CLIMATE CHANGE VULNERABILITY AND ADAPTATION IN AGRICULTURE AREAS IN THE BCI PILOT SITES

Socio-economic Profile and Vulnerability Assessment in Thailand

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February 2012

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Assessment of Climate Change Impacts on the Agriculture Sector in the BCI Tenasserim in Thailand - National Social and Vulnerability Survey

1. Background

The countries of the Lower Mekong Basin (LMB) are recognized as among the most vulnerable countries to climate change in the world. Their economies, ecosystem sustainability and social harmony are at risk. There is a high demand to better understand the potential impacts of climate change and climate variability, more informative decision making and in particular, the possible options for adaptation of these changes.

The Core Environment Program – Biodiversity Corridors Initiative (CEP – BCI) recently completed a study on biodiversity, food security and rural livelihoods in the GMS which identified the impacts of climate change on agriculture and rural livelihoods as a crucial issue. In response to this, the program is now embarking on a study to investigate this issue further.

The proposed study will consider the impacts of climate change on agricultural systems with an emphasis on rice production at three pilot sites: Xepian - Dong Hua Sao in Lao PDR, Tenasserim in Thailand, and Quang Nam Province in Viet Nam. The study will initially analyze the biophysical and socioeconomic baseline at these sites for understanding of present vulnerability and potential vulnerability in the future and the impacts of climate change on these. Coping and adaptation strategies to climate extremes and climate variations will be explored and assessed in order to strengthen existing strategies and develop alternative options that can effectively manage expected climate change impacts. The study will also assess adaptation options for rice production systems, agro-forest ecosystem based on risk and vulnerability.

Through the process of consultation and development of recommendations at both regional and local scales, the study is also expected to build capacity in relevant authorities on climate change impact assessment and adaptation planning.

2. Objectives

The purpose of this assessment is to implement GMS CEP activity on “Assessment of Climate Change Impacts on the Agriculture Sector”. This particular activity focuses on impacts of climate change on agricultural production system in 4 selected sites of Tenasserim connecting Western Forest and Kaeng Krachan Complexes on the western border of Thailand with Myanmar.

The proposed outputs for the study are:

1. Establishment of rice production systems baseline, biophysical and socioeconomic conditions at BCI sites
2. Assessment of the future yield of rice production and climate impacts on rice

production

3. Assessment of local vulnerability through a participatory consultation process
4. Development of adaptation options for local communities

The study is also expected to:

1. Strengthen awareness of climate change and adaptive capacity at local level
2. Develop better links between all stakeholders including GMS governments, provincial authorities and local communities.

3. Conceptual Framework

3.1. Literature review

Agriculture plays a crucial role in food security and employment of Greater Mekong Sub-region. Throughout GMS countries, rice remains as a critical crop. Agriculture accounts for 50 percent of total employment in Thailand, 69 percent in Vietnam, and 78 percent in Lao PDR (Singh 2007).

In the context of climate change, agriculture production in Asia in general and in GMS countries in particular will be affected and rice crop would be the largest potential impact from sea level rise (ADB 2009). Main economic activities of nearly 80 percent of the population of the region including subsistence agriculture, fisheries, and forest extraction are significantly affected due to high dependence on climate-sensitive resources such as local water, agricultural land and non-timber forest products. At the same time, they commonly have low adaptive capacity to anticipate, cope with, resist, and recover from the impact of a shock. Thus they are vulnerable to livelihood shocks, including those induced by climate change; especially the poorer households are the most at risk (Ellis 2000; Pretzsch 2003; Hunter 2007; Heltberg 2009). While rural livelihood strategies are also dynamic and able to respond to changing pressures and opportunities (Dorward et al. 2001; IPCC 2001), the speed and magnitude of climate induced changes may seriously challenge the adaptive capacity of some/all livelihood strategies (Brown et al. 2006; Smit and Wandel 2006).

The Greater Mekong Subregion (GMS) is one of the fastest growing regions in the world, which involves significant economic and social changes transforming economies, countries and natural landscapes in the Subregion. Some 70 million indigenous/ethnic peoples live in remote, mountainous and forested areas of the GMS, whose livelihoods highly depend on forest ecosystems and are most vulnerable to climate change impacts. Climate change scenario simulations show that the lower Mekong area will experience a variation in temperature and 10-30% increasing trends of precipitation (Snidvongs et al. 2006).

Vulnerability to climate change impacts varies widely across people, sectors, and regions because factors that determine vulnerability are usually embedded in broader

social, cultural, political, and economic structure. Since vulnerability, as defined by IPCC (2001), is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes, assessing vulnerability to climate change impacts has become crucial method to present intrinsic influence of climate change in development process.

Over the past few years, vulnerability, in general, has been well studied in development study by scholars like Bohle and Watts (1993) and Chambers (1989). Methods of vulnerability assessment have been developed in the fields of natural hazards, food security, sustainable livelihoods and other related fields (Downing 2002). In specific regards of climate change, literature of vulnerability has grown enormously by studies of Bohle et al. (1994), Downing (1992), Kasperson et al. (2001), Adger and Kelly (1999), etc. Downing and Patwardhan (2002) introduced a structured approach including tasks, analysis techniques for vulnerability assessment. In 2009, along with a toolkit for designing climate change adaptation, UNDP published a guide book on mapping climate change vulnerability and impacts Scenarios at Sub-National level. Vulnerability was considered as one of key steps to understand effects of climate change in specific environment and society. Yet, there's still need for vulnerability assessment at local level. There is an increasing demand for policy relevant and decision support information at micro levels derived from evidence-based assessment of local level vulnerability and adaptive capacity to climate change. A general conceptual model of vulnerability has emerged in the climate change related literature (Kelly and Adger, 2000; Downing, 2001; Turner et al., 2003; Smit and Pilifosova, 2003; Yohe et al., 2003; Adger 2006). However, empirical studies at local level are limited and inadequate (e.g. Gay et al., 2006; Wehbe et al., 2006).

The concept of community-based climate change adaptation is now under observation and action-learning in various countries (prominent are coastal and river line communities e.g. Bangladesh, Viet Nam, and the Philippines (Huq, 2007; Raihan et al., 2010; Shaw, 2006; Capili et al., 2005). Community-based vulnerability assessments have been employed in climate change adaptation, disaster management, poverty and food security fields that are aimed to contribute to practical adaptation initiatives (Jones 2001, Lim et al. 2004, turner et al. 2003, DFID 2004, FAO/WFP 2005). These "bottom-up" participatory vulnerability assessments require active involvement of stakeholders to allow for the recognition of multiple stimuli beyond those related to climate to include political, cultural, economic, institutional and technological factors (Smit and Wandel 2006).

3.2 Conceptual Framework

Recently vulnerability to climate change of human and ecological systems has been globally agreed to be influenced not only by physical exposures, the distribution of resources but also by social and government institutions. Climate variations and climate extremes tend to hasten or exacerbate society's existing conditions by affecting to security, livelihoods sustainability or access to resources. As represented in the following conceptual framework, vulnerability of a community or household is collectively created by

climate and non-climate risks faced by the community and its own characteristics, socio-economic conditions in the interaction with ecosystem characteristic under broader influence of development pressures.

Borrowing definition of vulnerability provided by IPCC (2007), vulnerability is defined as "*the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extreme. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.* Translated from the definition, following conceptual framework presents that vulnerability of a community to impacts of climate change can be assessed based on community's sensitivity which is presented by community's socio-economic conditions, interaction between community and agricultural system and based on community's exposure to climate change (e.g. community's geographic characteristics or agricultural system's condition) as well as community's adaptive capacity.

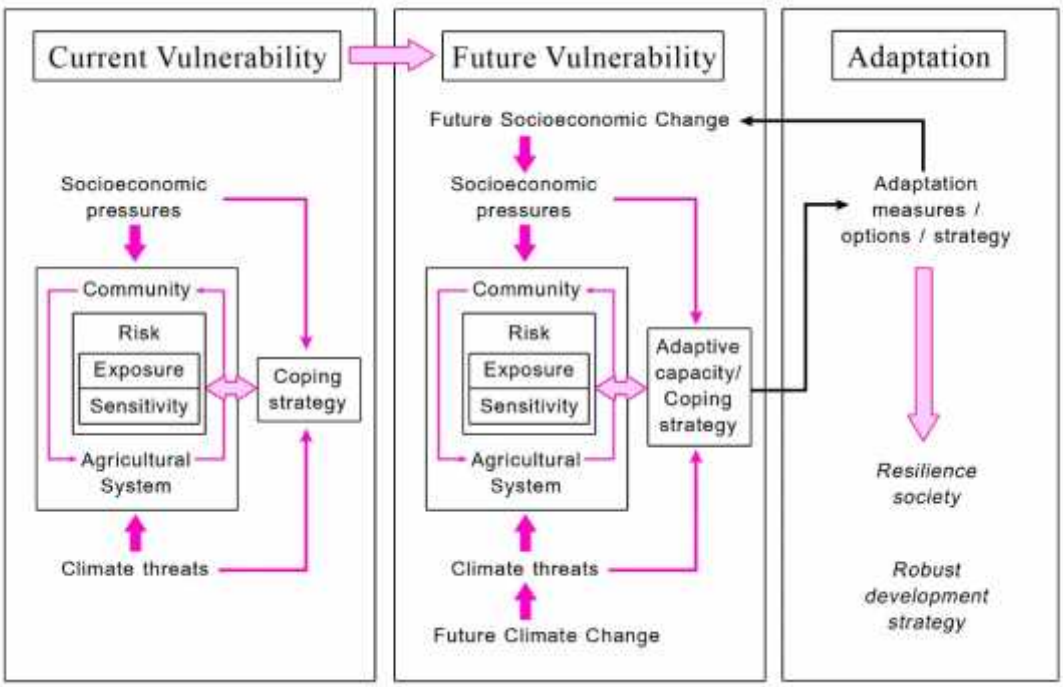


Figure1 Conceptual Framework of Community Vulnerability

Vulnerability of a community comes as consequence of a set of drivers. For many cases, it is impossible to separate sources of vulnerability either coming from climate, ecological, physical or social system. Coping or adapting strategies of the community have been evolving through time. Studying current stresses of climate and socio-economic development imposing on the community will bring into light effectiveness of existing coping strategies leading to answer research's question. "What can be done to strengthen and improve adaptive capacity of the community?"

Future vulnerability determined by future potential climate and non-climate risks,

and changes in socio-economic and ecological conditions of the community plays a key role in analysis part of the study. Apart from the fact that changes in community's exposure, sensitivity, and coping capacity would need different coping or adapting strategies, current adapting/coping strategies might not be still applicable in the future with different context and different risks. More importantly, potential changes or threats in the future would have great influence on interventions designed to strengthen or improve adaptive capacity and coping with present risks in order to achieve long-term and sustainable development **(Figure 1).**

Given the scope of the study, resilience of community under impacts of climate will be assessed in the interaction between vulnerability of community and vulnerability of agriculture system. Vulnerability of agriculture system to climate change impacts is one of major factors driving community's vulnerability. Changes in community's socio-economic and physical conditions and livelihoods pattern also either positively or negatively affect agriculture system. In responding to climate or non-climate risks, main aims of coping strategies of agriculture system is to maintain the same level of productivity which has strong influence on community's vulnerability as community with different social groups practicing different livelihood patterns facing impacts of climate in different aspects and uses different coping strategies to maintain livelihoods.

According to IPCC (2007), **Adaptation** is adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It involves adjustments to reduce the vulnerability of communities, regions, or activities to climatic change and variability. It can be classified as Anticipatory adaptation, Autonomous adaptation, and Planned adaptation.

- **Anticipatory adaptation** – Adaptation that takes place before impacts of **climate change** are observed. Also referred to as proactive adaptation.
- **Autonomous adaptation** – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.
- **Planned adaptation** – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state

4. Research design and methodology

4.1 Research design:

The study is designed to understand vulnerability of agricultural system and community based on three steps assessment approach

4.1.1 Assessing current vulnerability: This stage aims for understanding of present condition, risk and coping of agricultural and community in the study sites. The assessment focus on hoe agricultural system and community in the study site

are exposed and sensitive to climate risk as well as how the cope with risk that they are facing in order to analyze vulnerability and or resilience of the system and community to the climate risk. The assessment in this stages may covers;

- Collection of baseline information on the agricultural system as well as community social and economic condition, in order to formulate context of the study site. Information on agricultural system may include crop variety, crop management technique, crop calendar, crop production in various climate conditions (e.g. dry year, wet year, etc). Information on community may include population, economic profile, livelihood condition, etc.). Moreover, linkage between agricultural system and community, e.g. how community rely on agricultural production.
- Collection of information on current climate risk on agricultural system, which focus on key climate concerns that may affect crop production and response or preventive actions to cope with climate anomaly condition as well as effectiveness of such actions.
- Collection of key climate hazard that affect community and coping strategy as well as effectiveness of such strategy on such climate hazard.
- Evaluate risk and vulnerability of the agricultural system and community by summarize into exposure, sensitivity and coping capacity to climate hazard.

4.1.2 Assessing future vulnerability: Using understanding on current condition and profile to assess future risk and vulnerability to climate change which taken into consideration changes in socio-economic.

- Assessing changing or trend of foreseeable change in socio-economic condition that might affect exposure, sensitivity and coping of agricultural system and community to climate risk;
- Assessing impact and consequences of future climate change on exposure, sensitivity and coping capacity to climate risk of agricultural system as well as community.
- Evaluate risk and vulnerability of the agricultural system and community to future change by taking into consideration the way future climate and non-climate pressure may affect exposure, sensitivity and coping of agricultural system and community to climate risk.

4.1. 3 Adaptation planning and analysis: Analysis of the action and strategy that community is using and/or planning to cope with climate risk on agriculture as well as wellbeing of community. The analysis focuses on the effectiveness of such strategy and action to cope with future risk condition under influence of climate change as well as socio-economic change. Furthermore, new initiatives would also be identified as strategy to enhance current coping strategy to cope with to climate risk, which may include alternative options or new options to manage future risk which aims at resilience of agriculture system and community to climate risk. The analysis covers effectiveness of those options as well as enabling factor and critical success factor of each option.

4.2 Methodology

In general, the assessment will be conducted base on collection of data from study sites (e.g. secondary data collection and key informant interviews; participatory group discussion; household questionnaire survey), analyzing data from field collection using expert judgment and statistical analysis, synthesizing data from field collection with secondary data (i.e. future climate projection data), spatial analysis and mathematical modeling.

The methodology for each stage of assessment can be summarized as follows:

Stage 1: Assessing current vulnerability

Key activity	Method
Collection of baseline information on the agricultural system Note – key information covers: • Crop variety, crop management technique, crop calendar, crop production in various climate conditions (e.g. dry year, wet year, etc.) • Agricultural area • Role of agricultural activities in the study site e.g. contribution in food security, income, etc.	Field data collection: • Secondary data review, (source: online information and commune database-CDB 2009 and other reports) • Update and gap-filling commune data with commune chief/members, provincial Department of Planning, patriarch and the elder in the community
Collection of baseline information on community social and economic condition Note – key information covers: • Geographic aspect: Location, altitude, natural area, forest, river, agricultural land, etc. • Demographic aspect: Population, poverty, gender, ethnic minority, etc. • Economic aspect: key economic activities/source of income/productivity, household income/productivity, household expenditure/ consumption, etc.	Field data collection: • Secondary data review, (source: online information and commune database-CDB 2009 and other reports) • Update and gap-filling commune data with commune chief/members, provincial Department of Planning, patriarch and the elder in the community
Collection on information about current climate risk on agricultural system	Field data collection: • Key informants interview • Focus group discussion Technique used: • Climate hazard diagram • Hazard mapping • Seasonal calendar

Key activity	Method
Collection on information about current climate risk on community	Field data collection: • Key informants interview • Focus group discussion Technique used: • Climate hazard diagram • Hazard mapping • Seasonal calendar
Evaluate risk and vulnerability of the agricultural system and community	Field data collection: • Focus group discussion Technique planned: • Vulnerability matrix Analyze and synthesize data from field data collection.

Stage 2: Assessing future vulnerability

Key activity	Method
Assessing changing or trend of foreseeable change in socio-economic condition Note – key information covers: • How community see plausible change in the agricultural system and socio-economic condition in their area e.g. change in crop variety, livelihood condition, lifestyle, social/ economic structure, land-use land-cover change, deforestation, infrastructure (dam/ road / etc.), access to market, etc.	Field data collection: • Focus group discussion
Assessing impact and consequences of future climate change	Desk study: • Climate change scenario analysis (base on key climate concerns information collected by field data collection); • Modeling (crop model, hydrology model, etc.) Expert judgment • Workshop
Evaluate risk and vulnerability of the agricultural system and community to future changes	Desk study: • Vulnerability matrix (review vulnerability matrix – current vulnerability and apply future change to the matrix) Expert judgment

	• Workshop

Stage 3: Assessing future vulnerability

Key activity	Method
Assessing plausible options to cope with future vulnerability Note – key information covers: • Review existing coping strategy under future context • Exploring enhancement on climate risk management strategy • Exploring new options to manage future risk (taken current risk into consideration)	Desk study: • Focus group discussion – experts workshop • Model (crop model, etc.)

5. Background of study sites

5.1 Geography

The Biodiversity Corridors Initiative (BCI) is in the Tenasserim range in western Thailand, between the Western Forest Complex (WEFCOM) and the Kaeng Krachan Complex **(Figure 2).** To the west, both complexes border forested areas in Myanmar.

The biodiversity corridor area starts at the southern tip of Sai Yok National Park, adjoining a proposed extension area of Sai Yok, connecting with areas under the administration of the Royal Thai Army, the Princess Sirindhom Nature Study Center and touching on the northern borders of the Maenam Phachi Wildlife Sanctuary and the Chaloem Phrakiat Thai Prachan National Park. The total length of the corridor is over 70 km.

The Thai BCI Pilot Site is located in the Tenasserim – Western Forest Complex which covers two provinces, namely Ratchaburi and Kanchanaburi and consists of four clusters and five villages each located in the districts of Suan Phueng and Ban Kha in Ratchaburi Province in the project areas of Queen Sirikit Indigenous Plant Study Center, Princess Sirindhorn Natural Study Center, Thai Prachan National Park, and the district of Sai Yok in Kanchanaburi Province in the Sai Yok National Park. These are: the Northern section of the biodiversity corridor called the Sai Yok Cluster. The Southern section included the Suan Phueng cluster, the Thanaosri cluster and the Ban Bueng cluster **(Table 1).**

Table 1 BCI target clusters and Pilot village

Sai Yok Cluster – Sai Yok National Park (5 villages)

Village	Village No.	Sub-district	District	Province
Ban Ton Mamuang	7	Wang Kra Chae	Sai Yok	Kanchanaburi
Ban Bongti Noi	8	Wang Kra Chae	Sai Yok	Kanchanaburi
Ban Chai Thung	9	Wang Kra Chae	Sai Yok	Kanchanaburi
Ban Bongti Lang	2	Bong Ti	Sai Yok	Kanchanaburi
Ban Thung Ma Sue Yoh	4	Bong Ti	Sai Yok	Kanchanaburi

Suan Phueng Cluster - Princess Sirindhorn Nature Study Center (5 Villages)

Village	Village No.	Sub-district	District	Province
Ban Thung Fhak	2	Suan Phueng	Suan Phueng	Ratchaburi
Ban Phapok	3	Suan Phueng	Suan Phueng	Ratchaburi
Ban Thamhin	5	Suan Phueng	Suan Phueng	Ratchaburi
Ban Huay Phak	7	Suan Phueng	Suan Phueng	Ratchaburi
Ban Tako Lang	8	Suan Phueng	Suan Phueng	Ratchaburi

Tanaosri Cluster - Queen Sirikit Indigenous Plant Study Center (5 villages)

Village	Village No.	Sub-district	District	Province
Ban Tha Makham	2	Tanaosri	Suan Phueng	Ratchaburi
Ban Huay Muang	3	Tanaosri	Suan Phueng	Ratchaburi
Ban Huay Haeng	5	Tanaosri	Suan Phueng	Ratchaburi
Ban Huay Namnak	6	Tanaosri	Suan Phueng	Ratchaburi
Ban Bohwee	4	Tanaosri	Suan Phueng	Ratchaburi

Ban Bueng Cluster - Thai Prachan National Park (5 Villages)

Village	Village No.	Sub-district	District	Province
Ban Pong Krathing	1	Ban Bueng	Ban Kha	Ratchaburi
Ban Punam Ron	4	Ban Bueng	Ban Kha	Ratchaburi
Ban Dongka	9	Ban Bueng	Ban Kha	Ratchaburi
Ban Huay Makrud	10	Ban Bueng	Ban Kha	Ratchaburi
Ban Phuhin	13	Ban Bueng	Ban Kha	Ratchaburi

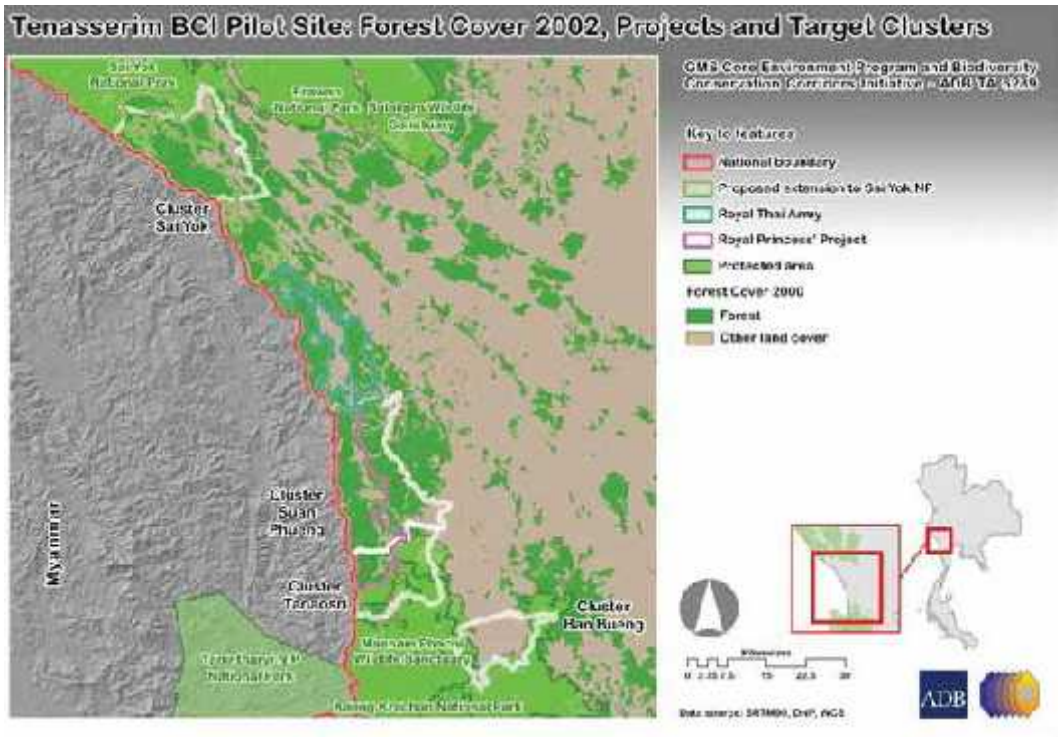


Figure 2 The Biodiversity Corridors Initiative (BCI) is in the Tenessarim range in western Thailand

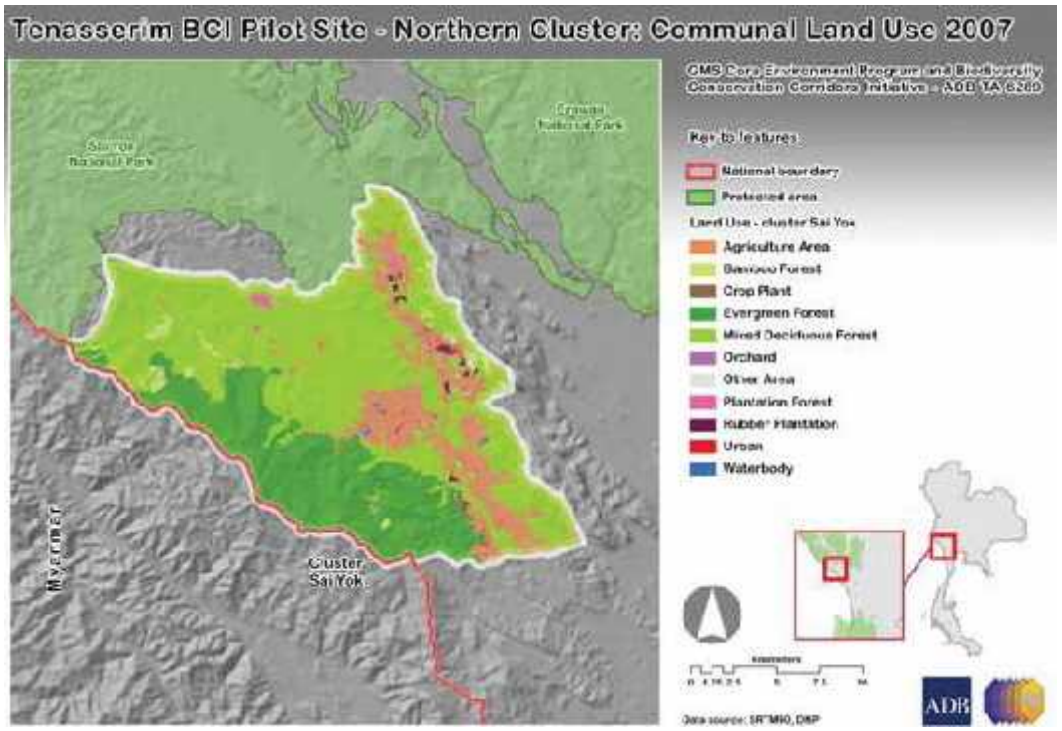


Figure 3 BCI Tenessarim Pilot Site, the Sai Yok cluster

In the Sai Yok cluster, there is a large patch of evergreen forest bordering with mixed deciduous forest, some parts of which are now under agricultural and other use. The link of evergreen and deciduous mixed forest along the border to Sai Yok National Park still seems to be intact **(Figure 3)**, although this link needs to be consolidated and restored in areas, which are degraded. Development activities in the northern cluster are rapidly expanding and it is important to demarcate a linear and unbroken forest corridor using existing patches to connect Sai Yok National Park in the north with the area administered by the Thai Military in the south.

