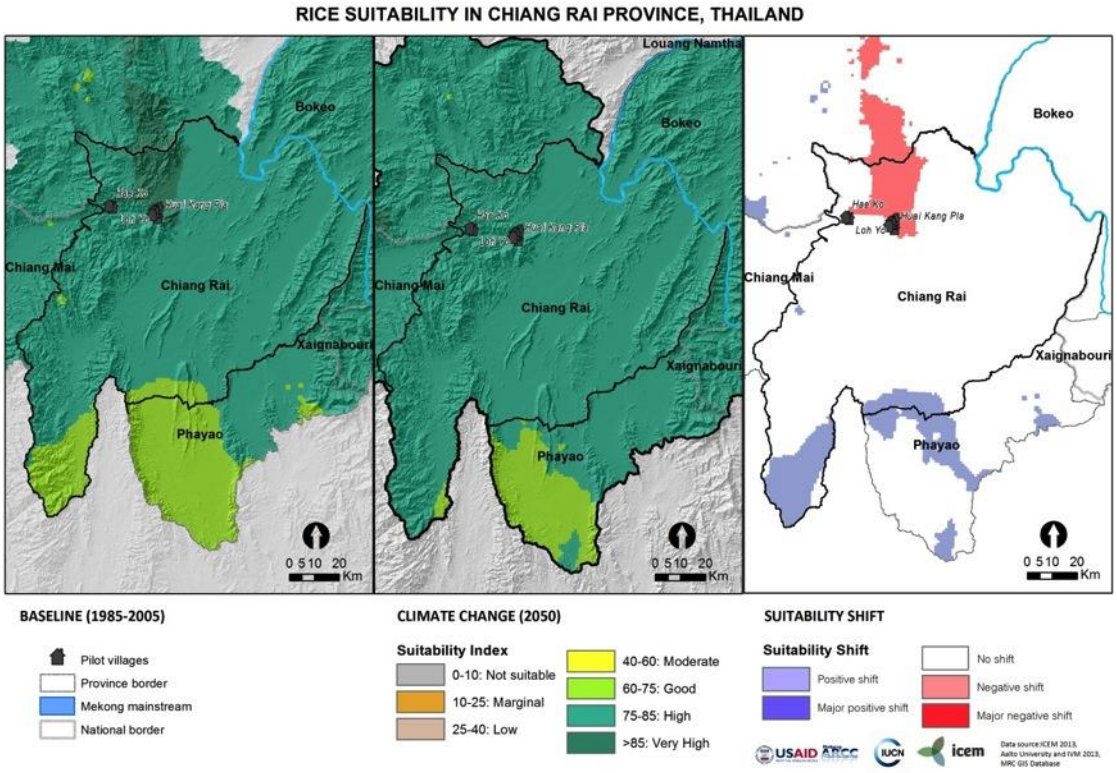
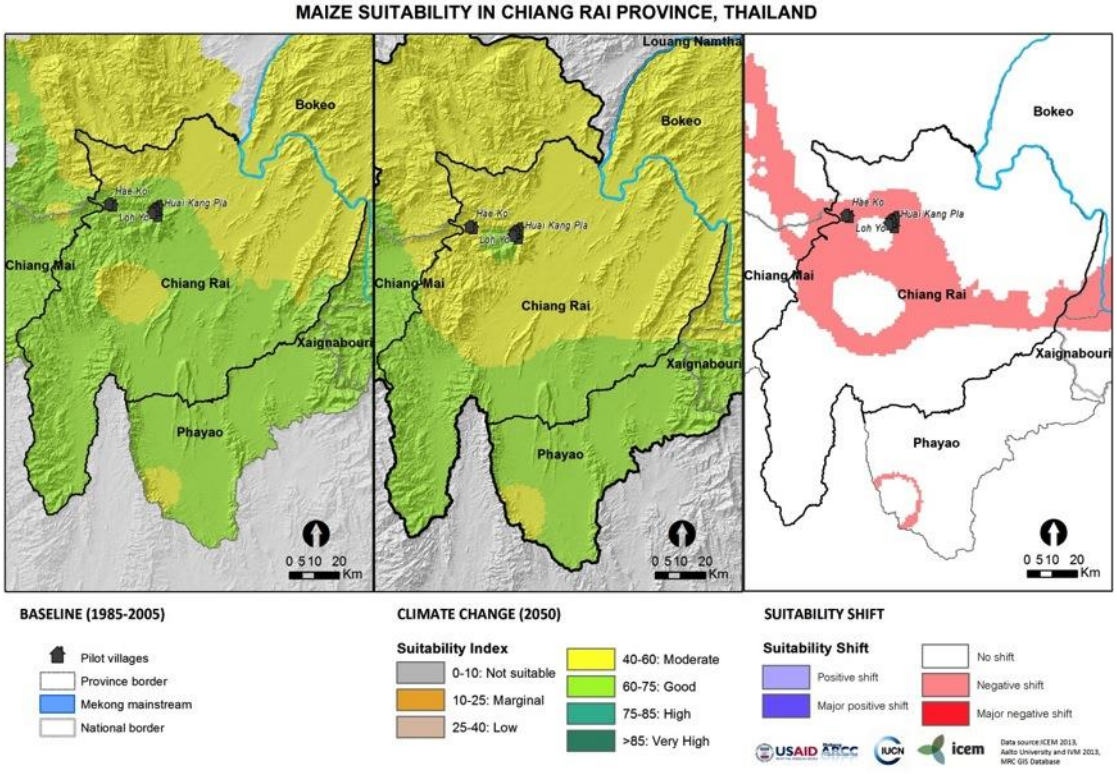