In the southern clusters **(Figure 4)**, a very narrow strip of mixed deciduous forest can be detected along the border, which appears broken in places, especially where mining activities were previously undertaken in the Suan Phueng Cluster. Cultivated land is mostly along areas of settlement and roads and large areas are covered with bamboo or mixed bamboo and deciduous forest. In the Ban Bueng Cluster, a very thin strip of forest is acting as a buffer between areas under development and the Thai Prachan National Park.

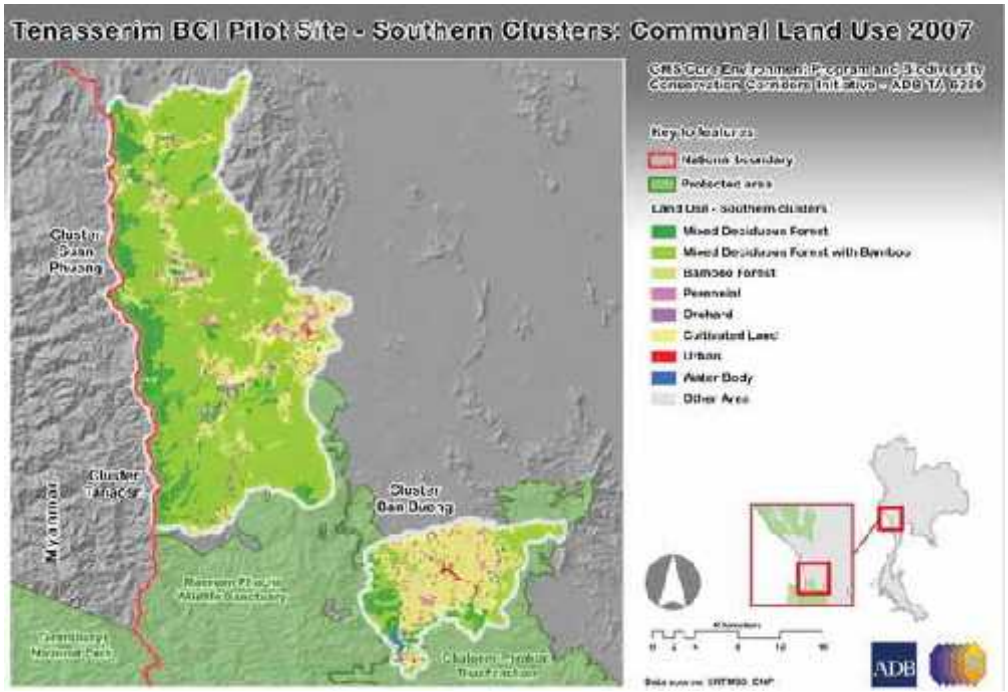


Figure 4 BCI Tenassarim Pilot Site, the southern clusters

5.2 Climate

Two weather stations are located near the BCI site; K10 weather station in Ban Lum Sum, SaiYok district, Kanchanaburi province and K25 weather station in Ban Bung, Banka district, Ratchaburi province.

Weather data over the period of 1965-2010 from 2 weather stations **(Table 2, Figure 5 and 6)** shows rainfall pattern from January to December. The K 10 weather station, which is located near Sai Yok cluster, has average annual rainfall higher than K25 weather station, which is located in three clusters in Ratchaburi province (1,238.5 mm and 1,193.6 mm). Average monthly maximum temperature of K25 weather station

is higher than K 10 station and average monthly minimum temperature of K25 weather station is lower than K 10 weather station. Average annual rain day of K10 and K25 weather station is 132 and 153 days, however, rain day of K10 station during rainy season (June to August) is higher than K25 station.

The climate of Sai Yok Cluster, which is monitored by the K10 weather station, is influenced by tropical monsoon conditions. The average annual rainfall of the area is 1,238.50 mm. The rainy season starts from April and extends to October, with drier conditions in June. The highest mean annual rainfall is recorded in October and the lowest is in January. The dry season lasts from November to April. December is usually the coldest month and April the hottest **(Figure 7).**

The Southern BCI pilot Cluster located near the Tenessarim ridge is highly influenced by the Southwestern monsoon. This area is characterized by hot tropical climate with daily temperatures ranging from 19.8-37.2° C. The rainy season lasts from May to October, with average precipitation of 1,193.6 mm per year. Winter generally lasts from November to January, with average temperatures of about 9.2-36.5° C. The dry season runs from February to April.

Table 2 Average monthly rainfall, maximum and minimum temperature of K10 weather station and K25 weather station (1965-2010).

Month	K10 A.Saiyok,Kanchanabiri			K25 A.Banka, Ratchaburi		
	Rainfall(mm)	Max T	Min T	Rainfall(mm)	Max T	Min T
January	2.7	35.3	13.8	2.6	36.5	9.2
February	34.5	37.9	16.2	18.8	38.3	11.0
March	48.5	39.7	18.5	55.7	40.0	13.8
April	116.6	40.2	21.5	107.0	39.8	18.0
May	155.3	38.4	22.4	165.0	38.5	20.6
June	106.7	36.8	22.7	79.8	37.0	20.7
July	137.0	35.8	22.4	108.4	36.8	21.1
August	137.0	35.6	22.5	90.2	36.4	21.3
September	223.0	35.6	22.2	194.5	37.0	21.4
October	230.6	34.8	20.8	295.3	34.8	19.7
November	42.2	34.2	16.1	68.6	34.4	14.1
December	4.3	34.1	13.5	7.6	34.3	10.6
Total	**1,238.5**			**1,193.6**		
Dry season	**132.3**			**153.3**		
Wet season	**1,106.3**			**1,040.2**		

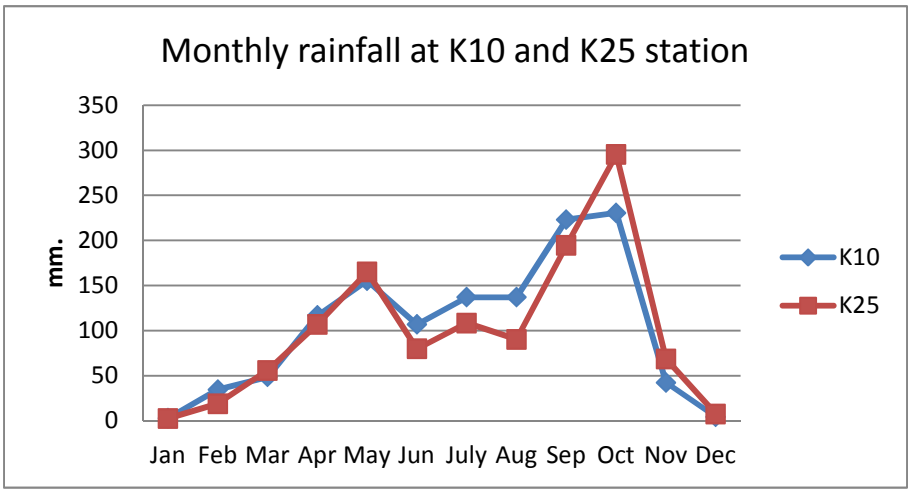


Figure 5 Average monthly rainfall of K10 and K25 weather station

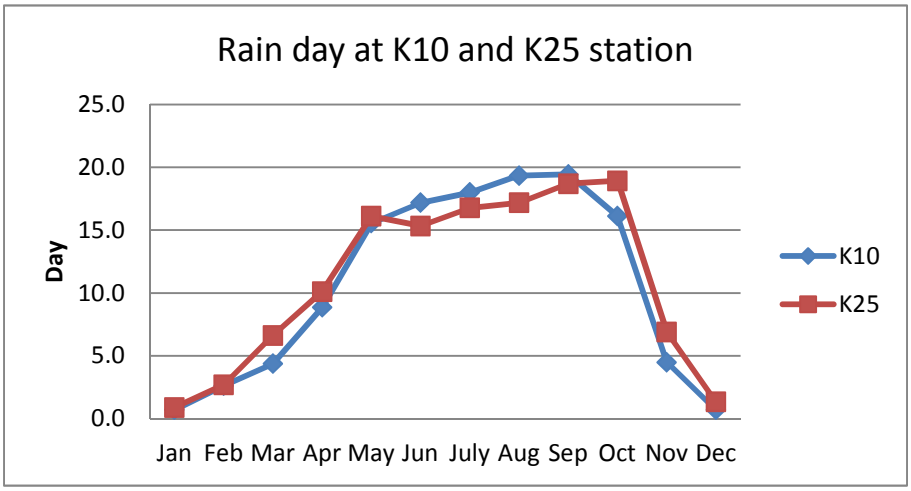


Figure 6 Annual rain day of K10 and K25 weather station

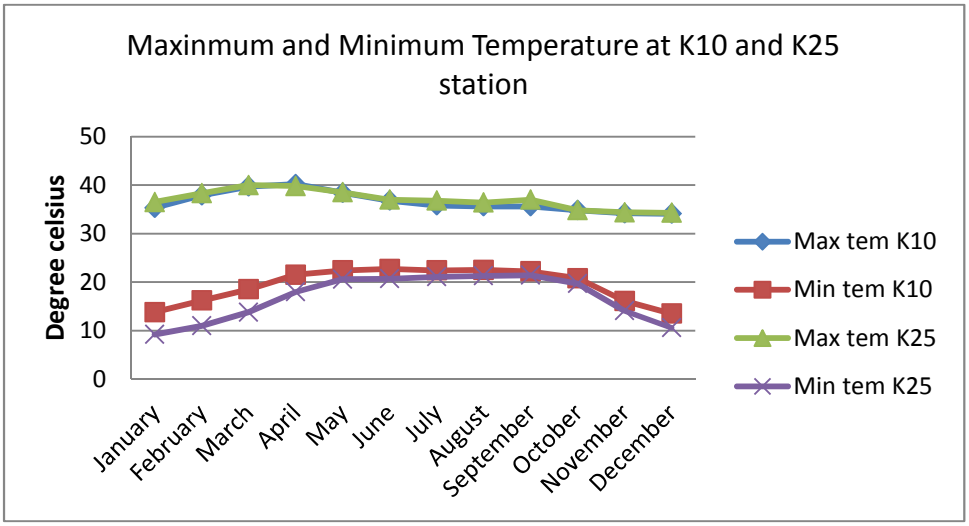


Figure 7 Average minimum and maximum temperature at K10 and K25 weather station

The climate of Sai Yok Cluster is monitored by the K10 climate station, is influenced by tropical monsoon conditions. The average annual rainfall of the area is 1,238.50 mm. The rainy season starts from April and extends to October, with drier conditions in June. The highest mean annual rainfall is recorded in October and the lowest is in January. The dry season lasts from November to April. December is usually the coldest month and April the hottest.

The Southern BCI pilot Cluster located near the Tenasserim ridge is highly influenced by the Southwestern monsoon. This area is characterized by a hot, tropical climate with daily temperatures ranging from 19.8-37.2°C. The rainy season lasts from May to October, with average precipitation of 1,193.6 mm per year. Winter generally lasts from November to January, with average temperatures of about 9.2-36.5°C. The dry season runs from February to April.

5.3 Agricultural system in BCI

In the past, farming system in each BCI cluster is shifting cultivation included Upland Rice, Cotton and local Maize in the mountain range and local chicken raising in the household. They had harvested NFTP from the forest e.g. wild animal, bamboo shoot, honey bee, mushroom, wood for make home and firewood etc. Agriculture production is for consume in the household and exchange goods in the community. Rain-fed is the main water resource for agriculture **(Table 3).**

In the present, Farming system is changed from the past, the most crop in BCI pilot site are maize, cassava, sugarcane and pineapple. The minor crops in these areas are upland rice, vegetable, mango, Para rubber **(Table 4)**. However, the main crop is different in each cluster. Maize, Cassava and upland rice are main crop in the Sai yok cluster. Cassava, Sugarcane, Pineapple and Mixed crop are main crop in the Saun Phueng cluster. Only Cassava, Sugarcane and Sweet banana are main crop in the Tanaosri cluster. And Pineapple, vegetables and cassava are main crop in the Ban Bueng cluster. The land use in each BCI shows in **Figure 8 to 11.**

Almost agriculture area in the BCI pilot sites is rain-fed agriculture. Especially in The Sai Yok, Suan Phuneg and Tanaosri cluster. Only Ban Bueng cluster, approximately 60% of agricultural household has own at least one water pump or electric generator.

Table 3 Agriculture system in BCI site in the past

Agricultural system in the past

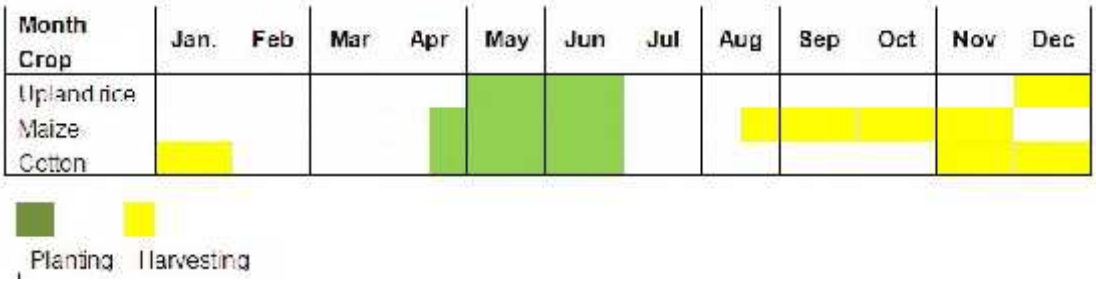
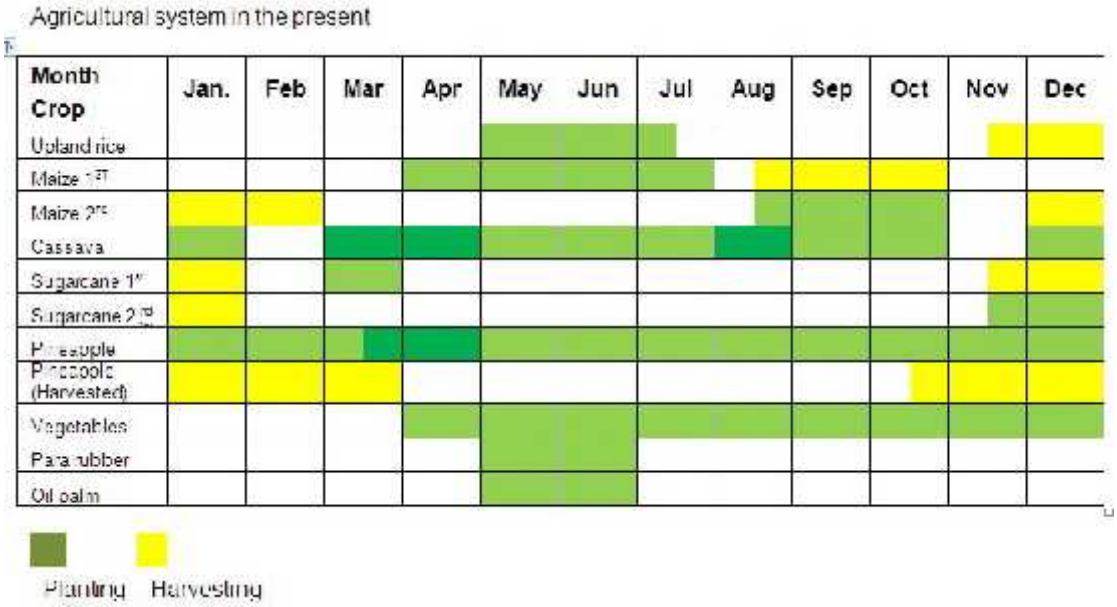


Table 4 Agriculture system in BCI site in the present



5.4 Community socio-economic condition

Population

The estimated total population in the clusters is 18,752 comprised of 5,051 households **(Table 5).** The total population of Sai Yok cluster, Suan Phueng cluster, Tanaosri cluster and Ban Bueng cluster are 3,927 / 4,741 / 7,140 and 2,944 people with a total of 1,060 / 2,480 / 1,327 and 634 households respectively. The average household size in the clusters is 4.4 people, which is household size 3.7, 3.9, 5.4 and 4.64 people respectively.

The majority of people in the clusters which is identify themselves as Thai, including significant numbers of ethnic minorities. The largest ethnic group is Karen, comprising about one-third of the population in the Tanaosri Cluster (Queen Sirikit Indigenous Plant Study Center) and the Suan Phueng Cluster (Princess Sirindhorn Nature Study Center). Mon and Burman ethnic groups are 4% in the Princess Sirindhorn Study Center and Sai Yok National Park. Small groups of Laotians, Chinese and Indians are spread across the site.

Table 5 Population, household and household size by cluster.

Cluster	Population	Household	Household size
Sai Yok cluster	3,927	1,060	3.7
Suan Phueng cluster	4,741	2,480	3.9
Tanaosri cluster	7,140	1,327	5.4
Ban Bueng cluster	2,944	634	4.6
Total	18,752	5,051	4.4

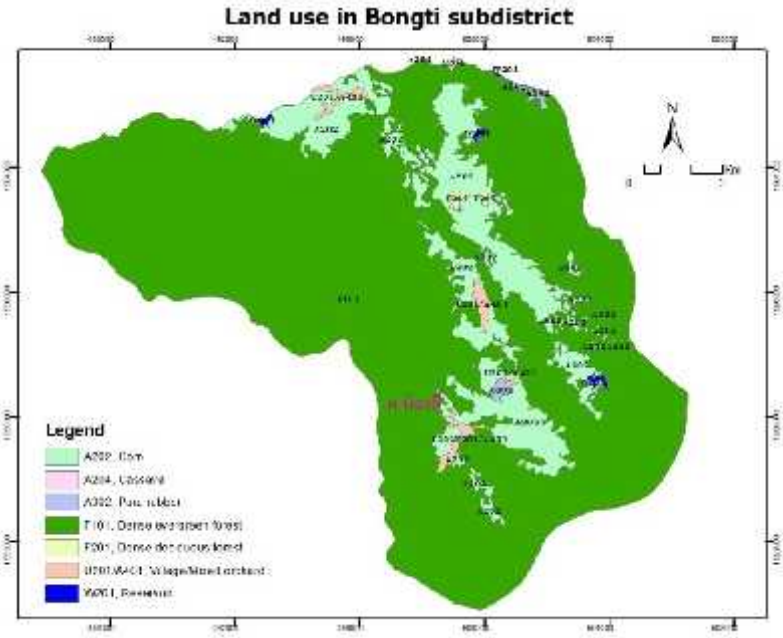


Figure 8 Land use in Sai Yok cluster

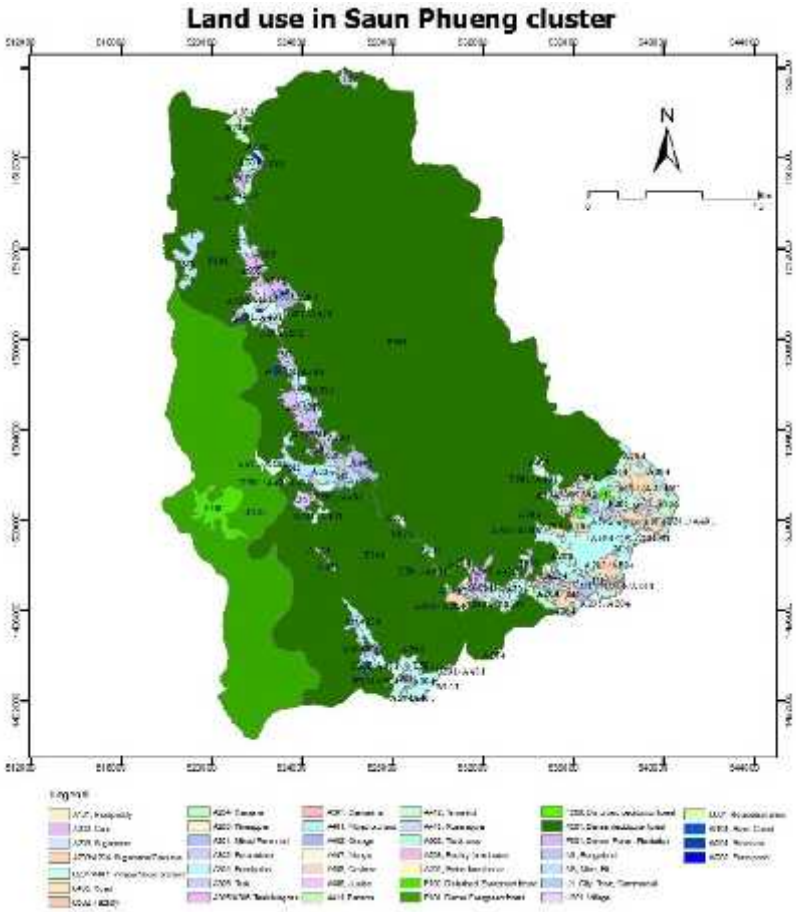


Figure 9 Land use in Saun Phueng cluster

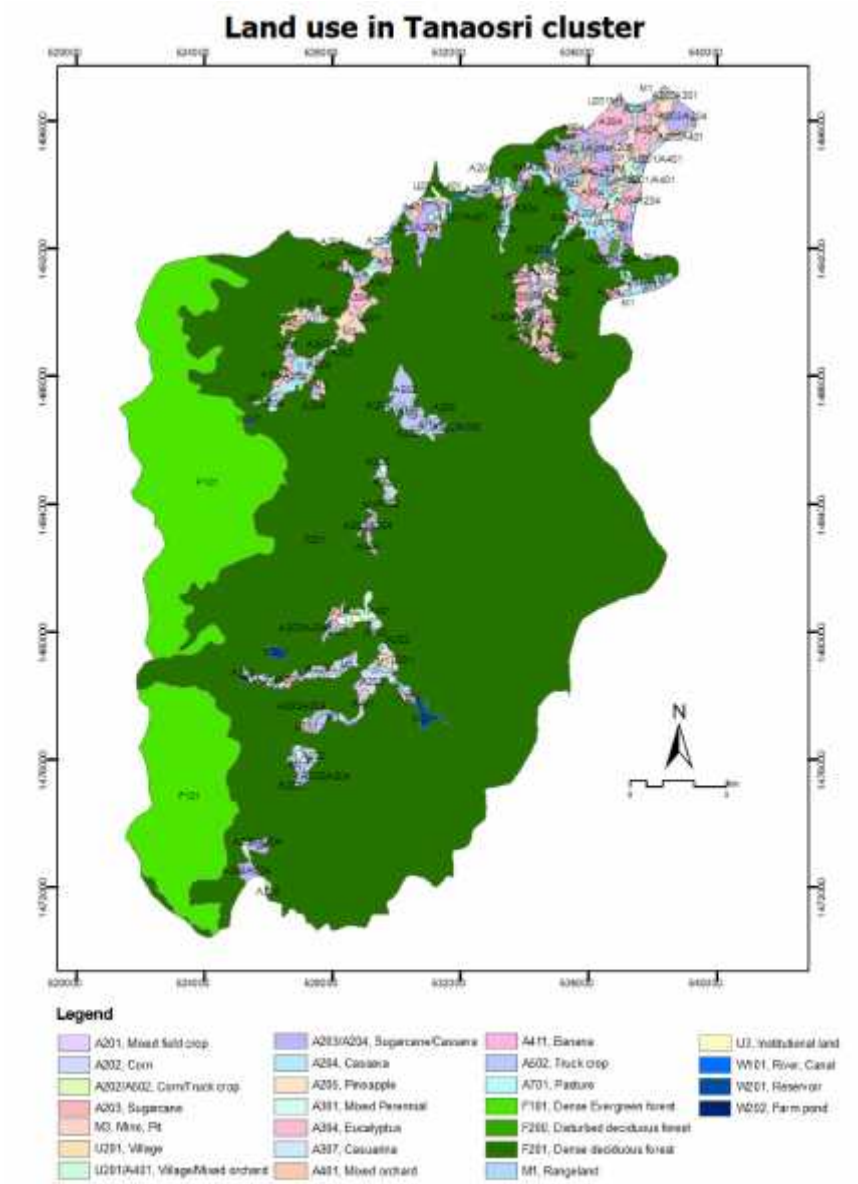


Figure 10 Land use in Tanaosri cluster

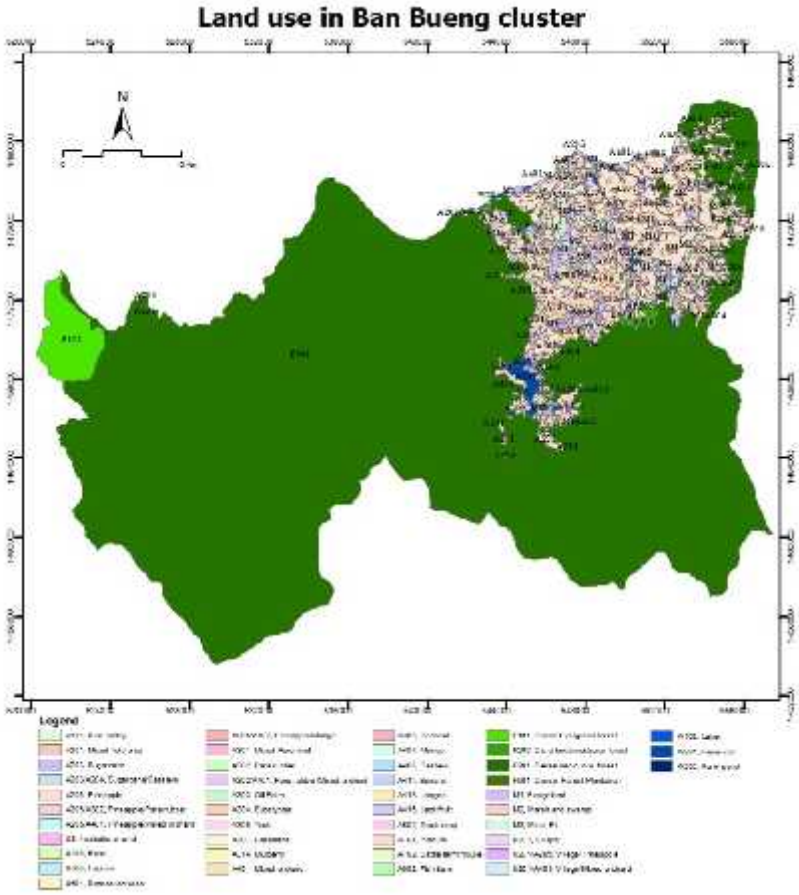


Figure 11 Land use in Ban Bueng cluster

Labor force

Almost half of population in this area, 48.65%, is engaged in agricultural system, however, the number varies from cluster to cluster. In the North cluster or Sai Yok cluster, agricultural household is 71.63% while Suan Phueng cluster, Tanaosri cluster, and Ban Bueng cluster is 22.29%, 64.27%, 36.42% respectively. And in each cluster, there are labor in agriculture sector of 58.79%, 55.27%, 53.91% and 71.77% of total population respectively.

The largest proportion of the working population is engaged in agricultural activities, with a significant number also supplying unskilled labor to larger farms or to other sectors, especially construction. Most households do not own land, with about 46% holding land use permits, with no right to sell it.

Villagers are highly dependent on the forest as an additional source of livelihood. More than 80% of the households gather bamboo shoots and mushrooms from the forest, as well as various types of vegetables and dried wood, for both consumption and sale. Households living in and around Sai Yok National Park also hunt wild animals and collect honey.

Poverty incident

Average monthly household incomes (Baht 6,500) in BCI target villages **(Table 6)** are much lower than the 2004 national monthly average (Baht 14,963), even though the respective provinces' average is very close, if not higher, than the national standard. The average expenditure level in this area is much lower than the national and provincial averages, with almost half of the household expenditures spent on food.

Table 6 household agriculture income by cluster (Baht)[1]

Income (Baht)	Sai Yok cluster	Suan Phuneg cluster	Tanaosri cluster	Ban Bueng cluster
Median	50,000	30,000	27,500	35,000
Minimum	500	200	320	640
Maximun	350,000	800,000	605,000	520,000
Average Income	**63,999.6**	**93,600.0**	**67,992.0**	**83,599.6**

6. Scope of assessment

The Thai BCI Pilot Site is located in the Tenasserim – Western Forest Complex which covers in Ratchaburi and Kanchanaburi Province that is consists of four clusters; (1) Sai Yok cluster (2) Suan Phueng cluster (3) Tanaosri cluster and (4) Ban Kha cluster. Assessment of climate change impact on agricultural system and community is conduct in each cluster.

This assessment is implementing by selected one village in each cluster. Village selection by consultation sub district administrative officer and report of GMS core environment program and biodiversity conservation corridors initiative. Four villages selected are;

(1) Sai Yok cluster, Ban Bongti Lang, Bongti sub district, Sai Yok district, Kanchanaburi Province
(2) Suan Phueng cluster, Ban Huay Phak, Suan Phueng sub district, Suan Phueng district, Ratchaburi Province
(3) Tanaosri cluster, Ban Bohwee, Tanaosri sub district, Suan Phueng district, Ratchaburi Province
(4) Ban Bueng cluster, Ban Huay Makrud, Ban Bueng sub district, Ban Bueng district, Ratchaburi Province

[1] Approximately 31 Baht = 1 US$

7. Study site present context

7.1 Sai Yok cluster, Ban Bongti Lang, Bongti sub district, Sai Yok district, Kanchanaburi Province

7.1.1 Topography

Ban Bongti Lang is one of four villages of Bongti sub district, Sai Yok district, Kanchanaburi Province, is in Sai Yok cluster **(Figure 12)**. It is distance approximately 104 kilometers from Kanchanaburi. Total land covers area of 6,653.49 hectares.

The village is situated inside the Sai Yok National Park, officially declared a National Park of Thailand on the 11th October 1980. The topography is mountainous covered by mixed deciduous and dry evergreen forest with bamboo. There is a teak plantation along the Kwae Noi River, which serves as an important habitat for wildlife.

7.1, 2 Population

Ban Bongti Lang has population 1,079 people, 376 household and average household size of 2.9. The majority of the population in this village are of Thai ethnicity (66.8 percentage) while the others (33.2 per cent) were identified as consisting of Karen, Burmese, Hmong and others.

7.1. 3 Income

The average monthly household income was 9,653.75 Baht or 39,946.58 Baht per head per year (CD,2011); 39.5, 27.9 and 32.6 percent of people has household monthly income less than 5,000 5,000-10,000 and more than10,000 baht respectively by(IPSR, 2007 sited in ADB TA 6289 report, 2008).

7.1.4 Land cover and use

The land in this village is mostly coved by forest which may either deciduous or mixed with bamboo. However land for agriculture also forms an extended area in the valley. Some common crops cultivated include cassava, maize, upland rice, mixed perennial, mixed orchard, and mixed field crop **(**see **table 7 and Figure 3).** The amount of land allocation for agriculture accounts for only about 19.08 percent, or 1,269 hectares. Ban Bongti Lang has the highest land used for cultivation in Sai Yok cluster (32.2 %) while the lowest in Ban Bongti Noi (11.6%). In the year 2010, Total crop areas are 525.6 Ha; Maize amount 371.52 Ha. Cassava amount 93.92 Ha. Para rubber amount 56.32 Ha and another horticulture amount 5.28 Ha. Farmer in this village has land for cultivation is range 0.8-3.2 Ha (average 2.4 ha.) In that land, farmer is only using it utilization but no ownership (Por bo tor 5).

The land cover under water bodies is about 5.535 hectares (0.08%) and this highlights the scarcity of water. Residential area includes only about 27.599 hectares (0.42 %).

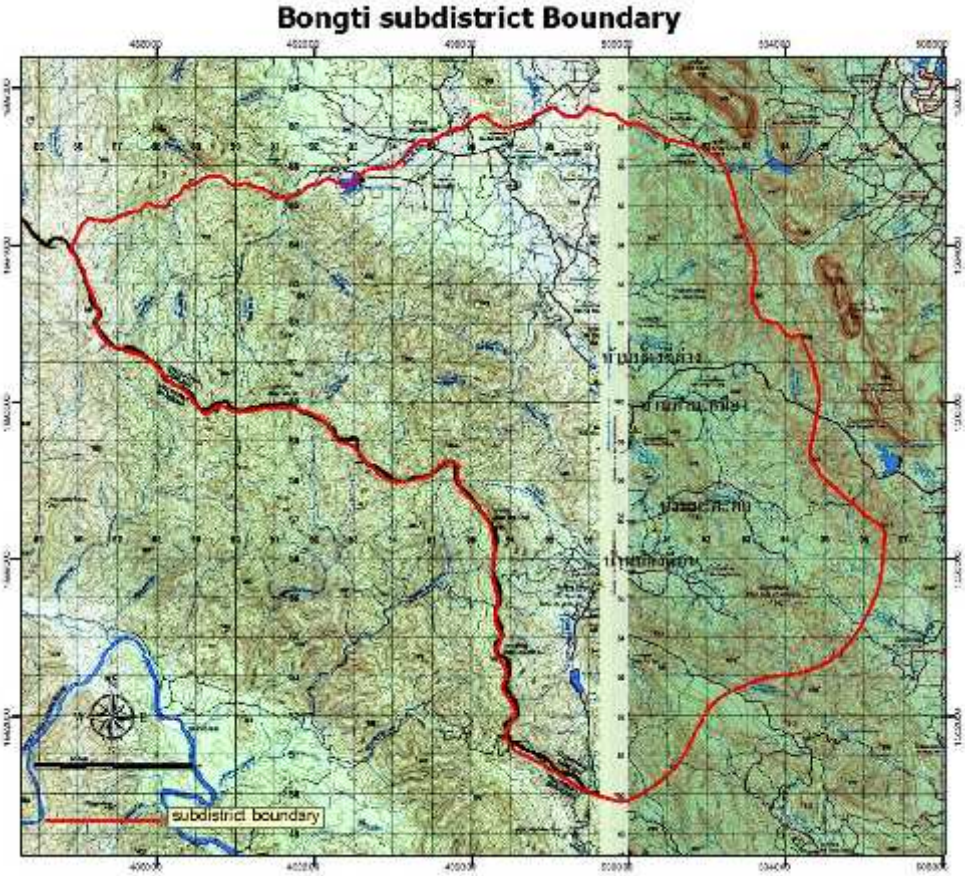


Figure 12 Topography of Ban Bongti Lang

Table 7 Land cover and Land use in 4 villages selected area (Hectare, ha)

Land types	Sai Yok cluster, Ban Bongti Lang	Suan Phueng cluster, Ban Huay Phak	Tanaosri cluster, Ban Bohwee	Ban Bueng cluster, Ban Huay Makrud
Evergreen forest	2,982.634	2,413.578	1,115.090	359.030
Mixed deciduous	2,187.66	2,947.57	3,611.904	133.703
Forest bamboo forest	25.133	166.949	274.498	0.000
Perennial area	35.642	22.129	9.697	12.253
Cultivated Land	1,269.190	525.980	425.170	894.752
Orchard	114.929	36.279	69.445	15.971
Urban area	27.599	21.905	8.475	28.477
Water bodies	5.535	21.369	9.272	21.417
Other area	5.165	0.000	0.000	4.603
Total area	**6,653.490**	**6,155.759**	**5,523.551**	**1,470.206**

7.1.5 River and water for Agriculture

Main River in Ban Bongti Lang is Huai Bongti. It originates in the Mountains on the Thai-Myanmar border. It passes through this village and joint the Kwae Noi river at Sai Yok districts **(**see **Figure 12).**

Rainfall is the major source for crop cultivated in this village, no irrigation water system. There are 3 weirs and 1 pond in the village but now 2 weirs is not working, water from another weir is not for agriculture. It is for consume or make pipe water. From the available water sources in the village it can be highlighted that the prevailing water resource system is not used for agricultural activities.

7.1.6 Agriculture and livelihood (past and present)

Ban Bongti is the Karen community who was migrated from Myanmar to this area during Second World War. In the past, agricultural system is shifting cultivation included Upland Rice, Cotton and local Maize or native Maize that grow it in the mountain range. Agriculture production is for consume in the household and exchange goods in the community and between communities. Rain-fed is the main water resource for agriculture. In the present, agricultural system are Maize, Cassava, Upland rice, Pineapple and Para rubber. Maize is the old crop in the area and expanded area very much in the year 1985. Cassava is start take planting in the village in the year 2001 and expanded area very much in the year 2006. Para rubber is introduced to this village in the year 1998. Beyond, some farmer has Para rubber intercrop with Maize. Almost crop for sale except upland rice is for household consume. Land for agricultural cultivation, People is no certificate of ownership but they only use it utilization. Average agricultural land is 0.8-3.2 ha.

7.1.7 Ecosystem services and livelihood

Ecosystem in this village is covered by dry evergreen forest and mixed deciduous forest of Sai Yok National Park in the Western part. Some of the forest resources present included mushrooms, bamboo and bamboo shoots. It was found that most people rely on the resources from forest for livelihood. While most people harvest forest resources for subsistence, others collect forest products for income generation. Some Non timber forest products (NTFP) are present in the forest and can be harvested at every time in the year while others are seasonal. Bamboo shoots and mushrooms for example are harvested only during special periods of the year when they flourish. Some people use the forest for gathering various types of vegetables and collects fuel wood from the forest.

7.1.8 Key climate concerns

Impacted of current climate threat or climate variability in the long time at Ban Bongti lang to livelihood and crop production can classify to 4 climate concerns; 1)Dry spells in the rainy season, 2)climate variation, 3)flood and 4)rain storm.

Dry spell Rainy season in this area started from April to the end of October in the past. Now, It has stating rainfall in middle March to the end of October. But rain day is less than in the past and in some year has dry spell during July to August or September. Dry spell in the rainy season is affected to growth and crop yield which is depend on dry spell level, type of crop and crop growth period. Upland rice is risk to lack of water during reproductive period (flowering to grain filling) and maize is risk to lack of water or sensitive during flowering to fertilization.

Rainfall fluctuation Rainfall is vary from year to year. Rainfall pattern is not regulation or not normal like in the past which is affected to time of crop planting and increasing risk of crop failure or decreasing crop yield. Usually forest fire is occurring every year because forest in the village is dry evergreen forest. But in some year which has more rainfall in March and April. It is no forest fire in that year such as in the year 2010 and 20111.

Flood Flooding in this area is flash flood from the mountain near Myanmar border which is only occurred in short time 1-2 days in the decade. It is usually occur in October during heavy rain period. It is affected to building of people and road in the community.

Rain storm Rain storm is occurred in dry season on March every year. It is damaged building or infrastructure of people such as the roof of house.

7.1.9 Current climate risk

Current climate risk in Ban Bongtilang is included 3 climate risks; 1) forest fire 2) rain storm and 3) flash flood (Figure 13)

Forest fire in this area is the same medium high impact from the past to present but it is less frequency.

There is no change in rain storm frequency, but with lower impact than the past.

Flashflood flash flood is less frequent with lower impact than the past.

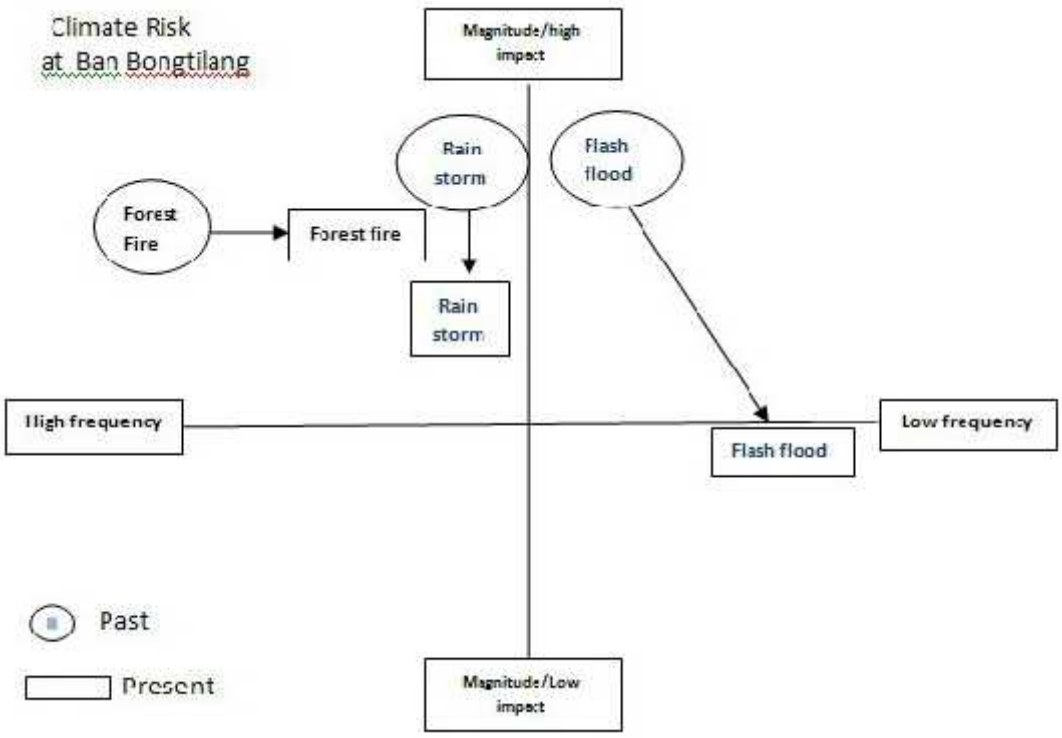


Figure 13 Current Climate Risk in Ban Bongtilang

7.2 Suan Phueng cluster, Ban Huay Phak, Suan Phueng sub district, Suan Phueng district, Ratchaburi Province

7.2.1 Topography

Ban Huay Phak is one of seven villages of Suan Phueng sub district, Suan Phueng district, Ratchaburi Province, is in Sai Yok cluster **(Figure 14).** It is distance approximately 68 kilometers from Ratchaburi and 15 kilometers from Suan Phueng district. Total land cover area of 984.92 hectares.

The village is situated inside the protected area of Princess Sirindhorn Natural Study Center. The topography is mountainous covered by mixed deciduous with bamboo, mixed deciduous forest and bamboo forest.

7.2.2 Population

Total population in Ban Huay Phak is 1,898 people ,747 household (2010), average household size of 2.54.

The majority of the populations in this cluster are of Thai ethnicity and Karen (68 and 36 percentage respectively).

7.2.3 Income

The average monthly household income was 8009.18 Baht or 37,838.62 Baht per head per year (CD,2011); 39.5, 27.9 and 32.6 percent of people has household monthly income less than 5,000 5,000-10,000 and more than10,000 baht respectively(IPSR, 2007 sited in ADB TA 6289 report, 2008).

7.2.4 Land cover and use

The land in this village is mostly coved by forest which may either deciduous or mixed with bamboo. However land for agriculture also forms an extended area in the valley. Some common crops cultivated include sugar cane; cassava, maize, and mixed field crop (cassava intercrop with maize) (see **table 7 and Figure 3**). The amount of land allocation for agriculture accounts for only about 8.55 percent, or 525.98 hectares. The land cover under water bodies is about 21.369 hectares (0.35%) and this highlights the scarcity of water. Residential area includes only about 21.905 hectares (0.36 %).

In the year 2010, Total crop area are 377.6 Ha; Sugar cane amount 112 Ha., Maize amount 16 Ha., Cassava amount 24 Ha., Pineapple amount 1.6 Ha., Para and another horticulture amount 224 Ha(DOAE,2010) . Farmer in this village has land for cultivation is range 0.69-1.98 Ha (average 1.49 ha.). However, In that land, farmer is only using it utilization but no ownership (Por bo tor 5). Because it is land of Treasury Department which is take care of Thai Royal Army under nation stability law year 2481.

7.2.5 River and water for Agriculture

Main river in Ban Huay Pak is Huay Pak river. It originates in the mountains and creeks that are located at the mountains on the Thai-Myanmar border. It passes through central this village and joints the Pa chi river at Ban Bo, Suan Phueng district. (see **Figure 13**).

Rainfall is the major source for crop cultivated in this village, no irrigation water system. There are 1 weirs and 1 waterfall for making mountainous pipe water. And have 2 reservoirs; Houy Pak and Tepprathanporn reservoir. They only are for making village pipe water. From the available water sources in the village it can be highlighted that the prevailing water resource system is not used for agricultural activities.

7.2.6 Agriculture and livelihood (past and present)

Ban **Huay Phak** is the Karen community who was migrated from Myanmar to this area during Second World War. They came here to work in the tin mine in the year 1925. In the past, agricultural system in this village is shifting cultivation included upland Rice and local Maize for subsistence in the mountain range. Some people made charcoal occupation (wood burning). In the year 1985, Thai government had close forest policy. The tin mine closed suddenly in that year. Karen farmer cannot cut the forest and burning it. Karen is expanded area very much to grow Maize (improved variety). Agricultural system is changing to grow Maize 2 times a year. Because of climate variation, serious drought is affect to growth and maize yield. Farmer brings cassava and sugarcane to grow it's in the area in the year 2005. Because it's is drought tolerance than maize. Agricultural system includes sugarcane, cassava and maize. Anyway, some farmer are still grow upland rice in the foothills in some year for consume in the household. Rain-fed is the main water resource for agriculture. Land

for agricultural cultivation, People is no certificate of ownership but they only use it utilization. People have to rent it from Treasury Department for cultivation.