Figure 29: Wet season average maximum temperature in Chiang Rai, Thailand (*published for USAID Mekong ARCC Project*)

Crop suitability maps for Chiang Rai

Note: The maps below are published for the USAID Mekong ARCC Project (*Source*: USAID Mekong ARCC data)





ANNEX 2: WEATHER DATA, CLIMATE PROJECTIONS AND CROP SUITABILITY MAPS SAKON NAKHON

Rainfall data for Sakon Nakhon

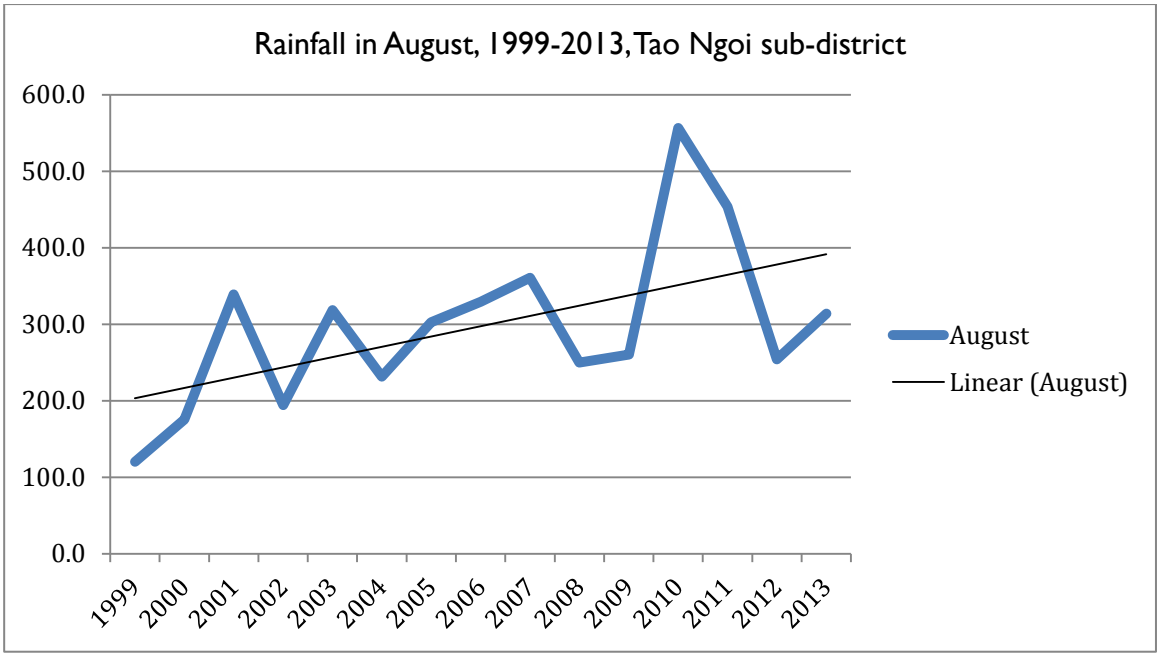


Figure 30: Rainfall in August in the years 1999-2013 in Tao Ngoi district (in mm) (*Source*: Thai Meteorological Department)