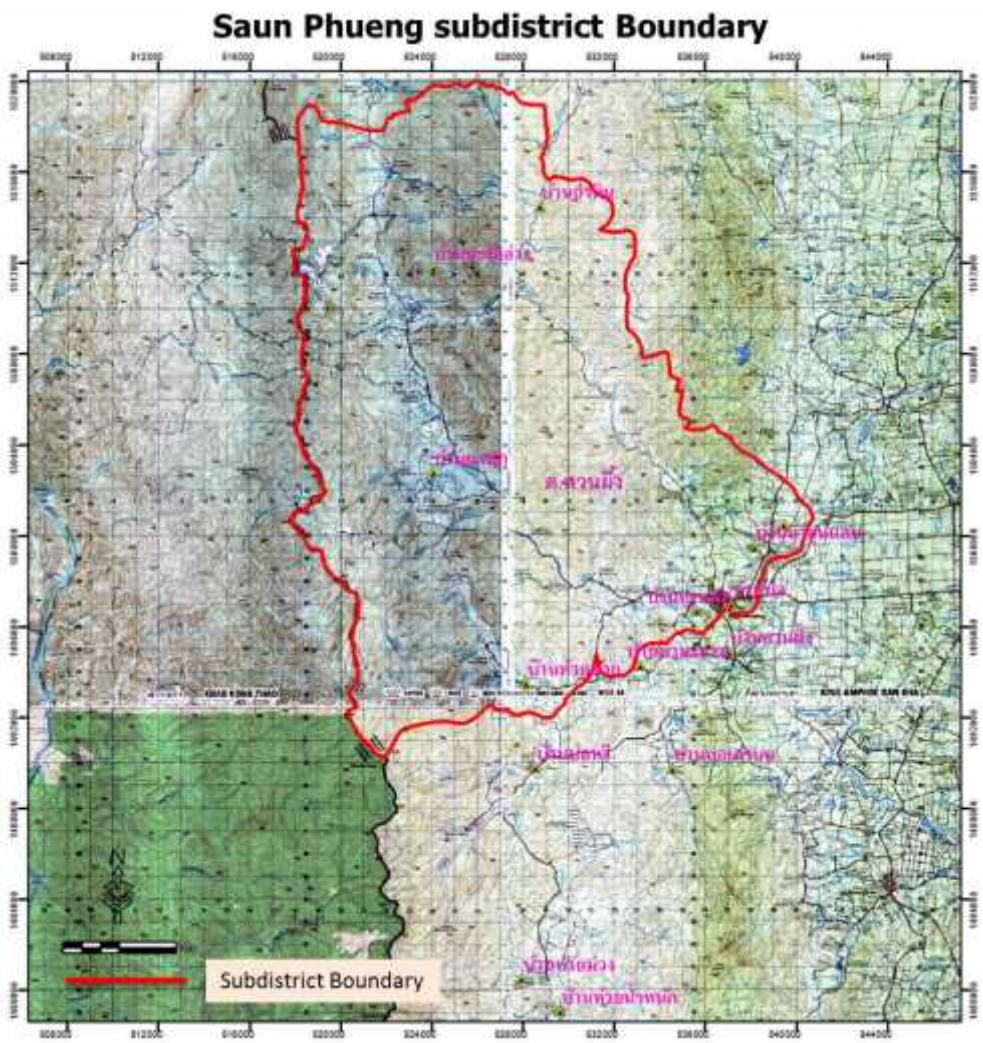


Figure 14 Topography of Ban Huay Phak

7.2.7 Ecosystem services and livelihood

Ecosystem in this village is covered by mixed deciduous with bamboo, mixed deciduous forest and bamboo forest in the West part. The forest is located of Princess Sirindhorn Natural Study Center. This area has Koajon waterfall which has water around year. It is original from Pulakka Mountain.

Some of the forest resources present included mushrooms, bamboo, bamboo shoots, Pakwanpa (*Melientha suavis Pierre*) and Pakkood(*Diplazium esculentum*). Mushroom is well known is Headkon (Termitomyces fuliginosus Heim). Most people rely on the resources from forest for livelihood. While most people harvest forest resources for subsistence, others collect forest products for income generation. Some Non timber forest products (NTFP) are present in the forest and can be harvested at

every time in the year while others are seasonal. Bamboo shoots and mushrooms for example are harvested only during special periods of the year when they flourish. Some people use the forest for gathering various types of vegetables and collects fuel wood from the forest.

7.2.8 Key climate concerns

Impacted of current climate threat or climate variability in the long time at Ban Huay Phak to livelihood and crop production can classify to 5 climate concerns; 1)Dry spells in the rainy season, 2)climate variation, 3)flood 4)rain storm and 5)heat weave.

Dry spell Rainy season in this area started from April to the end of November in the past. Now, Rainfall pattern is changed, It is shift from April to in middle February to the end of October. But rain day is less than in the past and in some year has dry spell during June to August. Dry spell in the rainy season is affected to growth and crop yield which is depend on dry spell level, type of crop and crop growth period. Upland rice is risk to lack of water during reproductive period (flowering to grain filling) in November and maize is risk to lack of water or sensitivity during flowering to fertilization (June to July).

Rainfall fluctuation Rainfall is vary from year to year. Rain fall is not regulation or not normal like in the past which is affected to period to crop planting and increasing risk of crop failure or decreasing crop yield. Usually, season for harvesting Headkon is one times a year in the end September to early October. In the year which abnormal rain like this year (2011). Headkon is often occurred (3 times) but it is low yield. Usually wildfire occurs in the forest every year because it is dry evergreen forest. In some year, no wildfire occurs in the dry evergreen forest because it has rainfall in February or March such as in the year 2010 and 20111.

Flood Flooding in this area is flash flood from the mountain near Myanmar border which is only occurred in short time in 1 day and 2 times in 10 year. It is usually occur in August-September during heavy rain period. It is affected to building of resort and road. Especially, flash flood is damaged 4 resorts and 1 building is collapse in the year 2010.

Rain storm Rain storm occurs in dry season on March or April. It affects building such as the roof of house and tree e.g. it causes banana tree to fall down.

Heat wave Air temperature in during March and April (summer) in this area is higher than in the past. It is affected to mental health and tiredness.

7.2.9 Current climate risk

Current climate risk in Ban Huay Pak is included 4 climate risks; 1) cold temperature 2) high temperature 3) rain storm and 4) flash flood (Figure 15)

Cold temperature, temperature in winter is not as cold as the past with less cold day, while the hot period is longer.

Flash flood in this area increase its impact from the past to present but with same frequency.

Rain storm has higher impacted and frequency than the past.

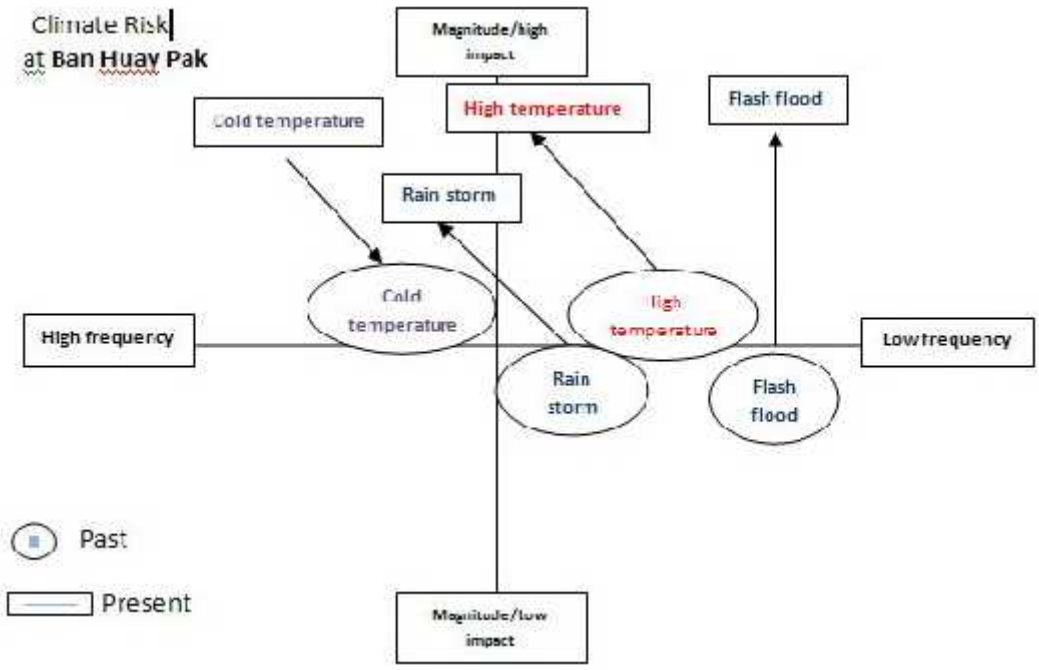


Figure 13 Current Climate Risk in Ban Huay Pak

7.3 Tanaosri cluster, Ban Bohwee, Tanaosri sub district, Suan Phueng district, Ratchaburi Province

7.3.1 Topography

Ban Bohwee is one of seven villages of Tanaosri sub district, Suan Phueng district, Ratchaburi Province, is in Tanaosri cluster **(Figure 16**). It is distance approximately 75 kilometers from Rachaburi and 20 kilometers from Suan Phueng district. Total land covers area of 5523.551 hectares.

The village is situated inside the protected area of Queen Sirikit Indigenous Plant Study Center and Princess Sirindhorn Natural Study Center. The topography is mountainous covered by mainly mixed deciduous with bamboo, mixed deciduous forest and bamboo forest. These cover 1,115.09 ha (20.19 percent), 3,611.904 ha (65.39 percent), and 274.498 ha (4.97 percent) respectively.

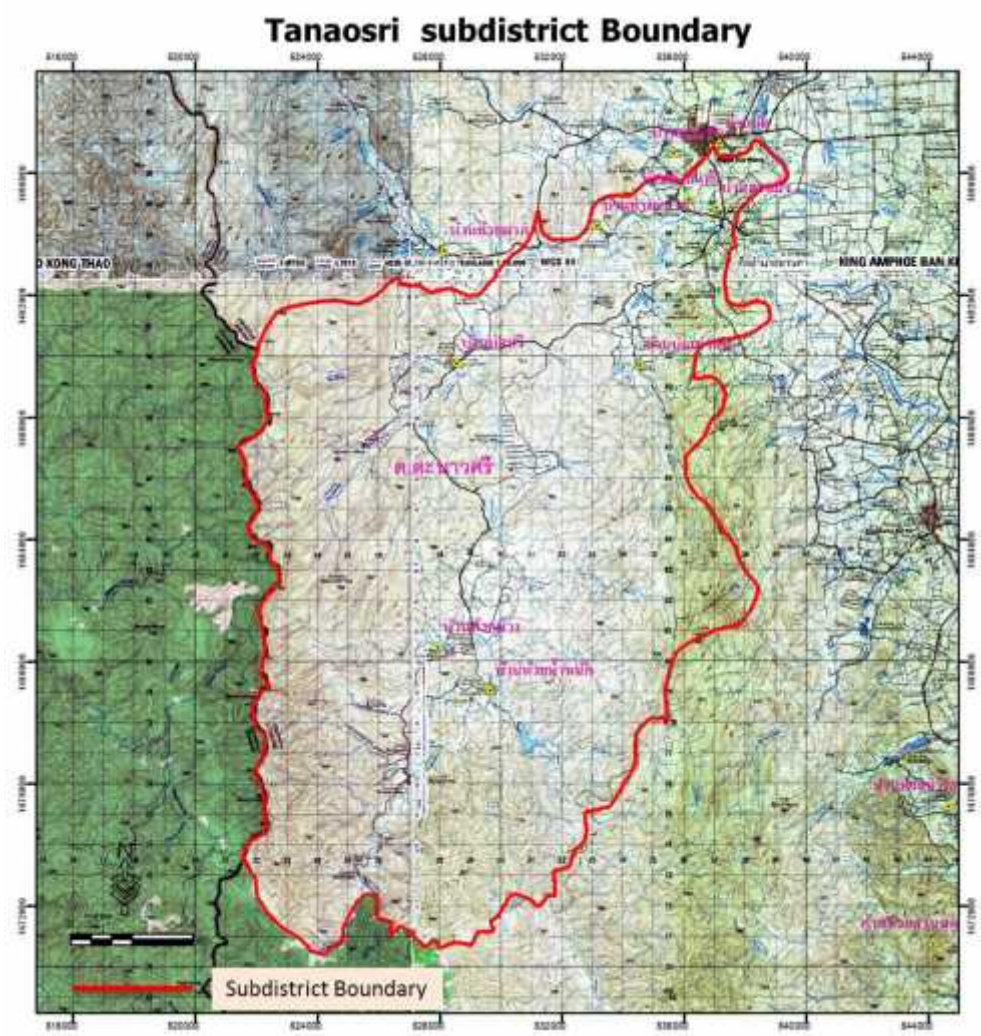


Figure 16 Topography of Ban Bohwee

7.3.2 Population

Ban Bohwee has population 1,570 people, 345 household (2011), average household size of 4.5. The majority of the population in this cluster are of Thai ethnicity (57.39 percentage) while another (42.61 per cent) were identified as consisting of Thai Karen.

7.3.3 Income

The average monthly household income was 9,697.50 Baht or 33,248.60 Baht per head per year (CD,2011); 39.5, 27.9 and 32.6 percent of people has household monthly income less than 5,000 5,000-10,000 and more than10,000 baht respectively(IPSR, 2007 sited in ADB TA 6289 report, 2008).

A majority of households in Ban Bohwee harvest forest resources for subsistence and income generation. Some households also use forest resources for income generation throughout the year, while others only harvest during a particular season. About 60 percent of households in this village harvest bamboo for Basketry

gathered all year round and bamboo shoot during September. And about 79 percent gather mushrooms from the forest.

7.3.4 Land cover and use

The land in this village is hilly plain and mostly coved by forest which may either deciduous or mixed with bamboo. However land for agriculture also forms an extended area in the valley. Some common crops cultivated include cassava, maize, sugarcane, upland rice, mixed orchard (Banana and Mango) (see **Table 7 and Figure 3)**. The amount of land allocation for agriculture accounts for only about 7.70 percent of total area, or 425.17 hectares. In the year 2010, Ban Bohwee has the total land used for agricultural 148.80 Ha; cassava amount 86.24 Ha., Sugarcane amount 24.64 Ha., Maize amount 12.32 Ha and mixed orchard amount 25.60 Ha (DOAE,2011).

The land cover under water bodies is about 9.272 hectares (0.17%) and this highlights the scarcity of water. Residential area includes only about 8.475 hectares (0.15 %). Land ownership, Farmer in this village like farmer another village in the cluster, Farmer has only workplace 140 household (41%) for cultivation 2.32 Ha. and for household settlement 0.08 Ha. That workplace was arranged by Thai Royal Army for move Karen ethnic from the mountain to lowland in the year 1989. Other people are no land for workplace. People can rent a land for cultivation from Treasury department.

7.3.5 River and water for Agriculture

Main River in Ban Bohwee is Huai Bohwee and Huai Kokmoo. It originates in the mountains and creeks that are located at the mountains on the Thai-Myanmar border. It passes through the North of the village and joint the Pachi river at Ban Tungkula, Suan Phueng district (see **Figure 16**).

Rainfall is the major source for household's drinking water and crop cultivation in this village, no irrigation water system. There is 1 weir in Huai Bohwee and 1 reservoir in Huai Kokmoo. Water from weir used in the household and Water from reservoir is for make pipe water. From the available water sources in the village it can be highlighted that the prevailing water resource system is not used for agricultural activities.

7.3.6 Agriculture and livelihood (past and present)

Ban Bohwee is the Karen community who was migrated from Myanmar to this area in the year 1958. In the past, agricultural system is shifting cultivation included Upland Rice, Cotton and local Maize in the mountain range. Agriculture production is for consume in the household and exchange goods in the community. Rain-fed is the main water resource for agriculture. In the year 1989, Thai government under working of Thai Royal Army emigrant Karen household from mountain to a plain in the valley and arrange land for habitat and cultivation. Upland rice system disappears from the farming system of community. In the present, agricultural system is Maize, Cassava, sugarcane, Pineapple, Para rubber, Palm oil. People from outside village rent a land to grow Pineapple, Para rubber and Palm oil in two year ago. Sugarcane just

introduces to grow in last two year. Land for agricultural cultivation, People is no certificate of ownership but they only use it utilization. Only 140 household has area for cultivated area, amount 2.32 ha per household.

7.3.7 Ecosystem services and livelihood

Ecosystem in this village is covered by forest which consists of mixed deciduous forest with bamboo, mixed deciduous forest and Bamboo forests. It located in the protected areas of Queen Sirikit Indigenous plant study center.

A majority of households in ban Bohwee harvest forest resources for subsistence and income generation. Sixty percent of households use forest resources for income generation throughout the year. They harvest bamboo for basketry, while others only harvest during a particular season. Bamboo shoots and mushrooms are gathered during rainy periods of rain, and bamboo is gathered all year round. People gather various types of vegetables and dead wood for household consumption as well as for sale.

7.3.8 Key climate concerns

Impacted of current climate threat or climate variability in the long time at Ban Bohwee to livelihood and crop production can classify to 3 climate concerns; 1) Dry spells in the rainy season, 2)climate variation, 3)rain storm.

Dry spell Rainy season in this area started from April to the end of October in the past. Now, it starts to rain in middle March to the middle of November. But rain day is less than in the past and in some years there is dry spell during June to August. Dry spell in the rainy season affects to growth and crop yield, which is depend on dry spell level, type of crop and crop growth period. Maize is risk to lack of water and highly sensitive if dry spell occurs during flowering to fertilization period in rainy season.

Climate variation Rainfall fluctuates from year to year. Rainfall pattern is not regulation or not normal like in the past which is affected to timing of crop planting and increasing risk of crop failure or decreasing crop yield. Usually wildfire occurs every year because it is dry evergreen forest. It has had rainfall in March since 5 year ago until now. It has effected to humidity in the forest and no wildfire in Ban Bohweee since five year. In some years, it affected water capital for village pipe water during dry season (March and April) where they use water from Bohwee waterfall to feed pipe water system.

Flood Flooding in this area is flash flood from the mountain near Myanmar border or Tanaosri range which is only occurred in short time 1 day a year and 2 year in the decade. It is usually occur in rainy season in September or October. It is affected to road and residence of people (home) which live near Bohwee River. Flash flood has a trend increasing violence.

Rain storm Rain storm is occurred in April or dry season. It is frequency 2 times in 10 year and has a trend increasing violence if compared in the past. It is damaged home and crop.

7.3.9 Current climate risk

Current climate risk in Ban Bohwee is included 3 climate risks; 1) forest fire 2) high temperature and 3) flash flood (Figure 17)

Forest fire in this area is rather higher impact from the past to present but it is same frequency.

High temperature, average annual temperature hotter than the past with more hot day.

Flash flood in this area is higher impacted from the past but it is the same frequency.

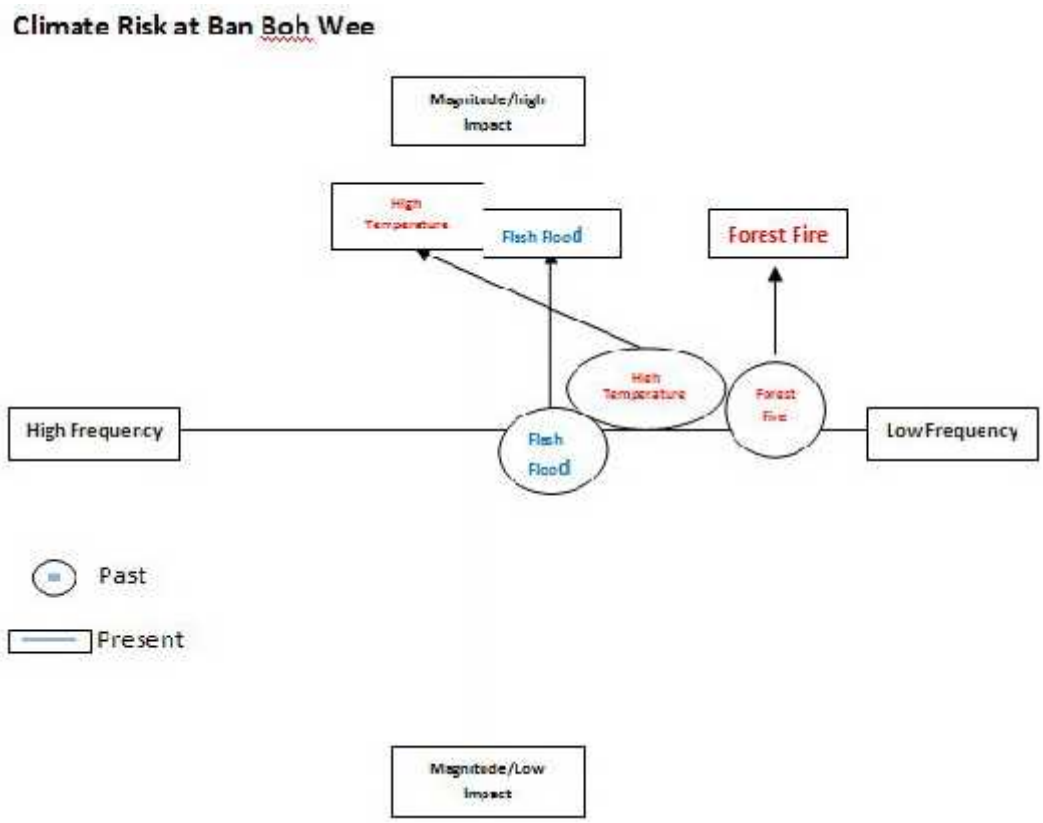


Figure 17 Current Climate Risk in Ban Bohwee

7.4 Ban Bueng cluster, Ban Huay Makrud, Ban Bueng sub district, Ban Bueng district, Ratchaburi Province

7.4.1 Topography

Ban Huay Makrud is one of thirteen villages of Ban Bueng sub district, Ban Bueng district, Ratchaburi Province, is in Ban Bueng cluster (**Figure 18**). It is distance

approximately 89 kilometers from Ratchanaburi and 20 kilometers from Ban Bueng district. Total land covers area of 1,470.206 hectares,

The village is situated close the Chalern Phrakiet Thai Prachan National Park, this is restricted forest land. The South of Ban Huay Makrud is mountain range in the Chalern Phrakiet Thai Prachan National Park. Topography of the village is plain and has slope from the South to the North. The mountainous covered by mixed deciduous and dry evergreen forest with bamboo.

7.4.2 Population

Ban Huay Makrud has population 484 people, 116 household (2011), average household size of 4.2, is a lesser population than other three villages in the cluster. The majority of the population in this cluster are of Thai ethnicity (94.59 percentage) while the others (10 per cent) were identified as consisting of Karen (3.37 per cent) and Mon (2.03 per cent) (CD, 2011).

7.4.3 Income

The average monthly household income was 20,014 Baht or 60,042.40 Baht per head per year (CD,2011); 39.5, 27.9 and 32.6 percent of people has household monthly income less than 5,000 5,000-10,000 and more than10,000 baht respectively(IPSR, 2007 sited in ADB TA 6289 report, 2008).

7.4.4 Land cover and use

Land use in Ban Huay Makrub is mostly used for agriculture. Major crop include pineapple, vegetables, cassava, and orchard. (see **Table 7 and Figure 3**). Data of DOAE in the year 2010, shown total land for agriculture is 528.8 Ha; the planted area of pineapple, cassava and vegetable is 385.92, 16, 24 hectare respectively. The amount of land allocation for agriculture accounts about 61 percent of total village areas, or 894.752 hectares. Ban Huay Makrub has the highest land used for cultivation in Ban Beung cluster while the lowest in Ban Pong krathing (391.458 Ha.).

The land cover under water bodies is about 21.417 hectares (1.46%) and this highlights the scarcity of water. Residential area includes only about 28.477 hectares (1.93 %).

7.4.5 River and water for Agriculture

Main river in Ban Huay Makrud is Huai Makrud and Pong kathing. It originates in the Mountain and creeks that are located at Chalern Phrakiet Thai Prachan National Park or the Mae Prachan mountain ridge (see **Figure 18).**

Rainfall is the major source for crop cultivated in this village, no irrigation water system. Nevertheless, some farmer used water from creeks or small natural water resource and Huay makrud reservoir for vegetable cultivation by water pump. There are 1 weir in Pong Kathing River and 1 reservoir in Huay Makrud River. Water resources from weir and reservoir are mainly for village water pine.

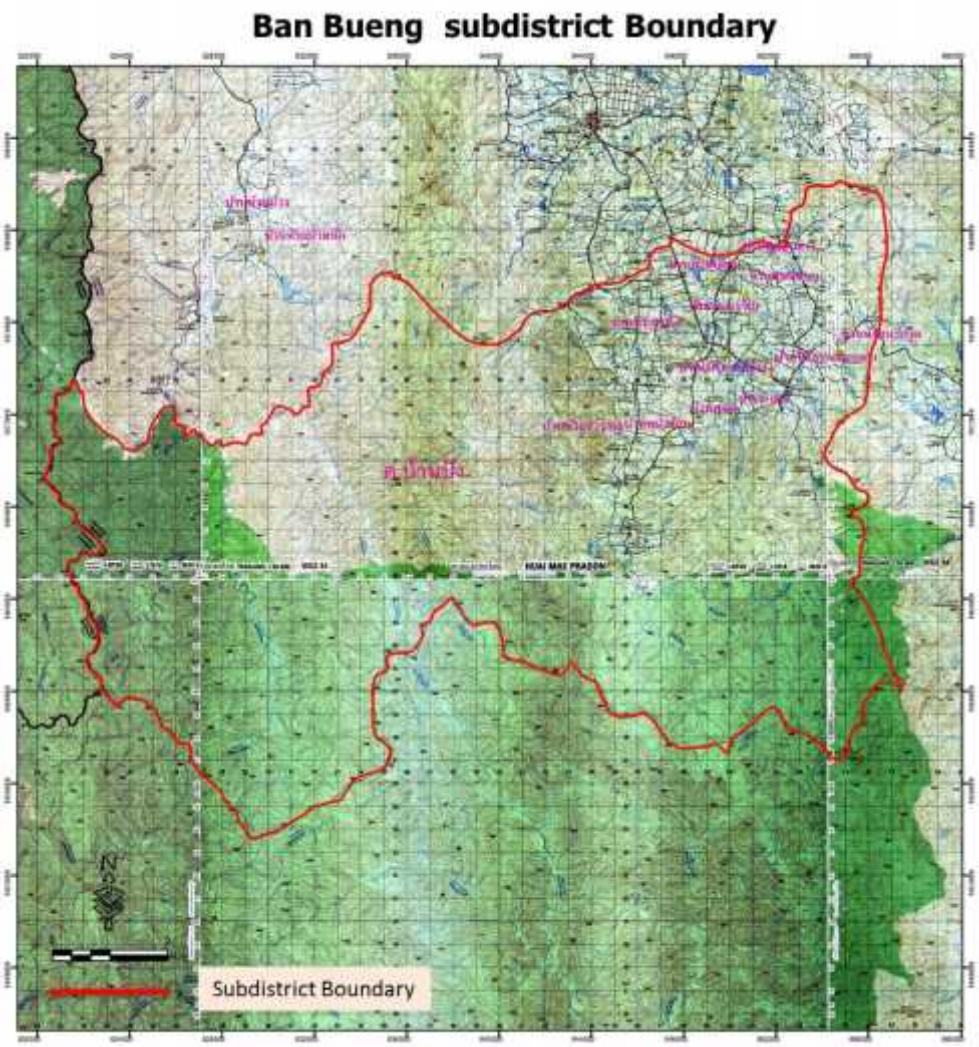


Figure 18 Topography of Ban Huay Makrud

7.4.6 Agriculture and livelihood (past and present)

Ban Huay Makrud was established 20 years ago. It separated from Ban Pong kathing. The people mostly consist of Thais and minority Karen and Mon ethnic. Minority Ethnic came from Myanmar. Upland rice, Maize and Cotton were the crops that were cultivated when the people originally settled in this area. Agriculture production is for consume in the household and exchange goods in the community. The tradition mixed cropping of the Karen has been changed due to climate change and market driver (market conditions). Crops such as pineapples, cassava and vegetables constitute a major source of subsistence for the people in this village and this cluster. Rain-fed is the main water resource for field crop agriculture. Creeks' water or small natural water resource and Huay makrud reservoir is resource for vegetable cultivation, they are used it by water pump.

Pineapple is introduced to grow for eat in this area in the year 1977 and grow for industry since the year 1985. Farmer grow vegetables for sale it at Srimuang market, Ratchaburi Downtown since the year 2001.

7.4.7 Ecosystem services and livelihood

Ecosystem in this village is covered by dry evergreen forest which consists of mixed deciduous forest, mixed deciduous forest with bamboo and Bamboo forest of the Chalern Phrakiet Thai Prachan National Park in the Southern part (Chalern Phrakiet Thai Prachan National Park was established in 2003). Non timber forest products (NTFP) include bamboo, bamboo shoot, mushroom, vegetable and herbs.

After Chalern Phrakiet Thai Prachan National Park was established, People in this village is restricted access to harvest NTFP because it actually against the law. However, people can harvest forest product in August such as bamboo for make crop stand and bamboo shoot for subsistence. Some Karen are harvest herbs, mushroom and honey bee in the dry season for subsistence.

7.4.8 Key climate concerns

Impacted of current climate threat or climate variability in the long time at Ban Huay Makrud to livelihood and crop production can classify to 4 climate concerns; 1)Dry spells in the rainy season, 2)climate variation, 3)flood and 4) rain storm.

Dry spell Rainy season in this area started from April to October in the past. Now, It has stating rainfall in middle March to the end of November. But rain day is less than in the past and in some year has dry spell during June to August. Dry spell in the rainy season is affected to growth and crop yield which is depend on dry spell level, type of crop and crop growth period. Upland rice is risk to lack of water during reproductive period (flowering to grain filling) and maize which grow in the early rainy season is risk to lack of water during flowering to fertilization.

Climate variation Rainfall is variable from year to year. Rainfall pattern is not regulation or not normal like in the past which is affected to time of crop planting and increasing risk of crop failure or decreasing crop yield.

For NTFP, climate variation is effected to season of Hed Kon mushroom booming (Termitomyces fuliginosus Heim). Time for harvested Hed Kon mushroom is changed from 2 times in August and during the end of September-middle October to 3-4 times in rainy season but it is low yield

Usually forest fire in this area occurs every year because it is dry evergreen forest. But it is no forest fire because it has rainfall in March- April since 2001.

Flood Flooding in this area is flash flood from the mountain in Thai Prachan National Park (Tanaosri range) which is only occurred in short time 1-2 days in each year. It is usually occur in October during heavy rain period. It is affected to vegetables near Huay Makrud River and canal. The vegetable area was damage 9.6 Ha. in year 2010.

Rain storm Rain storm is occurred in dry season on March or April. It is frequency 1-2 times per year in the past and change to 4-5 times per year. It is trend to increase and vegetables more damaged than in the past.

7.4.9 Current climate risk

Current climate risk in Ban Huay Makrud is included 3 climate risks like Ban Bohwee; 1) forest fire 2) high temperature and 3) flash flood **(Figure 19)**

Forest fire in this area is rather high impact than the past to present but it is same less frequency.

High temperature, average temperature in yearly is hotter in the past or has more hot day.

Flash flood in this area is higher impacted from the past but it is the same frequency.

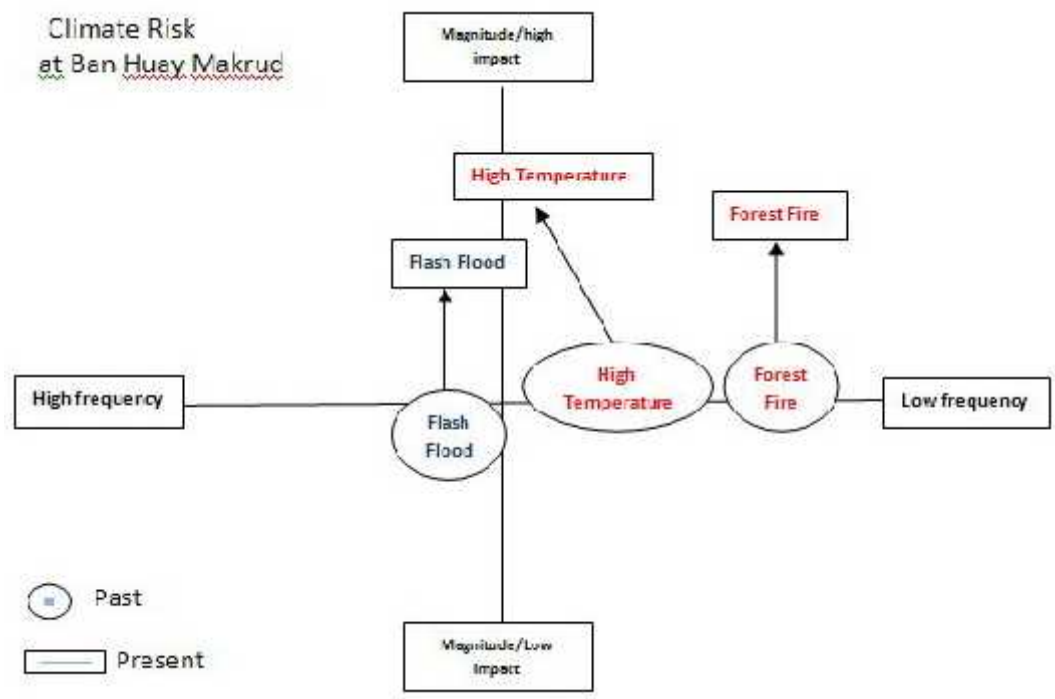


Figure 19 Current Climate Risk in Huay Makrud

8. Current climate risk in BCI Tenasserim

Current climate risk or hazard in the BCI Tenasserim in Thailand is different in each location from Sai Yok cluster to Ban Bueng cluster. It is concluded overall the main of climate risk in this areas can classify in 5 categories. (**Figure 20**)

1. Forest Fire

In the past, forest fire in BCI site is often occurred in Forest on the mountain during in March and April every year. Shifting cultivation is the main system in this area. Farmer has to prepare land by cutting tree and weed and burn it before planting crop in the next season such as upland rice, local maize and cotton. In the present, although in this area is restricted to do shifting cultivation but 71.1 percentage or 82,080.1 ha of land type is mixed deciduous forest and mixed deciduous with bamboo and bamboo forest. It is high risk to occur forest fire. Information from villagers, Phenomena of forest fire is not often than in the past but it is more impact to community and orchard area than in the past.

2. Flash Flood

Flash flood in BCI in BCI site is only occurred in the short time 1-2 times in two decade in the past. Flash flood has trend to increase and impact to infrastructure of community (house and resort). It is occurred 1-2 times in the last decade. Causes of flash flood are; 1) area of forest is less than in the past 2) increasing of field crop areas such as maize and cassava 3. Rainfall has trend to increase.

3. High Temperature

In the summer, temperature is higher than in the past. High temperature is affected to mental health of human (often lose temper or moody) and effected to quality of pineapple. High temperature is trend to increase than in the past decade.

4. Low Temperature

Observation of villagers, winter season in the present is shorter than in the past and no winter season in some year. They are no wear coat in winter. Besides it is effect to quality of vegetable in the winter such as cabbage, Chinese cabbage and broccoli e.g.

5. Rain Storm

Rain storm is occurred in dry season o March or April every year but it is little effect to community in the past. Information from the area, rain storm has trend to increase and more impact to infrastructure and crop damage more than in the past. (e.g. maize and banana fall disorderly).

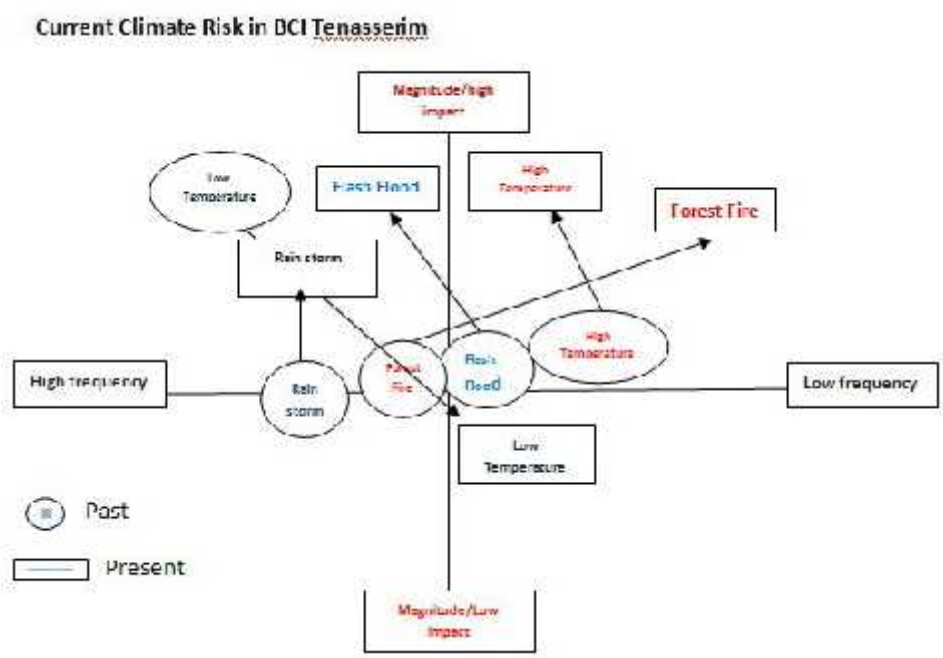


Figure 20 Current Climate Risk in BCI Tenasserim

9. Key climate concerns in BCI Tenasserim

The study area is influenced by tropical monsoon characteristic Savanna type. Rainy season starts in April and extends to October, with heavy and frequency rains

from September to October. Dry spell conditions during June to July. Winter starts in November to January and hot dry period from March to April. In BCI tenasserim pilot site has 2 weather stations; 1) weather station K10 at Ban Lum Sum near Bongti sub district in the northern section of BCI (Sai Yok cluster) and 2) Weather station K25 at Ban Ka in Ban Bueng district or the southern section of BCI (3 clusters in Ratchaburi Province). Weather data from the year 1996 to 2010, average precipitation of K10 is 1,238.5 mm per year while average precipitation of K25 is 1,193.6 mm per year. Rain day of K10 is 127 days and K25 is 131 days. Day time temperature is reaching 5.8-43.0^{O}C and 5.0-45.5^{O}C at K10 and K25 respectively.

Observing irregular climate variation by people in BCI site study: 1) shifting in rainy season, rainy season is starting faster than in the past 2) Rainfall in the end rainy season less than in the past 3) rainstorm is stronger wind and often during March and April, which incurred some damage crop and house's roofs 4) Dry spell during rainy season (June-August) 5) Climate more variation, Rainfall pattern is not the same pattern that is more fluctuate which farmer is difficult to manage cropping season e.g. when is time to start growing crop? 6) Warmer weather, in the recent years, cold weather in the winter is not occur or litter cold or some year they have not to wear a coat. High temperature in dry season (March to May), high temperature is effected to heat stress to human and animal and influence to mental health. And 7) Light intensity in the recent is more than in the past.

Major climate risks in the study area are drought and floods, which have direct impacts on crop productivity, human health and NTFP collection. In general, BCI Thailand site is located in the valley that cultivation land is in the slope of mountain or higher elevation faces more risk of drought and has a little plain.

Summary, Key climate concerns in BCI tenasserim site can classify 2 groups: 1) Agricultural system and 2) Community

9.1 Agricultural system

Climate concern in agricultural system related with 6 crops. e.g. upland rice, cassava, Maize, sugarcane, pineapple and vegetables.

Upland rice; 1) Dry spell occurs during June to August and in October in some year. Rice might face water shortage during panicle initiation (PI) which effected to rice yield. 2) More rainfall at harvesting time in November (Ban Bongti, Sai Yok cluster). It is effected to rice yield damage that caused by fungi.

Cassava; 1) Dry spell during March-June and August-September that cassava aphis is spread; it is affected to growth and cassava yield very much. 2) More rainfall in October, cassava root is decay especially cassava which is plant in the low land or plain.

Maize; 1) Dry spell during June to July between maize has flowering and silky. It is effected to almost loose or low yield. 2) More rain at harvesting time (August-September): Fungi are attack to maize seed and rotten seed.

Sugarcane; 1) Dry spell during June to August, it is loss yield 50 percent of normal yield. 2) Dry-forest fire, it is risk to forest fire which occurs in March and May especially in Ban Bongti lang.

Pineapple; 1) Dry season- height temperature and low humidity in March to May is caused of fruit burn and withered.

Vegetables; 1) Dry spell-vegetables are lack of water during August to September and dry season during February to May, they used water from canal but it is no water around year. 2) Flash flood during October, Vegetables is damage. e.g. Ban Huay Makrud case.

9.2 Community

Climate concerns in community can classify to 3 items; 1) infrastructure 2) human health and 3) NTFP harvesting

9.2.1 Infrastructure climate concern of infrastructure has 2 items; 1) flash flood in October has higher impact on infrastructure of people and resort that located near river bank. 2) Windstorm often occurs in April or May which incurred some damage roofs of house.

9.2.2 Human health Key climate concern in human health is relate with biological and mental health

Biological health; climate variation, hot and cool rapid change is stimulate human weak to attract disease. 1) Cold fever, child group is risk to cold fever more than other group. 2) Malaria, all group risk to malaria especially in the villages which has people are harvested something in the village and has people travel go and back Thai and Myanmar. 3) Diarrhea, this disease is occur in the dry season during March to May, child group high risk of diarrhea especially the village has water pipe that no hygienic system. 4) Dengue is spread in wet season; child group is risk of dengue

Mental Health; high temperature in dry season people each group is risk of mental health and hot fever.

9.2.3 NTFP harvesting Key climate concern in natural forest product is related quantitative, qualitative and timing of product.

Forest; 1) forest is risk to forest fire in March and April every year if no rainfall in February or March because forest type in this area is Mixed Deciduous forest with bamboo and bamboo forest. 2) Dry-rainfall variation, abnormal rainfall is impact to bamboo shoot booming and bamboo to make basket in the next year. e.g. Ban Bohwee case.

Hed Kon mushroom (Termitomyces fuligineosus Helm); climate variation is effected to Hed Kon reincamation or germination. Hed Kon mushroom's flower is occur unusually time. (Normal, it's flowering in October when abnormal year, it has flower two or three times in end of July, September and early October but it is low yield.

10. Current vulnerability of agricultural system and community in BCI Tenessarim

Vulnerability of agricultural system and community in the BCI Tenessarim is different from site by site **(Table 8 to 11).** Overall of vulnerability in this area is feature

vulnerability of agricultural system 8 vulnerabilities and vulnerability of community 3 vulnerabilities.

10.1 Current Vulnerability of Agricultural system

Upland rice is still plant in three clusters of BCI site except in Thanaosri cluster. Upland rice production area is exposure to dry spell period (June-August or October). Dry spell occurs approximately 2-3 year in the decade. Approximately 50- 100% of rice yield is damaged. Although farmer has many mechanisms to cope risk such as changed planting area, planting date, drought tolerance variety and grow many varieties in the area. But they unable forecast weather, these mechanism adaptations to cope risk is medium effectiveness. Upland rice system is still medium vulnerability.

Maize is planted in each clusters of BCI site twice a year, approximately 100% of maize production area is under dry spell risk and rainfall during harvesting which dry spell occurs approximately 4-5 year in the decade and rainfall during harvest occurs each year. 1st crop is risk to dry spell and rainfall during harvesting more than 2nd crop. Although farmer has many mechanisms to cope risk such as planted in the 2nd crop, used improved variety but many farmers is still planting maize 2 times a year. Also, maize system in BCI site is high vulnerability to current climate.

Cassava is planted in each clusters of BCI, approximately 100% of production area is under risk of cassava aphis that caused of dry spell. Approximately 20-50% of production area and yield is damaged. Although farmer has many mechanisms to cope risk such as expand spacing, growth it in the early month of year, used insecticide and restorative drug. But that mechanism is insufficient for cope the problem. Vulnerability of cassava system in the BCI site is medium vulnerability to climate change.

Sugarcane is only planted in three clusters of BCI site except Ban Bueng cluster. Approximately 60-100% of production area is under dry spell and 50% of production area is under forest fire risk in dry season. Dry spell and forest fire occurs approximately 2-3 and 8 year in the decade respectively. Approximately 30% of production area gets it yield average 50%. Farmer is coping capacity by grow it in early rain season and changed variety. That mechanism is insufficient for cope the problem. Sugarcane system in the BCI site is high vulnerability to climate change.

Pineapple is planted mostly in Ban Bueng with some areas in Suan Phueng and Tanaosri cluster of BCI site. Approximately 40-100 % of production area is under high temperature in dry season that caused of fruit burn and low yield. Mechanism adaptation by wrap a fruit with news paper and it leaf. It is found that mechanism is medium effectiveness for cope the problem. Pineapple system in the BCI site is medium vulnerability to climate change.

Vegetables is planted only in Ban Bueng clusters of BCI site, Approximately 35% of production area is under flash flood risk in October and flash flood occurs approximately 5 year in the decade. The production area is 100% sensitive to flash flood. Farmer is coping by avoid to grow it near river bank. That mechanism is still low effectiveness for cope the problem. Vegetable system in the BCI site is high vulnerability to climate change.

Bamboo shoot is only harvested in three clusters of BCI site, except Ban Bueng cluster. Approximately 50% of bamboo area is under dry spell/rainfall variation risk. Dry spell/rainfall variation occurs approximately 3 year in the decade. Approximately 30-100% of bamboo area is sensitive. Rainfall variation is caused of bamboo shoot stunt and fertility of bamboo in the next year. The mechanism adaptation such as harvested it only 1 month in the year and crate conservative measurement such as harvested for consume in the household, sell it in the community only and harvest only old bamboo stem for making basket. That mechanism is insufficient for cope the risk. Bamboo system in the BCI site is still high vulnerability to climate change.

Hed Kon mushroom is only harvested in three clusters of BCI site except Thanaosri cluster. Approximately 100% of mushroom area is under to weather variation (fluctuate) and weather variation occurs approximately 3-7 year in the decade. Hed Kon is very sensitive; flowering 2-3 times and approximately 50% of total yield is loss. No measurement to cope this risk, Hed Kon mushroom in BCI site is high vulnerability to climate change.

10.2 Current Vulnerability of community system

Resort/infrastructure in Suan Phueng and Ban Bueng clusters of BCI site, approximately 10-30% of infrastructure was under flash flood risk, which approximately occurs once in the decade. Approximately 10% of household/infrastructure is affected of flash flood. Mechanisms such as constructed reservoir/ weir, construction building far the river and dame in river bank are sufficient to reduce risk. Community infrastructure is low vulnerability to flash flood.

Extreme weather disease; cold fever and mental health, Extreme weather (rainfall and temperature fluctuate) is caused of disease. Approximately 100% of people are under extreme weather and data record from public health care unit in community in the BCI site shown risk level of each disease is more than standard. It is people in a community are high vulnerability to Extreme weather disease but public health system has good system to control disease and people have mechanism to reduce risk of high temperature. So that people in BCI site is low vulnerability to these disease.