Climate projection maps for Sakon Nakhon

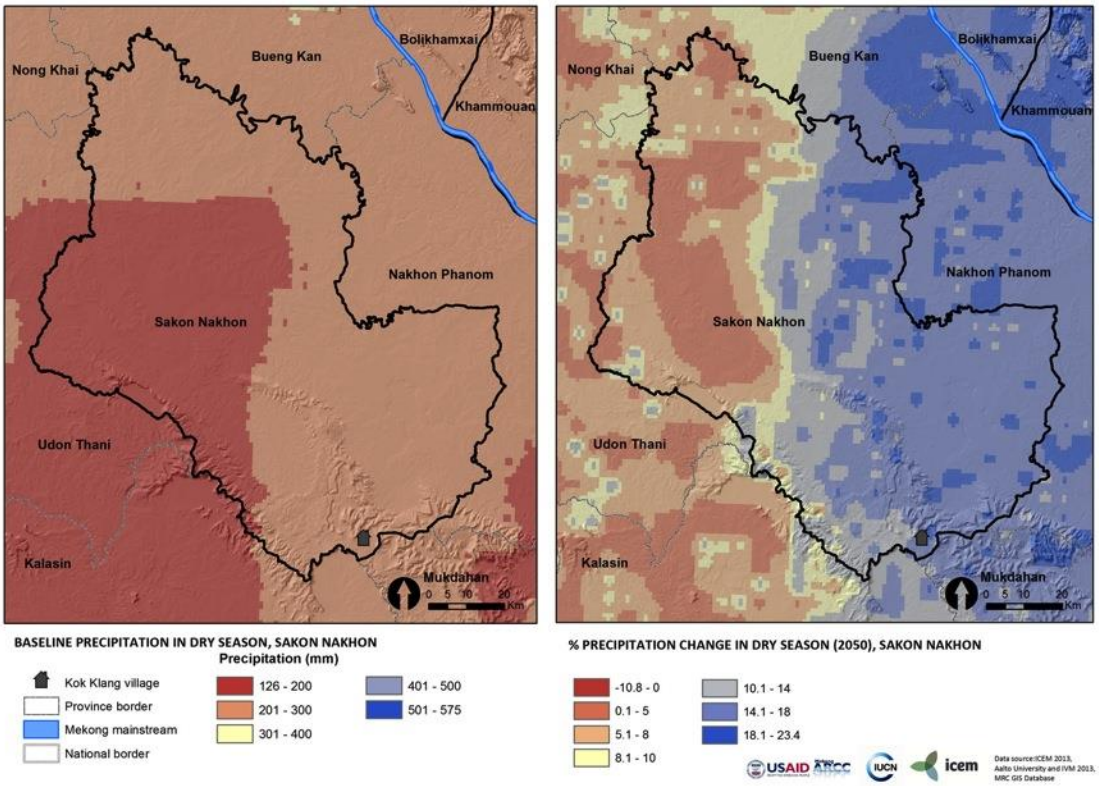


Figure 31: Dry season precipitation in Sakon Nakhon, Thailand (*published for USAID Mekong ARCC Project*)