Vector born disease; malaria and dengue. Approximately 100% of people in community exposure to disease because communities settle near Thai-Myanmar border (spread area of malaria), people go and out all year and weather variation in the west season (more rainfall and high temperature). Data record from Malarai unit control and public health care unit in community in the BCI site shown risk level of each disease is more than standard. It is people in a community are high vulnerability to vector born disease but public health system has good system to control disease. So that people in BCI site is low vulnerability to these disease.

11. Current coping mechanism/strategy to climate threats

Common coping strategies of people in BCI site in response to crop failure and community impact due to climate threat in the past are:

- **Rearrange cropping pattern** Farmer is changed time to grow crop to appropriate time for reducing risk of drought. e.g. planting maize in 2nd time (August-September), intercropping maize with cassava,
- **Changing crop variety or new crop which is more drought tolerance than old crop** e.g. changing old maize variety to improved variety, changing from maize to grow cassava, sugarcane and or pineapple

- **Do extra labor work** e.g some area such as people in Suan Phueng (Ban Huai pak), farmer is fail to grow maize in the long time, they are go to work in agricultural filed, resort, OTOP center and local factory for earn more money.
- **Migration- remittance** e.g. villagers who has little cultivation land, has only one person move to work in downtown or other province and send money to home.
- **Buy rice from market instead grow rice for subsistence** e.g. 1) Farmer who grows upland rice however in some year rice yield is loss or no rice yield. They are adapting by buy it from the outsider instead of planting rice. 2) Some villagers, rice crop is failed, they adapt to grow cassava or maize and sell it to buy rice for consume in the family.
- **Sell livestocks** e.g. some villagers in Ban Bueng cluster (Ban Huai Makrud) besides they are often planting filed crop, They raise goat for sale like saving money when they have effected from climate variation.

12. Socio-economic change in BCI area

For long term adaptation measures in BCI Tesnasserim were also taken place:

- **Infrastructure**
  Some area construction infrastructure for irrigation system and hygienic water system such as at Ban Huay Makrud, construction and upgrade of irrigation schemes and canal provides farmers to vegetables during dry spell/summers. While Ban Boh Wee is construction and upgrade pipe water system to hygienic system (clean water for drinking during dry season) and construction weir to reserve water for pipe water.
- **Cropping system and new management**
  Try out new drought tolerance rice and demonstration new method to grow rice such as input fertilizer instead shifting cultivation (rotation area every 3 years. Change to use the new crop variety, e.g., used improved crop variety or drought tolerance such as Para rubber, oil palm and maize etc.

- **Institutional arrange**

  Some communities arrange by reforestation or restoration forest such as at Ban Boh Wee, Rotation Bamboo forest or arrange bamboo forest zone of harvesting bamboo shoot for baskets.
- **Allocate land**

  The government should to allocate land for cultivation and community forest.
- **Tourism**

  People who have no land ownership for cultivation, more population in the household and resort blooming in BCI Tenessarim move to work in tourism sector such as worker in resort, worker in forest office for restoration forest.

Table 8 Vulnerability matrix at Ban Bongtilang

Sector at risk Ban Bongtilang	**Risk form Climate**	**Exposure to Impact of Current Climate Threat/ Pressure**	**Sensitivity to Impact of Climate Threat**	**Coping Capacity/ Mechanism Adaptation**	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
Agriculture System					
Upland rice	Dry spell during month 6 (June)	• About 60% of upland rice production area is considered under climate risk from dry spell • Severe dry spell occurs approximately 2-3 years in a decade.	About 15-20 % of upland rice production area is damaged when dry spell occur	• Change planting area from upland to low land (higher soil moisture) • Shifting planting period to June-July, avoid planting March-May • Use drought tolerance rice variety such as Kor Yai rice	3 mechanisms are sufficient to reduce risk from climate threat.
Upland rice	Rainfall during harvesting time (prolonged rainy season – rain around November)	• Approximate 100% of upland rice production area is exposed to risk • Severe late rainfall occurs approximately 4-5 years over a decade.	• Approximately 70% of upland rice production area is risk to damage • Approximately 40% rice yield reduced due to fungi problem	• Harvest after end of rain and put in shade to dry • Use sundry method • Use shorter maturity variety, e.g. Kao Ta Hang rice variety (harvested in September)	These mechanisms are sufficient to reduce risk and considered effective.

Sector at risk Ban Bongtilang	**Risk form Climate**	**Exposure to Impact of Current Climate Threat/ Pressure**	**Sensitivity to Impact of Climate Threat**	**Coping Capacity/ Mechanism Adaptation**	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
Sugarcane *(note: emerging crop, just started to plant in the study area over the past 3 years)*	Dry condition – forest fire	• Approximate 50 % sugarcane production area is under risk to forest fire • Forest fire occurs approximately 8 years over a decade.	About 50 % total production loss due to fire can be expected	Harvest before dry period (before March, when forest fire normally occurs)	This mechanism reduces exposure to risk and considered effective
Cassava	Dry condition - dry spell, in March-May caused pest problem: cassava aphis (pink mealybug)	• Approximately100.% of production area is at risk to cassava aphis • Dry spell occurs every other year	Approximately 20-25 % of production area is damaged (upland plantation is more affected than cassava in the lowland)	• Expand spacing between plant (from 0.5 x 1m to 0.7 x 1.3 m) to reduce pest spread • used insecticide and restorative drug	These mechanisms are only moderately effective in coping with pest problem.
Cassava – low land area	High rainfall in wet season, especially in October, causes cassava root decay	• Approximately 100% of production area is risk to root decay. • Soil saturation occurs every year	Approximately 100.% of production area is sensitivity and root decay each year	• Seasonal short cycle crop to substitute crop loss, e.g. vegetable • Plant it in slope area of mountain	These mechanisms can be highly effective to reduce exposure to risk, but availability of slope area of the mountain for

Sector at risk Ban Bongtilang	**Risk form Climate**	**Exposure to Impact of Current Climate Threat/ Pressure**	**Sensitivity to Impact of Climate Threat**	**Coping Capacity/ Mechanism Adaptation**	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
					agriculture is limited.
Maize	Dry spell during June-July	• Almost 100% of production area is exposed to dry spell risk • Severe dry spell occurs once in a decade.	Approximately crop damage would be expected by 70% of total production area when severe dry spell occurs (especially when dry spell occurs during flowering and silky period).	• Shift planting time to be during July–August • Use improves variety – drought tolerance variety	These mechanisms are only moderately effective in coping with risk.
Maize (normally planted in April – May)	Rainfall during harvesting period (August – September – note: maize matures and ready for harvest in 4 months time)	• Approximately 70-80% of production area is under risk to yield damage. • Severe rainfall occurs almost every year	Approximately 10% of total production area or yield is damaged.	• Split planting period into 2 crops, 2nd crop to be planted in August • Use improved variety (thick outermost shell, protect water to inner, no fungi)	These mechanisms are effective in reducing exposure and sensitivity to climate risk, but 2nd crop may risk drought problem.
Para rubber	Dry condition during dry season, especially during Para rubber age of 1-2 years.	• Approximately100% of planting area is under risk • Frequency of risk is about twice in a decade	Approximately 40% of young plant dies when severe dry condition occurs	• Use older stock, 2 years old and above, to plant.	This method is moderately effective in coping with climate risk.

Sector at risk Ban Bongtilang	**Risk form Climate**	**Exposure to Impact of Current Climate Threat/ Pressure**	**Sensitivity to Impact of Climate Threat**	**Coping Capacity/ Mechanism Adaptation**	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
Para rubber	High number of rain day over the year (prolonged rainy season)	• Approximately 100% of harvested areas is under risk • Frequency of risk is about twice in a decade	Approximately 100% of harvested areas is sensitivity to climate threat	No measure to cope with risk situation for the time being.	N.A.
Bamboo shoot harvesting	Dry spell or rainfall fluctuation	• Approximately 50% of bamboo forest in the mountain is under risk to rainfall fluctuation • Dry spell or rainfall variation occurs almost every year.	Approximately 100 % of total bamboo shoot is stunt	• Limit harvesting period, only allows in certain period of the (August or September) • Limit harvest amount, only for household and community consumption	These mechanisms are moderately effective to cope with risk.
Hed Kon mushroom (Termitomyces fuliginosus Heim)	Climate variation (rainfall pattern anomaly)	• Approximately 100% of mushroom areas is under risk from climate variation • Severe climate variation occurs approximately 7 years in a decade.	• 30% loss of total Hed Kon mushroom harvesting yield (compared with normal year)	No measures	
Pak Van Pa	Dry condition and	• Almost 100% of	• 100% of mountain	• Create fire buffer	The coping

Sector at risk Ban Bongtilang	**Risk form Climate**	**Exposure to Impact of Current Climate Threat/ Pressure**	**Sensitivity to Impact of Climate Threat**	**Coping Capacity/ Mechanism Adaptation**	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
(*Melientha suavis Pierre*) and wild vegetables	forest fire, especially during February and March	harvesting area (mountain range) expose to climate risk • Frequency of risk ,7 in a decade (present)	area. • But forest fire is stimuli for sprout treetop of Pak Van Pa.	• Burning forest before forest fire occurs.	mechanism is moderately effective.
Socio-economic sectors					
Household /infra-structure	Flash Flood	• Approximately 10% of households in the village is under risk • Flash flood occurs once in a decade	3% of household in the village is under severe risk	• Construct dyke and reservoir in Ban Tai Mueng • construct weir (4 weirs) in Ban Bongti	The coping mechanism is moderately effective
Cold fever	Climate variation in wet season	Most of child population is under risk of cold fever	Approximately 30% of child population affected.	• Public healthcare – sub-district • Private doctor	Highly effective
Malaria	Climate variation in wet season induces vector-borne disease	Most of population in the area is at risk of malaria.	Almost 30% of population in the village affected by malaria	• Public healthcare – sub-district • Private doctor	Highly effective
Dengue fever	Climate variation in wet season induces	Most of child population is under risk of dengue fever	Small number of population is affected	• Public healthcare – sub-district	Highly effective

Sector at risk Ban Bongtilang	**Risk form Climate**	**Exposure to Impact of Current Climate Threat/ Pressure**	**Sensitivity to Impact of Climate Threat**	**Coping Capacity/ Mechanism Adaptation**	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
	vector-borne disease		(Ratio 35:100,000)	• Private doctor	

Table 9 Vulnerability matrix at Ban Huay Pak

Sector at risk	Risk form Climate	Exposure to Impact of Current Climate threat/pressure	Sensitivity to Impact of Climate	Coping Capacity/ mechanism Adaptation	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
Agriculture System					
Upland rice	Dry spell during July-August	• Approximately 50% of upland rice production area is under dry spell risk • Dry spell occurs approximately twice in a decade	Approximately 80 % of upland rice risk damage under dry spell	• Change planting area from upland to low land (higher soil moisture) • Shift planting to middle August and use short cycle variety, preferably drought tolerance variety • Plant various rice varieties	These mechanisms of coping capacity are moderately effective.
Sugarcane	Dry spell during month June - August	• Approximately 60 % sugarcane production area considered expose to risk, especially in hillside area • Serious dry spell occurs twice in a decade	Approximately 50 % of production area damaged	• Changed sugarcane variety from Khon Kaen 2K to Lampang variety • Plant various varieties	These mechanisms are low effective to cope with dry spell risk.

Sector at risk	Risk form Climate	Exposure to Impact of Current Climate threat/pressure	Sensitivity to Impact of Climate	Coping Capacity/ mechanism Adaptation	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
Cassava	Dry-Dry spell , in month 5-8 (May-August) spreading of cassava aphis (pink mealybug)	• Approximately 50.% of production area is risk to cassava aphis • Dry spell occurs approximately twice in a decade	Approximately 50 % of production area is damaged, especially in the hillside	• Expand planting space to reduce pest spreading • Adjusting crop calendar. Planting in May-June and avoid planting in December – January • Select proper variety to match planting area: Kan Dang or Rayong 5 variety for hillside plantation and Kaset 50 or Rayong 9 variety for sandy soil	These mechanisms are not quite effective to cope with cassava aphis risk.
Pineapple	High temperature during dry season (March-April)	• Approximately 40% of production area considered under high temperature risk especially in upper hillside • High temperature occurs approximately twice in a decade.	Pineapple will have low yield and fruit burn.	• Wrap paper around the fruit • Use pineapple leaf to cover its fruit	These mechanism is moderately effective to cope with high temperature condition.
Maize	Dry spell during in	• Almost the whole	In severe drought year,	• Inter cropping	These coping

Sector at risk	Risk form Climate	Exposure to Impact of Current Climate threat/pressure	Sensitivity to Impact of Climate	Coping Capacity/ mechanism Adaptation	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
	June-August	production area considered under dry spell risk • Dry spell occurs approximately 7 years in the decade.	total loss for the crop season can be expected, especially if dry spell occurs during flowering and silky	Maize-Cassava during September-October or 2nd round cropping in September – October • Use improved maize variety	mechanisms are moderately effective
Bamboo shoot	Dry spell or fluctuation of rainfall distribution during rainy season	• Approximately 100% of bamboo forest under risk. • Dry spell occurs approximately 8 year in a decade	• Limited harvest yield in dry year • Rainfall variation is caused of Bamboo stunt • Forest fire is more severe in following year	• Community formulate regulation to control limited harvesting, both amount and harvesting period • Create fire buffer	These coping mechanisms are not sufficient or low effective.
Hed Kon mushroom (Termitomyces fuliginosus Heim)	Climate variation (rainfall pattern anomaly)	• Approximately 100% of mushroom areas under risk. • Climate variation occurs approximately 7 years in a decade.	• Approximately 30% yield loss of total Hed Kon mushroom yield (compared with normal year)	No measures	No mechanism to cope.
Pak Van Pa (*Melientha suavis*	Severe dry period and forest fire	• Approximately 100% of area	100% of mountain area. But forest fire is stimuli	• Create fire buffer • Burn forest before forest	The coping mechanisms are

Sector at risk	Risk form Climate	Exposure to Impact of Current Climate threat/pressure	Sensitivity to Impact of Climate	Coping Capacity/ mechanism Adaptation	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
Pierre) and wild vegetables	occurs in February and March	• Forest fire occurs approximately 7 year in a decade (present)	sprout treetop of Pak Van Pa.	fire occurs.	moderately effective.
Socio-economic sectors					
Tourism resort /infra-structure	Flash Flood	• Approximately 50% of resort under risk • Flash flood occurs approximately twice in a decade	Approximately 1/3 of resort in the area get severe damage when flash flood occurs	• Construct dyke near river bank • Reconstruct new building/room	These coping mechanisms are insufficient to cope with risk or low effective.
Village / Tourism Resort	Prolonged dry period in dry season (February-May) - lack of water for consumption	• Approximately 30% of household in the community are under risk. • Severe dry season that causes shortage of water consumption for community occurs approximately 4 years in a decade.	Almost 10% of household is severely affected by lack of water consumption	• Digging water well or underground water • Construct alternative pipe water systems (Tambon administrative and hospital) and use water from Huay Pak weir and mountain • Water allocation and prohibit tourism resort to use village's pipe water	These mechanisms are sufficient to cope with drought risk.

Sector at risk	Risk form Climate	Exposure to Impact of Current Climate threat/pressure	Sensitivity to Impact of Climate	Coping Capacity/ mechanism Adaptation	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
				system	
Cold fever	Climate variation in wet season	Approximately 100% of child group under risk of disease	Approximately 1-2% of child affected by disease	• Public healthcare – sub-district • Private doctor	Highly effective
Malaria	Climate variation in wet season induces vector-borne disease	Approximately 100% of labor wages expose to disease, especially Karen Christ who work in agricultural sector in Kanchanaburi. Now it is spread from older to the younger population.	Approximately 2.5% of people in the community is effected	• Public healthcare – sub-district • Special malaria clinic which located in the village (malaria control) • training malaria knowledge to people (supported by WHO)	Highly effective
Dengue fever	Climate variation in wet season induces vector-borne disease	Approximately 100% of child group are at risk of Dengue fever	Less than 1% of children in the community is effected	• Public healthcare – sub-district • Private doctor	Highly effective

Table 10 Vulnerability matrix at Ban Boh Wee

Sector at risk Ban Boh Wee	**Risk form Climate**	**Exposure to impact of Current Climate threat/pressure**	**Sensitivity to Impact of Climate**	**Coping Capacity/ mechanism Adaptation**	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
Agriculture System					
Maize	Dry spell during July-August	• Almost the whole production area considered under risk • Severe dry spell occurs approximately twice in a decade	In severe drought year, total loss for the crop season can be expected, especially if dry spell occurs during flowering and silky	• Shift planting time to be during August-September • Use improves variety – drought tolerance variety	These coping mechanisms adaptations are moderately effective to cope with climate threat.
Cassava	Dry condition during prolonged dry spell period in May-August causes spreading of cassava aphis (pink mealybug)	• Almost the whole production area considered under risk • Severe dry spell occurs approximately twice in a decade	Approximately 50 % of production area is affected by cassava aphis threat, especially in the hillside area	• Expand spacing (.8*1 m) • Shift planting to February – March and avoid planting in April – May • use Rayong 9 variety, which is drought tolerance variety	These mechanisms are low effective to cope with climate risk.
Sugarcane	Dry spell during June-August	• Almost total production area considered under dry	Approximately 30% of production area may loss 50% production yield (15	• Shift crop calendar, grow sugarcane in early rainy season (April-May)	These mechanisms are not sufficient or low effective to cope with

Sector at risk Ban Boh Wee	**Risk form Climate**	**Exposure to impact of Current Climate threat/pressure**	**Sensitivity to Impact of Climate**	**Coping Capacity/ mechanism Adaptation**	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
		spell risk • Severe dry spell occurs approximately twice in a decade	tons per rai in normal rain year VS 8 tons in bad year)	• Use improved variety such as Lampang variety	climate threat.
Bamboo shoot	Dry spell or fluctuation of rainfall distribution during rainy season	• Approximately 60% of bamboo forest under risk. • Dry spell occurs approximately 3 years in a decade	• Limited harvest yield in dry year • Rainfall variation is caused of Bamboo stunt • Forest fire is more severe in following year	• Community formulate regulation to control limited harvesting, both amount and harvesting period • Create fire buffer	These coping mechanisms are not sufficient or low effective.
Hed Kon mushroom (Termitomyces fuliginosus Heim)	Climate variation (rainfall pattern anomaly)	• Approximately 100% of mushroom areas under risk. • Climate variation occurs approximately 3 years in a decade.	• Approximately 50% yield loss of total Hed Kon mushroom yield (compared with normal year)	No measures	No mechanism to cope.
Socio-economic sectors					
Road / infra-structure	Flash Flood	• The road go to 25 household in the west	• Some parts of road would be affected but	• Construct waterway for road	These mechanisms are highly effective to

Sector at risk Ban Boh Wee	**Risk form Climate**	**Exposure to impact of Current Climate threat/pressure**	**Sensitivity to Impact of Climate**	**Coping Capacity/ mechanism Adaptation**	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
		of village has flood in 2-3 hour (4.15 % of household in the village) • Flash flood occurs approximately 2 years in the decade	the house is not damage	• Use alternative road	cope flash flood
Cold fever	Climate variation in wet season	Most of child population is under risk of cold fever	Approximately 60-70% of child population affected.	• Public healthcare – sub-district • Private doctor	Highly effective
Malaria	Climate variation in wet season induces vector-borne disease	Most of population in the area is at risk of malaria.	Only 1% of population in the village affected by malaria	• Public healthcare – sub-district • Private doctor	Highly effective
Diarrhea	Dry season during March-May	Approximately 100% of child group risk of Diarrhea	• Approximately 20% of child group in the village affected • Approximately 10% of older group affected	• Public healthcare – sub-district • Private doctor	The public healthcare system is highly effective and sufficient to cope with disease
Handicraft - basket weaving group	Forest fire in severe dry year - climate variation	Approximately 80% Bamboo forest is under risk of forest fire	Most bamboo shoot is stunt and affect quantity of bamboo for basket in the	• Zoning bamboo forest for rotation harvesting • Control bamboo	These mechanisms are moderately effective to cope with

Sector at risk Ban Boh Wee	**Risk form Climate**	**Exposure to impact of Current Climate threat/pressure**	**Sensitivity to Impact of Climate**	**Coping Capacity/ mechanism Adaptation**	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
			following year	harvesting	risk

Table 11 Vulnerability matrix at Ban Huay Makrud

Sector at risk	Risk form Climate	Exposure to impact of Current Climate threat/pressure	Sensitivity to Impact of Climate	Coping Capacity/ mechanism Adaptation	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
Agriculture System					
Upland rice	Dry spell during October	• Almost the whole production area considered under risk • Dry spell occurs approximately 3 year in a decade.	100 % of upland rice production area is damaged (100% yield loss)	1.used dry tolerance rice variety (light age rice)such as Lahung variety 2. distribution risk by growing rice many varieties (Maewong, Lahung, and kaw Dang (late rice variety)	These coping capacity are low effectiveness to cope risk.
Cassava	Severe dry condition and prolonged dry spell period in March-May and August-September, causes risk of cassava aphis (pink mealybug)	• Almost the whole production area considered under risk • Dry spell occurs approximately twice in a decade	Approximately 20 % of production loss	• Use insecticide and restorative drug • Change crop variety – use Huay Bong variety and Rayong 9 variety	These mechanisms are low effective.
Maize	Dry spell during August-September	• Almost the whole production area	Approximately 90% production loss (especially	• Adjust crop calendar – planting in July–August	Current coping capacity is low

Sector at risk	Risk form Climate	Exposure to impact of Current Climate threat/pressure	Sensitivity to Impact of Climate	Coping Capacity/ mechanism Adaptation	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
	and February- May	considered under risk • Dry spell occurs approximately every other year	when dry spell occurs during flowering and silky)	• Use improved variety – drought tolerance • Switch crop to pineapple	effective.
Vegetables	Prolonged dry spell during in August - September and February - May	• Almost the whole production area considered under risk • Dry spell occurs approximately 8 year in a decade	Approximately 70% of production area may loss during severe dry spell period	• Adjust crop calendar – focus on rainy season to winter season only • Use sprinkler system for crop and pump water from Huay Makrud creek and other small creeks	These mechanisms are moderately effectiveness to cope with risk.
Vegetables	Flash flood in rainy season - October	• Approximately 1/3 of production vegetable area considered risk • Flash flood occurs almost every other year	Total loss can be expected when flash flood occurs	• Adjust crop calendar – avoid planting in October • Define flood risk zone	These mechanisms are low effective.
Pineapple	High temperature and strong solar radiation (sun light) can cause fruit burn especially during	Almost the whole production area considered under risk	In severe year, high damage can be expected.	• Use paper to wrap fruit the fruit • Use pineapple leaf to cover its fruit • Spray water to pineapple	These mechanisms are moderately effective to cope with risk.

Sector at risk	Risk form Climate	Exposure to impact of Current Climate threat/pressure	Sensitivity to Impact of Climate	Coping Capacity/ mechanism Adaptation	
		Description/Indicator	Description/Indicator	Description/Indicator	Effectiveness
	fruit development to harvest.			plantation during April-May (Big gun sprinkler - only rich farmer)	
Hed Kon mushroom (Termitomyces fuliginosus Heim)	Climate variation (rainfall pattern anomaly)	• Almost total mushroom harvesting area considered under risk. • Rainfall pattern anomaly occurs approximately 3 years in a decade	• Approximately 50% yield loss of total Hed Kon mushroom harvest (compared to normal year)	No measures	N.A.
Socio-economic sectors					
Human health	High temperature in dry season affect mental health and causes fever (hot fever)	Approximately 100% of population is under risk to high temperature.	Approximately 10% of population are affected by hot fever and mental health	• Public healthcare – sub-district • Private doctor	These mechanisms are moderately to cope with high temperature.

13. Climate change and future climate risk

13.1 Climate change

Analysis of future climate change in BCI site is based on future climate scenario from ECHAM4 climate model, A2 scenario, and downscaled to 25x25km grid using PRECIS regional climate model[2]. The analysis compare climate of the 2 periods, during years 1980-2009 and years 2020-49. Geographical coverage covers two BCI sites, Northern BCI site (Sai Yok cluster) and Southern BCI site (three clusters).