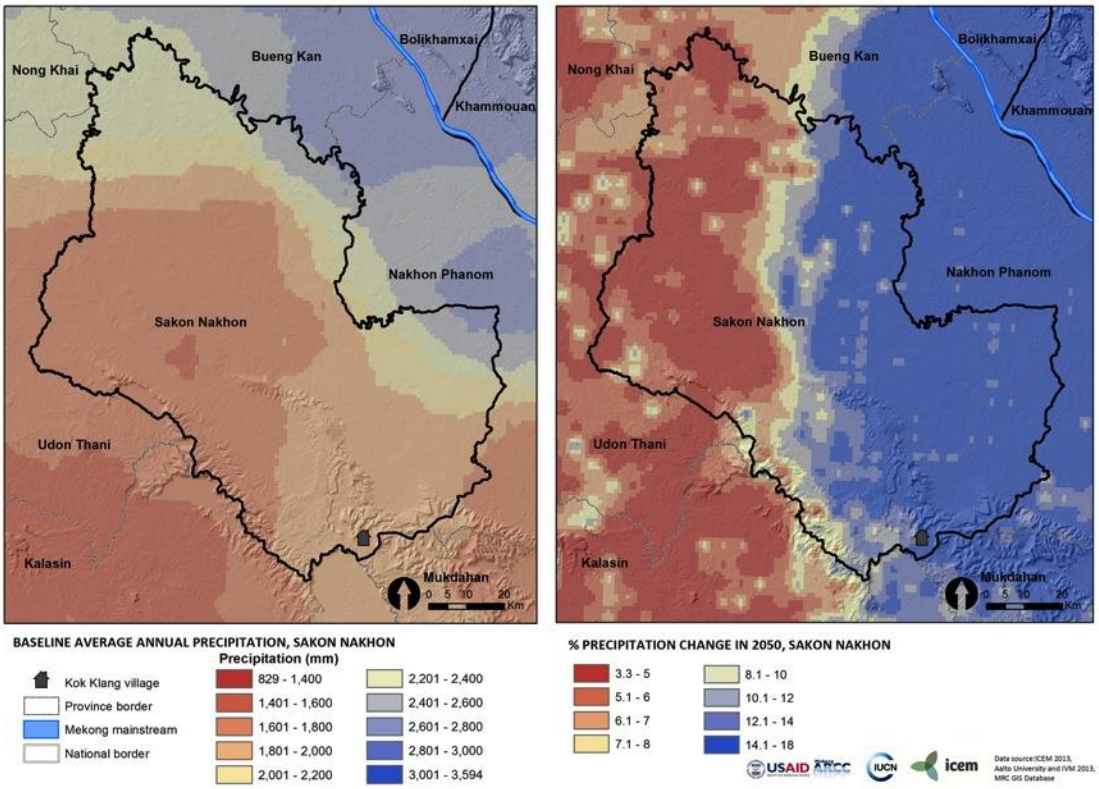


Figure 32: Annual average precipitation in Sakon Nakhon, Thailand (*published for USAID Mekong ARCC Project*)

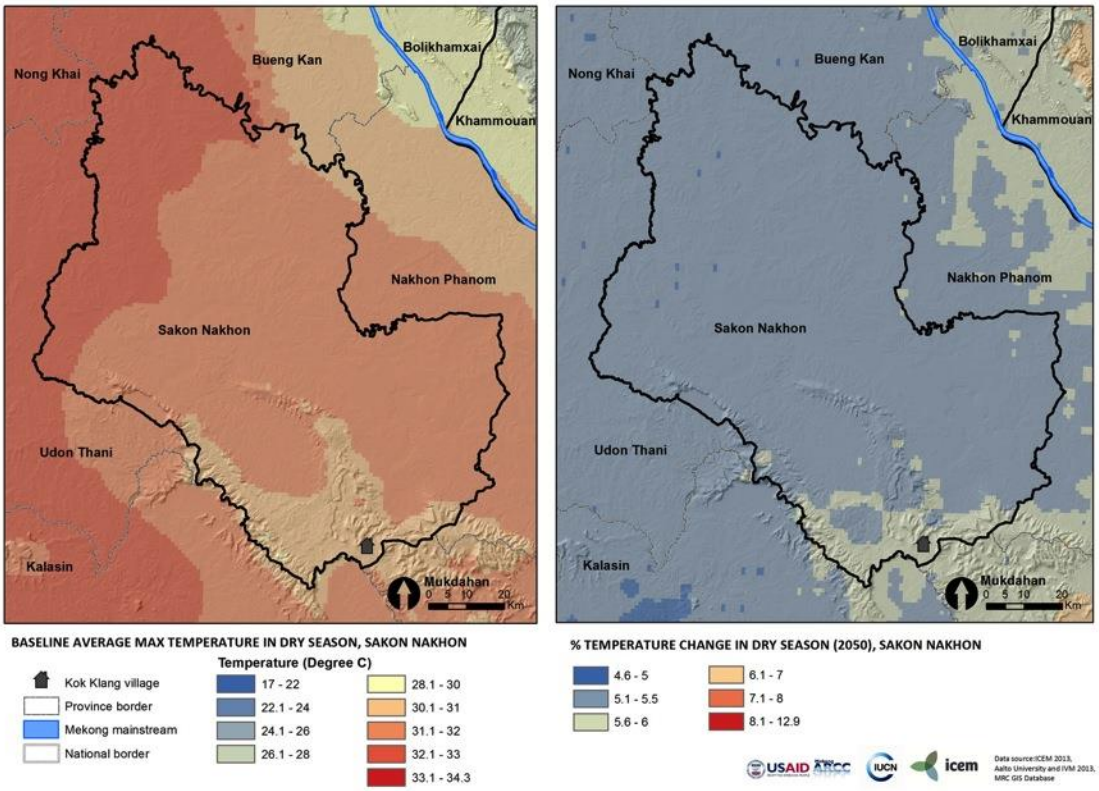


Figure 33: Dry season average maximum temperature in Sakon Nakhon, Thailand (*published for USAID Mekong ARCC Project*)