Rainfall Average total rainfall in the future (years 2020-2049) is not significant from the base year (years 1980-2009) both of the Northern and Southern BCI site. In the Northern BCI site has average annual rainfall amount 1,224 and 1,202 mm **(Figure 21 and 22)** in the base year and future year respectively. While in the Southern BCI site has average annual rainfall amount 1,719 and 1,680 mm. in the base year and future year respectively. Standard deviation (SD) of total rainfall rainy period in the base year of the Northern BCI site is lower than in the future. While standard deviation (SD) of total rainfall rainy period in the base year of the Southern BCI site is higher than in the future.

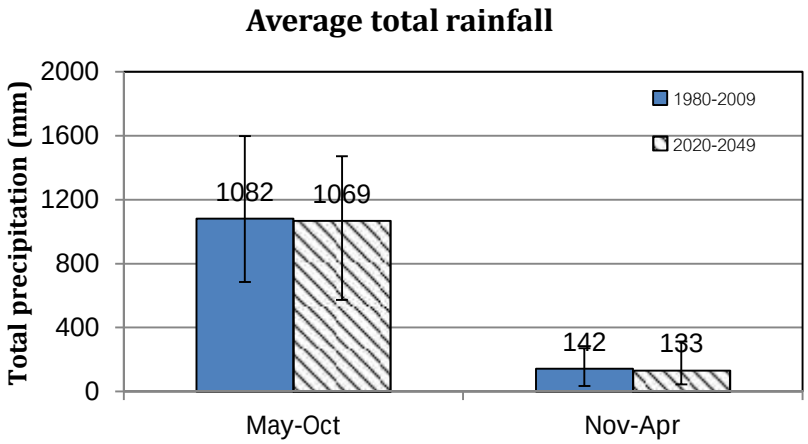


Figure 21 Average total rainfalls in the Northern BCI site

[2] The simulation of high resolution future climate projection for Southeast Asia region was conducted by Southeast Asia START Regional Center (SEA START RC) as part of research project under support by Asia-Pacific Network for Global Change Research and Thailand Research Fund (2007-2008). Data from the simulation is available for public use at http://cc.start.or.th/. (*Chinvanno, S., V. Luang-Aram, C. Sangmanee and J. Thanakijmethavu. 2009. Simulation of Future Climate Scenario for Thailand and Surrounding Countries. Southeast Asia START Regional Center technical report. Thailand Research Fund)*

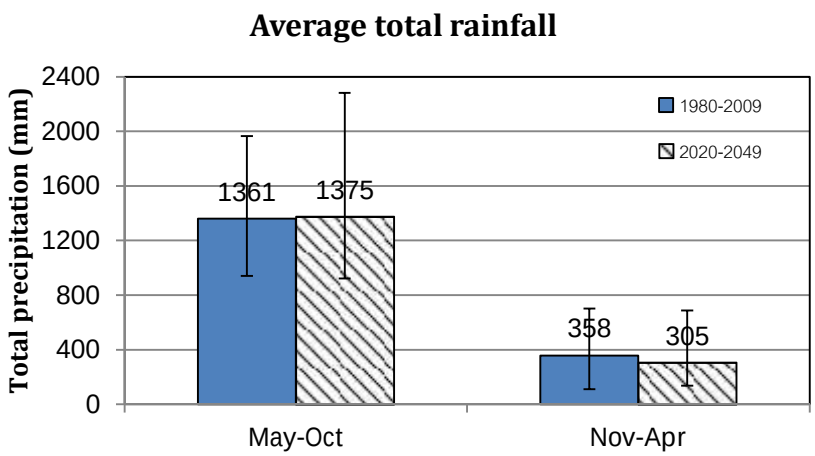


Figure 22 Average total rainfalls in the Southern BCI site

Average monthly rain has the same pattern in the base year and the future both BCI sites **(Figure 23 and 24).** In the Northern BCI site, average monthly rain is more than 100 mm start in June to October and in the Southern BCI site average, monthly rain is more than 100 mm start in April to October.

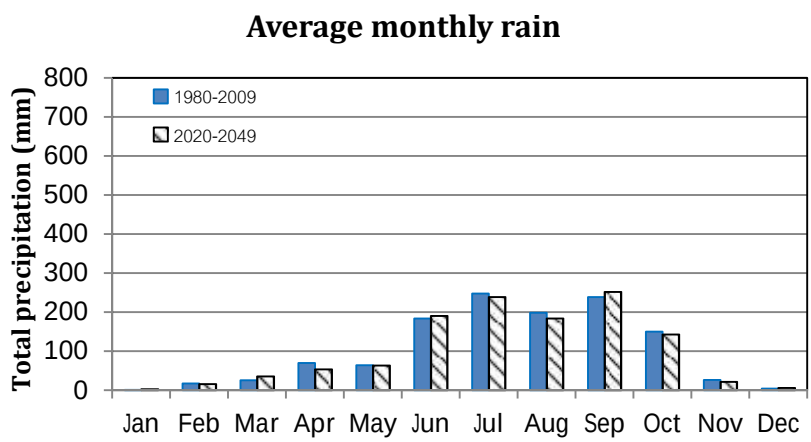


Figure 23 Average monthly rainfalls in the Northern BCI site

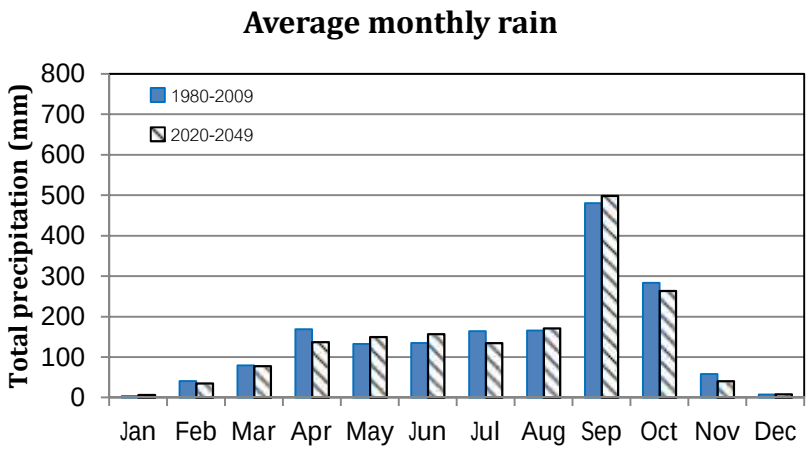


Figure 24 Average monthly rainfalls in the Southern BCI site

Number of dry day occurrence (daily rainfall <3mm.) during June-Aug. In the Northern and Southern BCI site, Number of dry day in the future is more than in the base year and has trend to increase. **(Figure 25 and 26)**

Daily rainfall distribution that more than 3 mm per day has trend to decrease in the future in the both BCI sites **(figure 27 and 28).** But in the Southern BCI site, daily rainfall is more than the Northern BCI site.

Rainfall and Intensity, Both BCI sites have rainfall intensity in the future more than in the base year **(Figure 29 and 30).** The Northern BCI site, rainfall intensity is 12.1 and 12.5 mm. per day. While rainfall intensity of the Southern BCI site is 15.2 and 16.5 mm. per day and it is higher in the Northern BCI site.

In Northern BCI site, average total annual rainfall in the driest year is 976 and 771 mm in base year and future year **(Figure 31).** While in the wettest year, average total annual rainfall is 1,524 and 1,518 mm in base year and future year. Monthly rainfall in the driest and wettest year have trend to shift to the month at the beginning of the year **(Figure 32).**

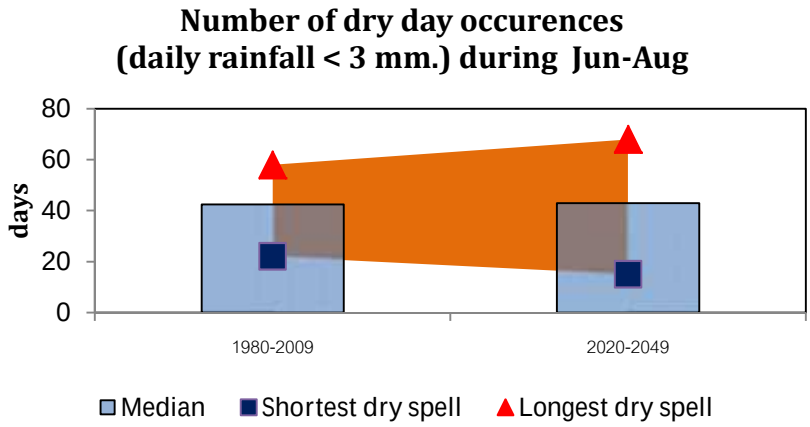


Figure 25 Number of dry day occurrence (daily rainfall <3mm.) during June-Aug. in the Northern BCI site

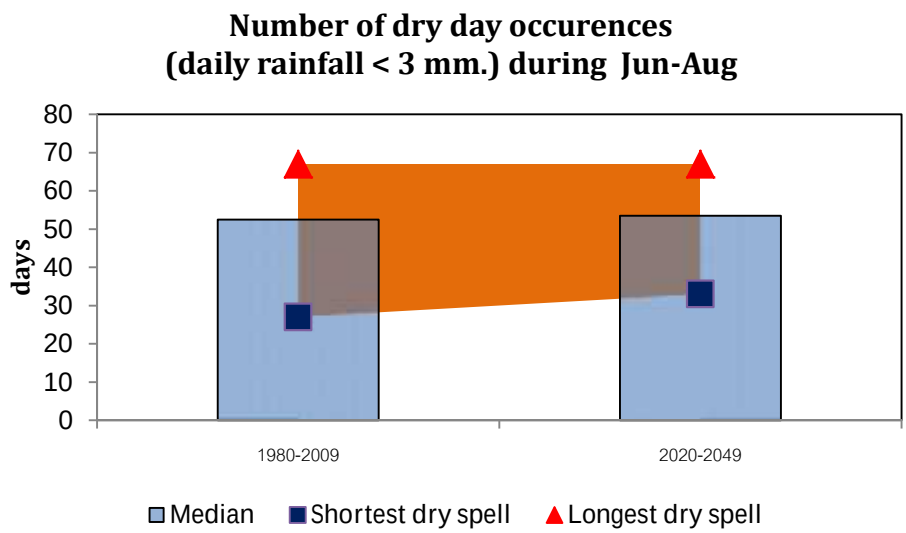


Figure 26 Number of dry day occurrence (daily rainfall <3mm.) during Jun-Aug. in the Southern BCI site

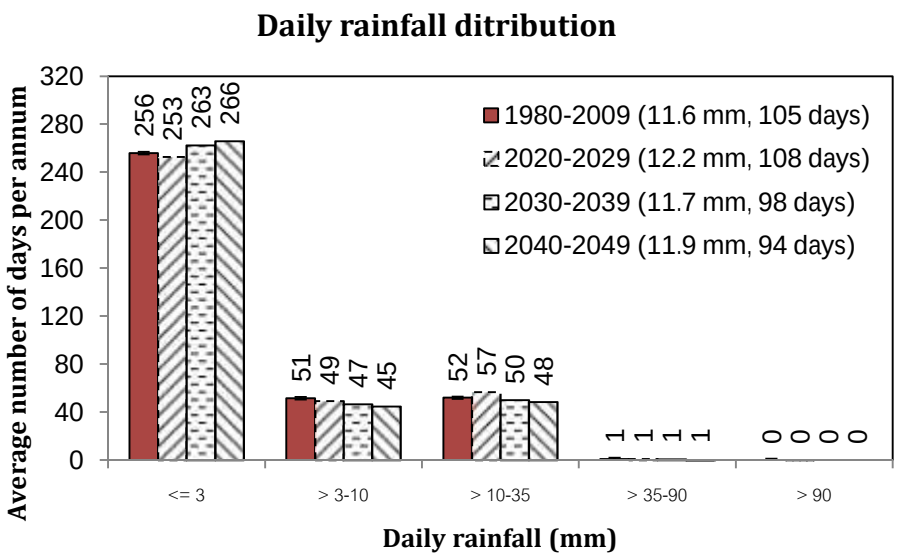


Figure 27 Daily rainfall distributions that more than 3 mm per day in the Northern BCI site

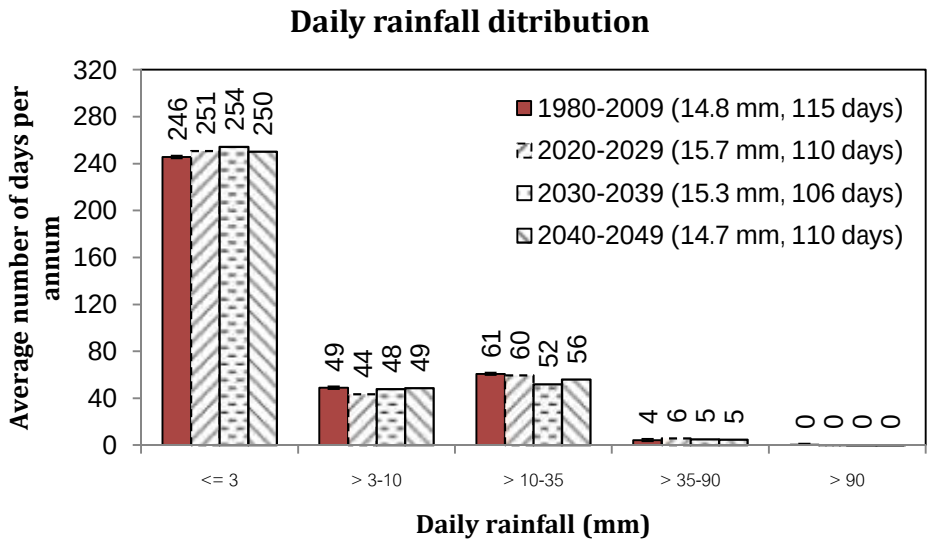


Figure 28 Daily rainfall distributions that more than 3 mm per day in the Southern BCI site

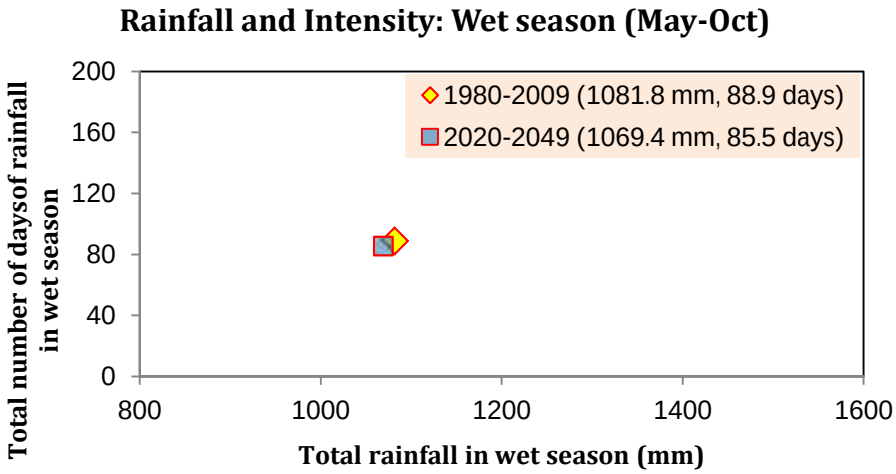


Figure 29 Rainfall and Intensity in the Northern BCI site

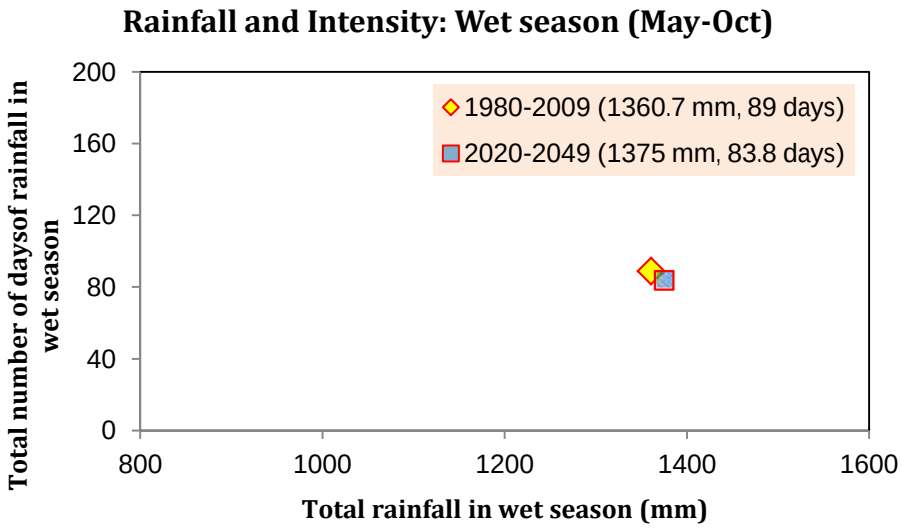


Figure 30 Rainfall and Intensity in the Southern BCI site

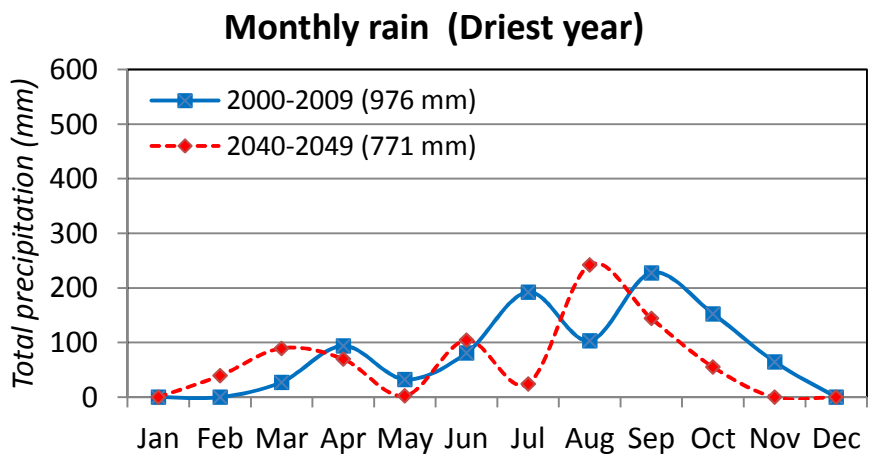


Figure 31 average total annual rainfall in the driest year in the Northern BCI site

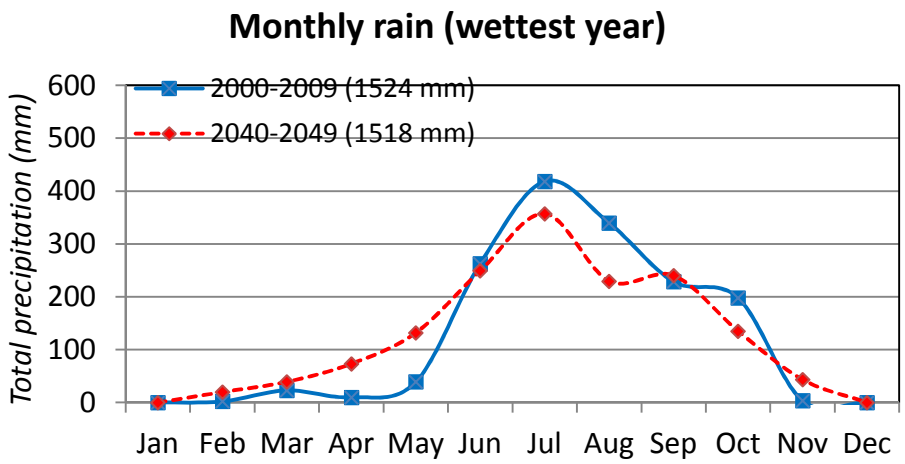


Figure 32 average total annual rainfall in the wettest year in the Northern BCI site

In Southern BCI site, average total annual rainfall in the driest year is 1,514 and 1,354 mm in base year and future year and rainfall is trend to shift to the month at the beginning of the year. While in the wettest year, average total annual rainfall is 2,207 and 2,456 mm in base year and future year and rainfall is trend to shift to the month in rainy season **(Figure 33 and 34).**

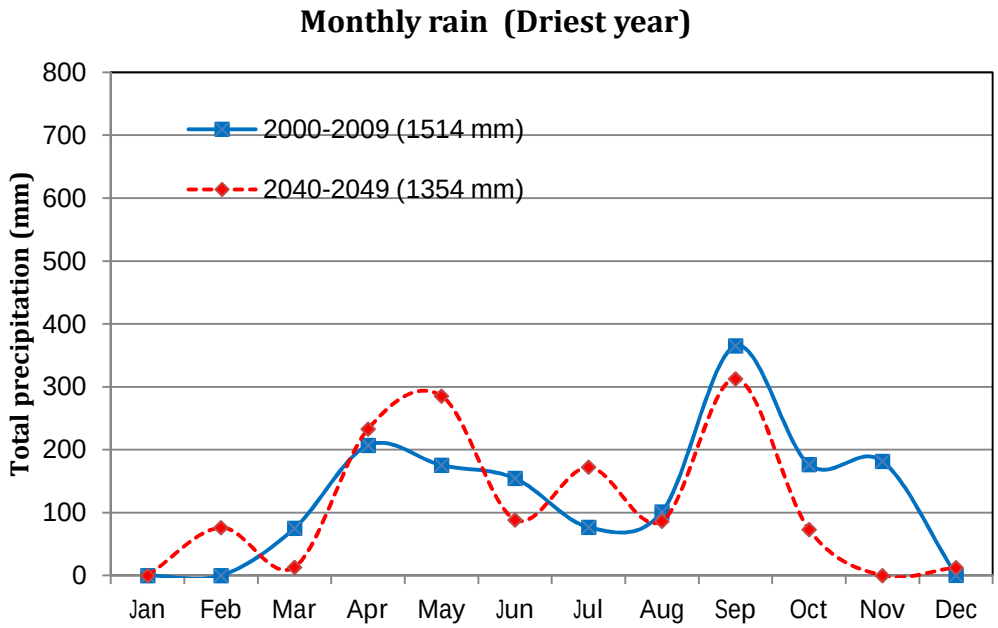


Figure 33 average total annual rainfall in the driest year in the Southern BCI site

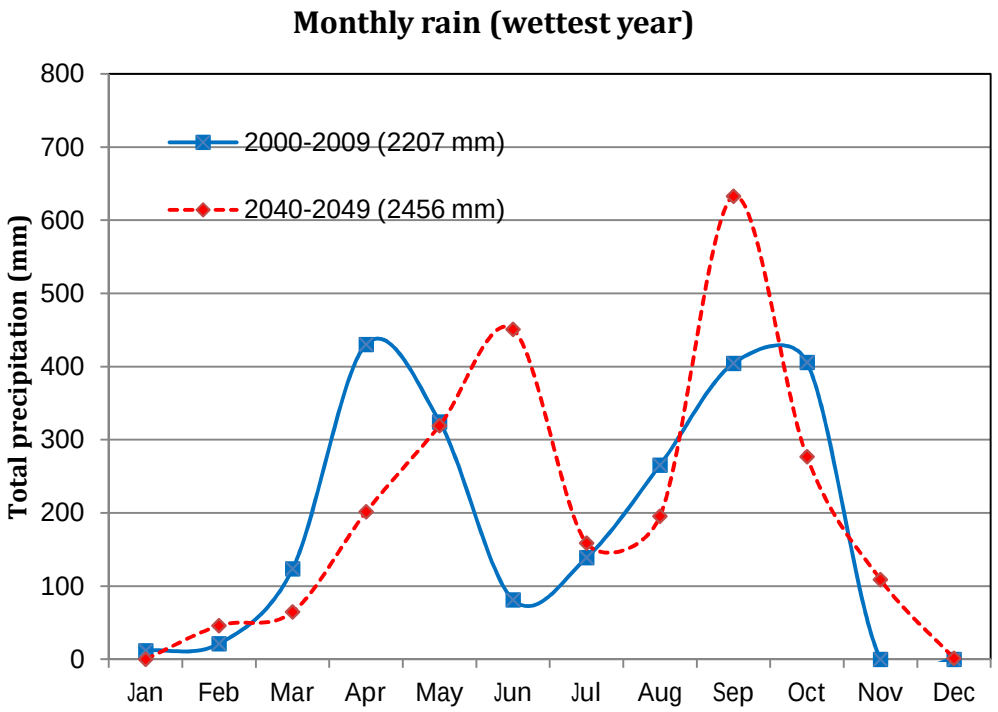
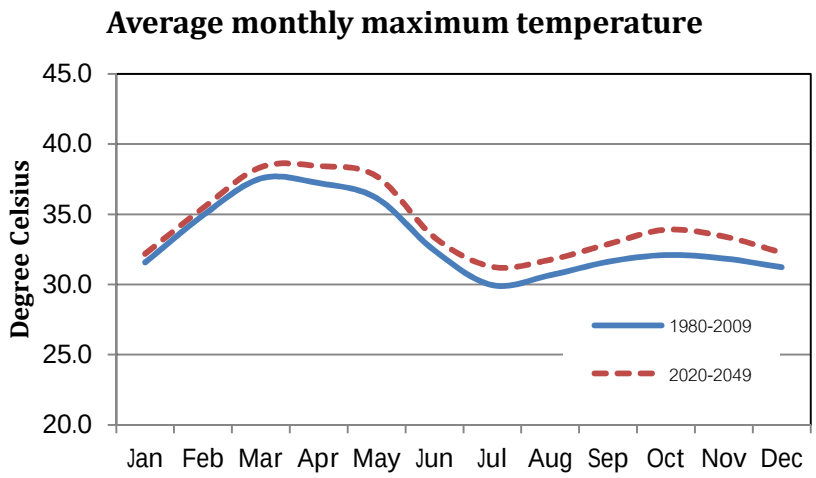


Figure 34 average total annual rainfall in the wettest year in the Southern BCI site

Temperature Average monthly maximum and minimum temperature all year in the future of both sites is higher than in the past **(Figure 35 and 36).** Distribution of days that maximum temperature 35 °C during Mar-May in both BCI sites is trend to increase in the future **(Figure 37 and 38).** It is show that air temperature in the future is hotter than the present.