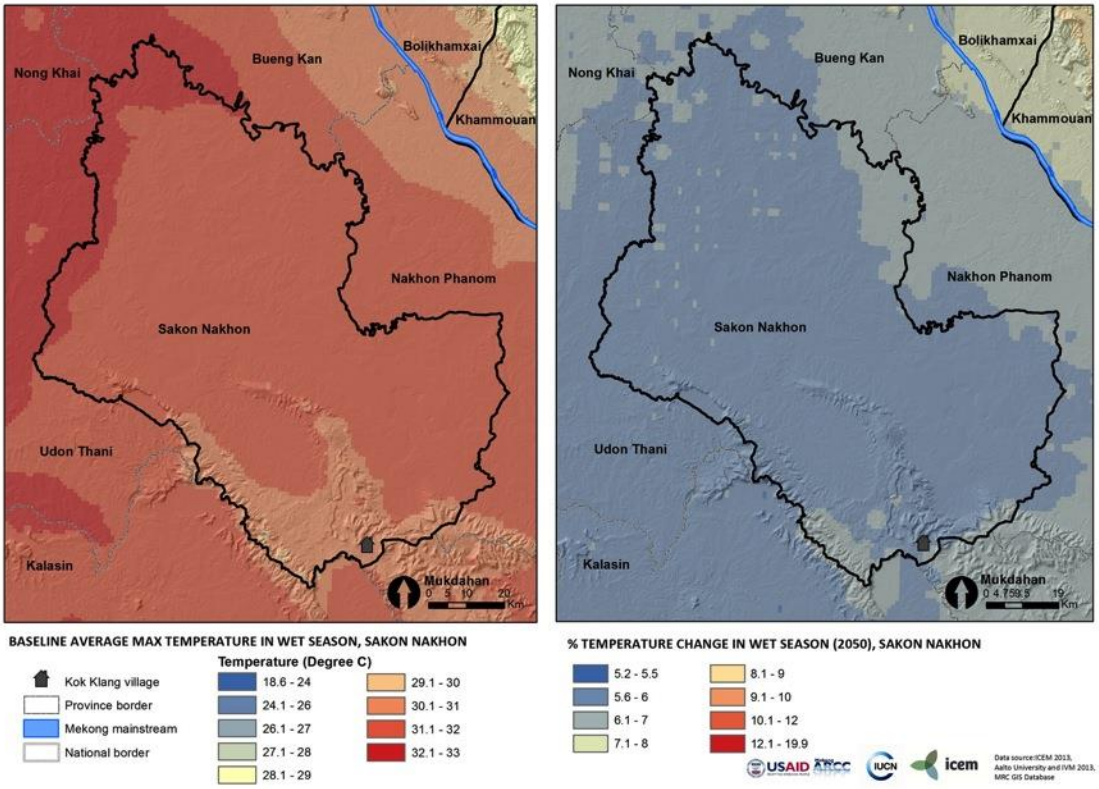
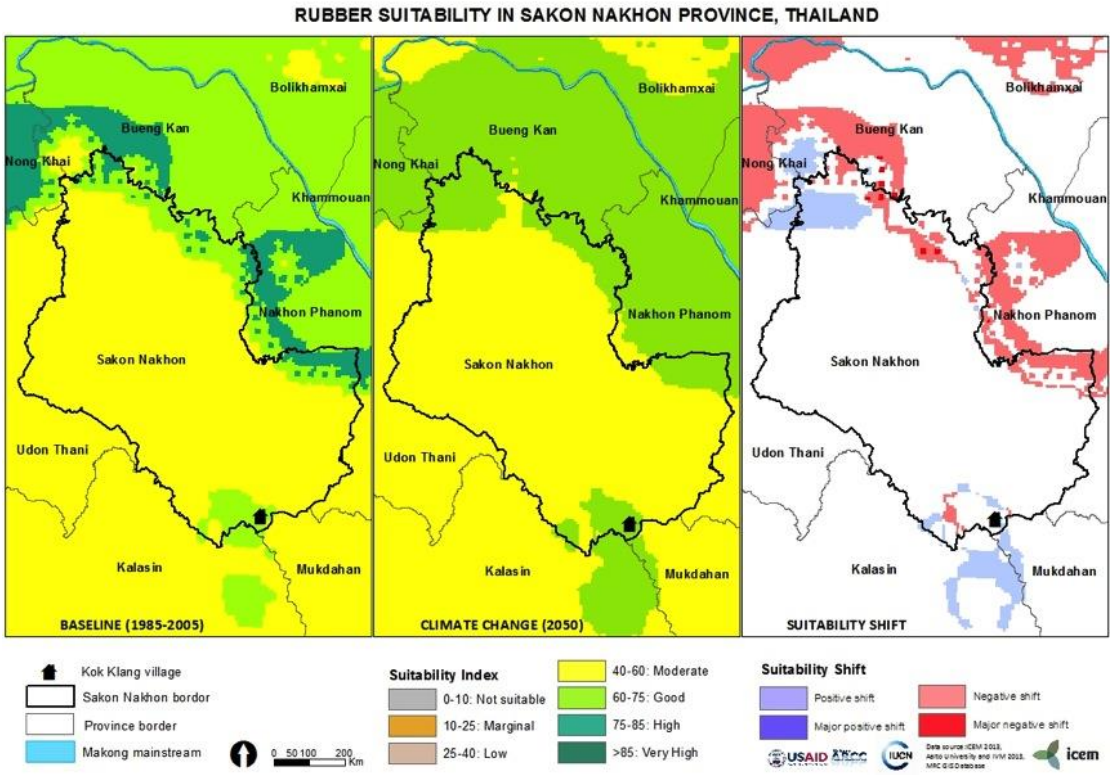
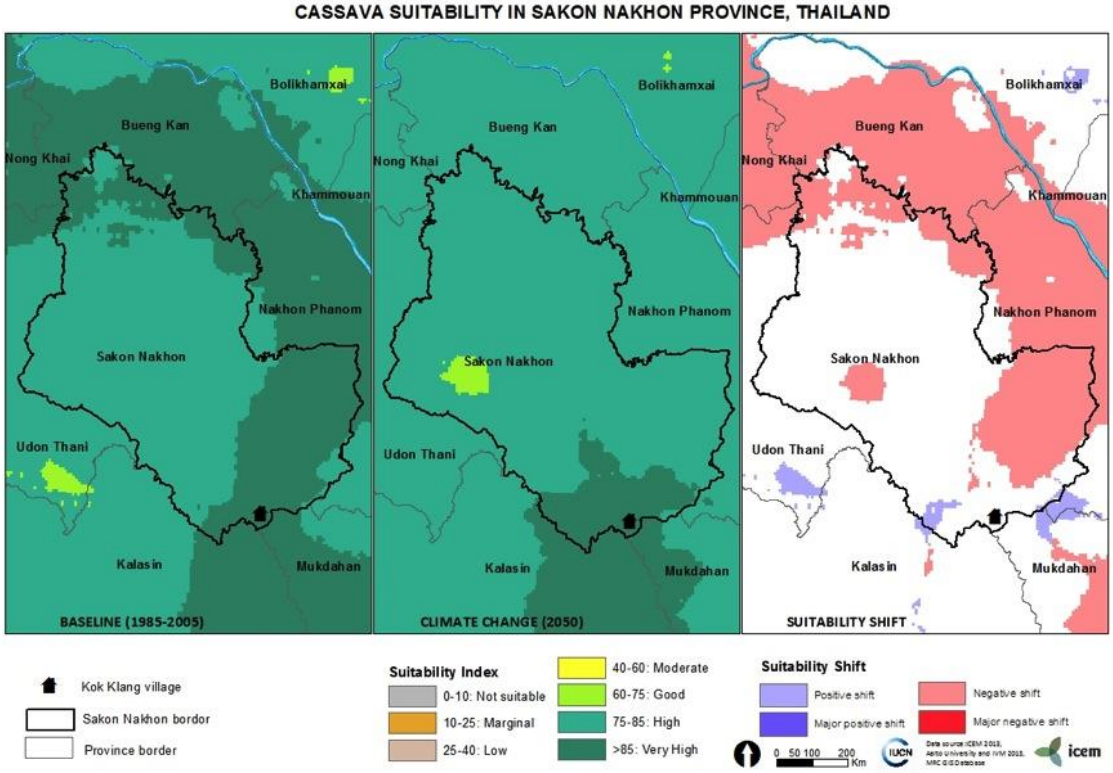


Figure 34: Wet season average maximum temperature in Sakon Nakhon, Thailand (*published for USAID Mekong ARCC Project*)

Crop suitability maps for Sakon Nakhon

Note: The maps below are published for the USAID Mekong ARCC Project (*Source*: USAID Mekong ARCC data)





RICE SUITABILITY IN SAKON NAKHON PROVINCE, THAILAND