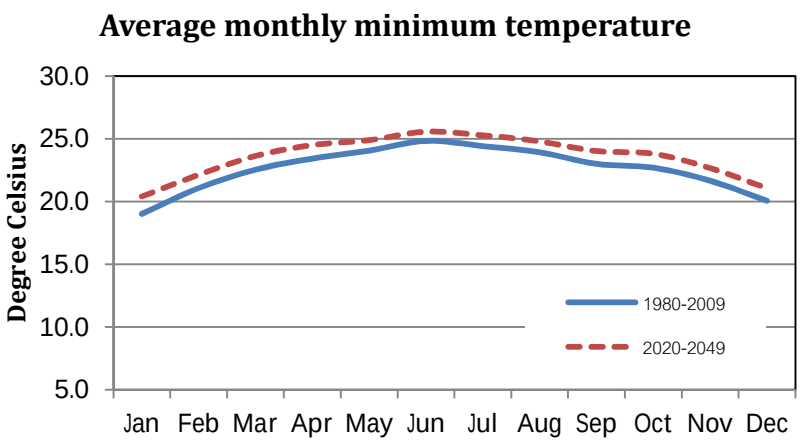
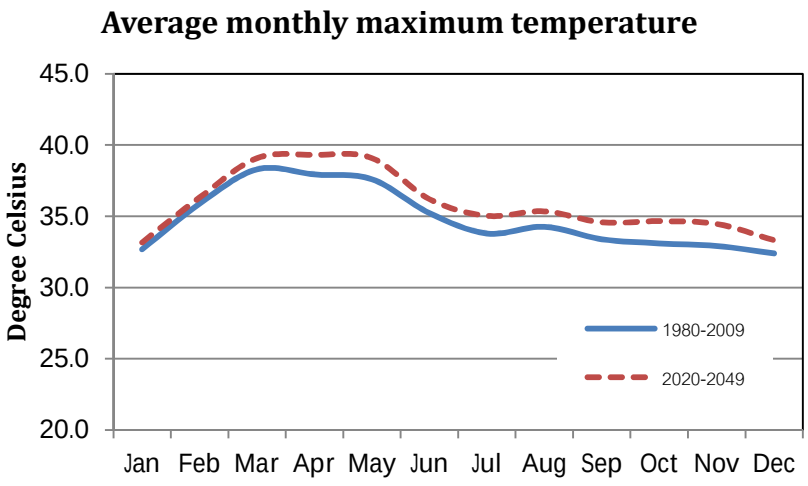


Figure 35 Average monthly maximum and minimum temperature in the Northern BCI site



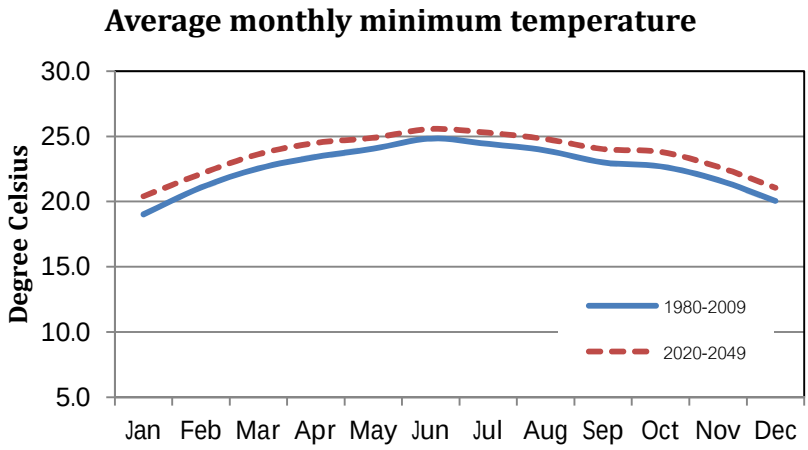


Figure 36 Average monthly maximum and minimum temperature in the Southern BCI site

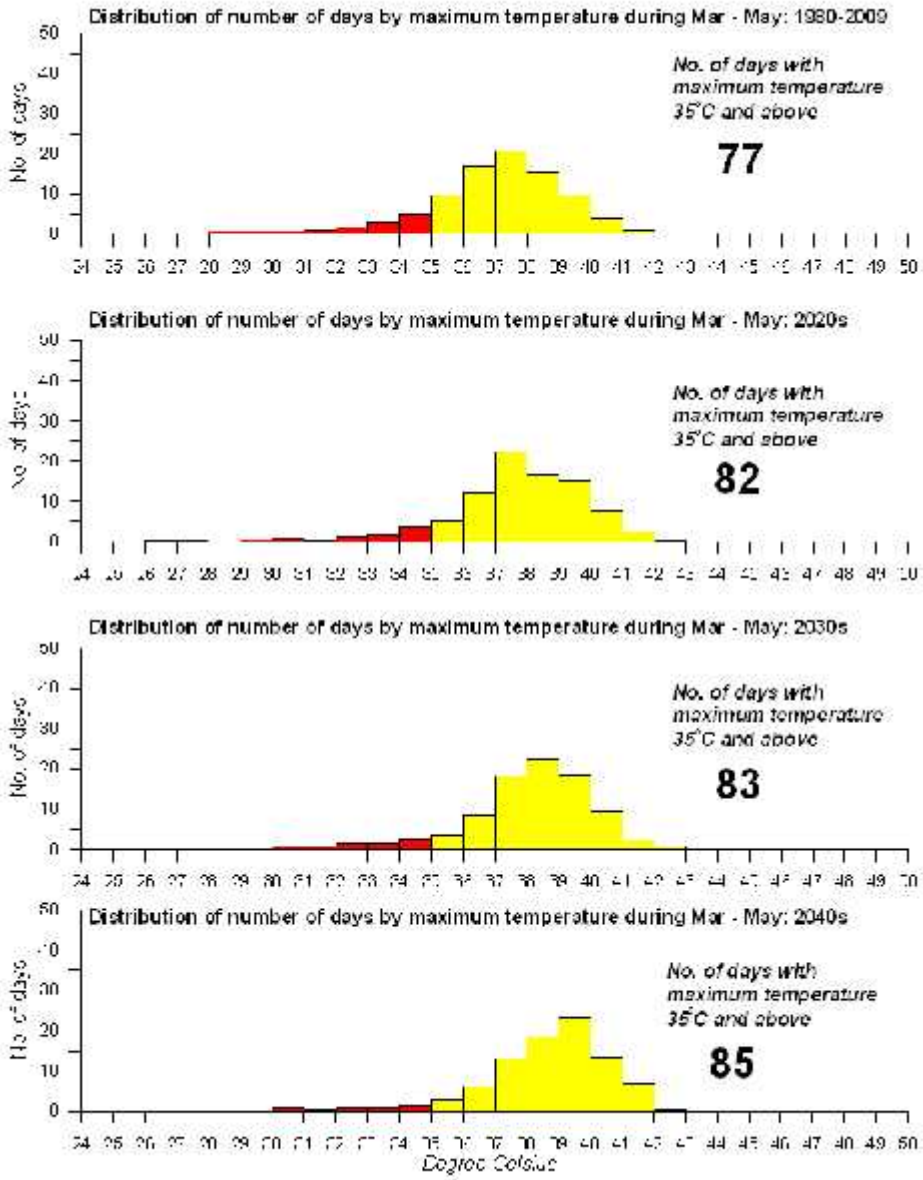


Figure 37 Distribution of days that maximum temperature 35 °C during Mar-May in the Northern BCI site

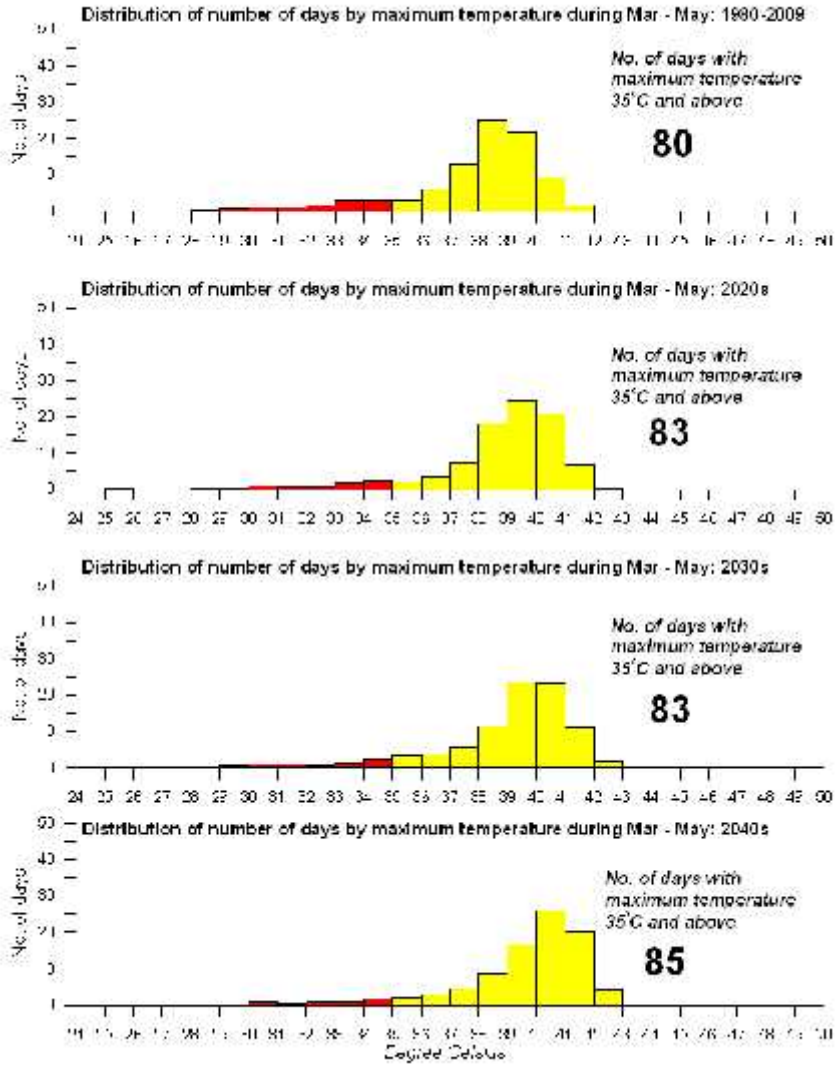


Figure 38 Distribution of days that maximum temperature 35 °C during Mar-May in the Southern BCI site

Climate data from year 1980 to 2049, it found that climate is change in 4 items e.g. 1) number of dry day 2) daily rainfall distribution that more than 3 mm per day 3) average total annual rainfall and 4) average temperature

Number of dry day occurrence (daily rainfall <3mm.) during June-Aug has trend to increase in BCI site.

Daily rainfall distribution that more than 3 mm per day has trend to decrease in the future in the both BCI sites

Average total annual rainfall in the driest year and the wettest year is less than in the past. Except the wettest year of the southern BCI part that average total annual rainfall in the future is more than in the past. Monthly rainfall in the driest and wettest year in the BCI site has trend to shift to the month at the beginning of the year.

Average temperature in BCI site in the future has trend to increase every month both minimum and maximum temperature.

13.2 Future climate risk

From weather data in the future with mention in the upper part, climate risk in BCI tenasserim will conclude 4 categories as same as in the present **(Figure 39);**

1) **Forest fire** from weather data in the future, number of dry day and daily rainfall are increase and temperature is higher than in the past while forest in BCI site is mostly cover by deciduous or mixed with bamboo. Also, forest fire is change to more occurring and high frequency.

2) **Flash flood** rainfall in the future not different than the past and intensity may slightly increase, however, land cover is more bare soil, therefore, flash flood may change to be more severe

3) **High temperature** average yearly temperature in the future is higher than the past. It is affected to mental health of human, crop production and quality of crop.

4) **Rain storm** temperature in dry season is higher and rainy season is shift to beginning of the year. Rain storm may be more frequency and high impact. It is affected to crop loss and infrastructure damage.

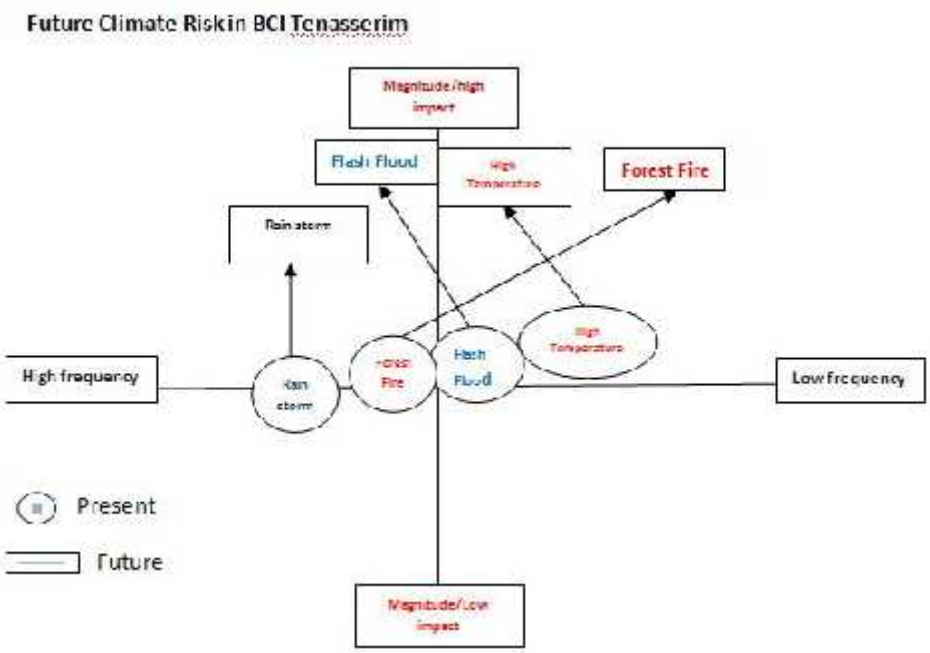


Figure 39 Future Climate Risk in BCI Tenaserrim

13.3 Future social pressures

Social in community is not the same pattern all time. Social change is depending on many factors. e.g. socio-economic, national policy, market, climate, and Globalization. Social in BCI community site same other community in the world is changing from the past to present. Social in this area will change very much in the future. Climate change is only driver that force social change. Beyond that driver, it has other factors which are important key driver will force social in community to risk are:

- **Restricted land use** The land in each village of BCI site is located in protected area and is in control of Treasury department. Land use area is not expanding more although

people can rent it from that department or pass Thai Royal Army in the area. Farmer has a few cultivation lands, increasing of population in the area in the future and land fertility is decrease. Farmer incomes will not enough for living. Some people will migrate to work in outside area or worker in forestry plantation.

- **Controlled shifting cultivation** Farmers usually grow upland rice for subsistence. National policy has prohibited law to do shifting cultivation. Also, upland rice can do it and will appear soon. Farmer has to earn money to buy rice for consume.
- **Controlled and limited NTFP collecting** Collection NTFP is trend to less than in the past caused from Climate change, increasing population, hunting restricted and same forest area. Villagers cannot hunt wild animal because they are living in the protected area. They have to buy meat and vegetable from the outside.
- **Market access** Main road and network road in the BCI site almost is asphalt and concrete. Good transportation make easy for villager and merchant to access market in downtown. Outside merchant can access community to buy raw material and sell goods. Livelihood will change.
- **Lacks of land ownership** Many people in BCI site is no landowner, some household has only land for workplace and inhibit is 2.4 ha and live in rain-fed area. Crop production is not many for income. They will move to work the outside area.
- **Outsider investment** In some area of BCI site, Outsider people come to investment a hotel and resort e.g.Suan Phueng cluster. Farmers are risk to crop cultivation, many people adapted from farmer to worker in hotel or resort. It makes sure he will get money day to day or monthly.
- **New crop, mono-croping and sustainability** Some crops' price has highly increased over the last decade and attracted farmer. Para rubber and palm oil crop is a new crop in this area. It is a trend to expand area of those crops very fast in five year. Land holding is changed from villager to outsider who has money to rent it from government or villagers. Some villager sells it and no land for cultivation. Finally, land is in hand of rich man.
- **Soil fertility degradation and sediment** Land use of BCI site is in the valley and mountain side. Land utilization is changed from forest to field crop along time. It is impact to soil fertility and sediment and is affected to crop growth and yield.

14. Climate change and agricultural productivity change

Many crops are growth in BCI Tenasserim sites. The five main crops that farmer growth it for selling and livelihood in their household include cassava maize sugarcane pineapple and upland rice. DSSAT software (Decision Support System for Agrotechnology Transfer) is used to run crop simulation for studying impact of climate change on crop. Future daily weather data used for the simulation was based on PRECIS and ECHAM4 A2 climate model from SEA START RC that has weather grid size 20x20 square kilometer. The models cover two time periods, which are 1980-2009 (base-year), 2030--2059. In BCI site has weather grids. Run crop simulation of each crop by using weather grid which has planted.

Upland rice During year 1980-2009 (base year), upland rice yield are 3,773, 3,720 and 3474 kilograms per hectare in the year 1980-1989, 1990-1999 and 2000-2009 respectively. The percentage of coefficient of variation is 15.5, 9.8 and 17.2 respectively. While in the year 2030-2059, upland rice yield are 3,299, 3,244 and 2,876 kilograms per hectare in the year 2030-2039, 2040-2049 and 2050-2059 respectively. The percentage of coefficient of variation is 14.1, 14.1 and 11.6 respectively **(Figure 40).** It is shown that upland rice yield has a trend to decrease in the future which compared it with the base year.

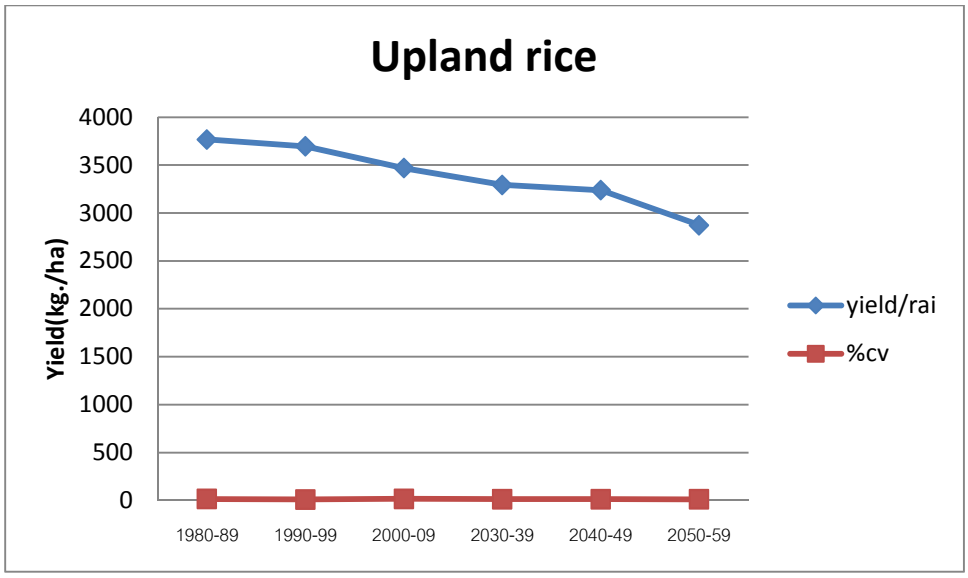


Figure 40 upland rice yields in the base year and year 2030-59

Cassava During year 1980-2009 (base year), Cassava yield (KU50 variety) are 52.3, 47.5 and 46.2 tons per hectare in the year 1980-1989, 1990-1999 and 2000-2009 respectively. The percentage of coefficient of variation is 6.8, 20.3 and 11.4 respectively. While in the year 2030-2059, upland rice yield are 45.37, 45.8 and 43.5 tons per hectare in the year 2030-2039, 2040-2049 and 2050-2059 respectively. The percentage of coefficient of variation is 16.9, 21.5 and 10.5 respectively **(Figure 41).** It is shown that cassava yield has a trend to few decrease in the future and has coefficient of variation more than the base year.

Maize Run maize simulation 2 times by using Garill 1113 variety(improved variety); the 1st time planting it in the early rainy season in May and 2nd time planting it in August. During year 1980-2009 (base year), Maize that planted in the 1st time, Maize yield is 2,157.5, 3,344.4 and 3.438.7 kilograms per hectare in the year 1980-1989, 1990-1999 and 2000-2009 respectively. The percentage of coefficient of variation is 57.1, 20.6 and 30.8 respectively. While in the year 2030-2059, maize yield is 2,414.5, 2,222.5 and 2,518.1 kilograms per hectare in the year 2030-2039, 2040-2049 and 2050-2059 respectively. The percentage of coefficient of variation is 51.5, 57.6 and 31.62 respectively**.**

Maize that planted in the 2nd time, Maize yield is 3,637, 3,457.9 and 3,371.4 kilograms per hectare in the year 1980-1989, 1990-1999 and 2000-2009 respectively. The percentage of coefficient of variation is 10.6, 8.0 and 19.5 respectively. While in the year 2030-2059, maize yield is 3,105.8, 3,225.8 and 3.301.9 kilograms per hectare in the year 2030-2039, 2040-2049 and 2050-2059 respectively. The percentage of coefficient of variation is 11.3, 7.2 and 10.8 respectively**.**

Maize is planted in 2nd times or in August has a yield higher than in the 1st time or in May and has the percentage of coefficient of variation less than. However, Maize yield that planted in August has trend to few decrease in the future. Maize that planted in 1st time has a trend to increase yield during the year 1990-2009 but its yield has trend to decrease in the future. It is shown that Maize is planted in the 2nd time has yield higher and less risk than in the 1st time. **(Figure 42)**

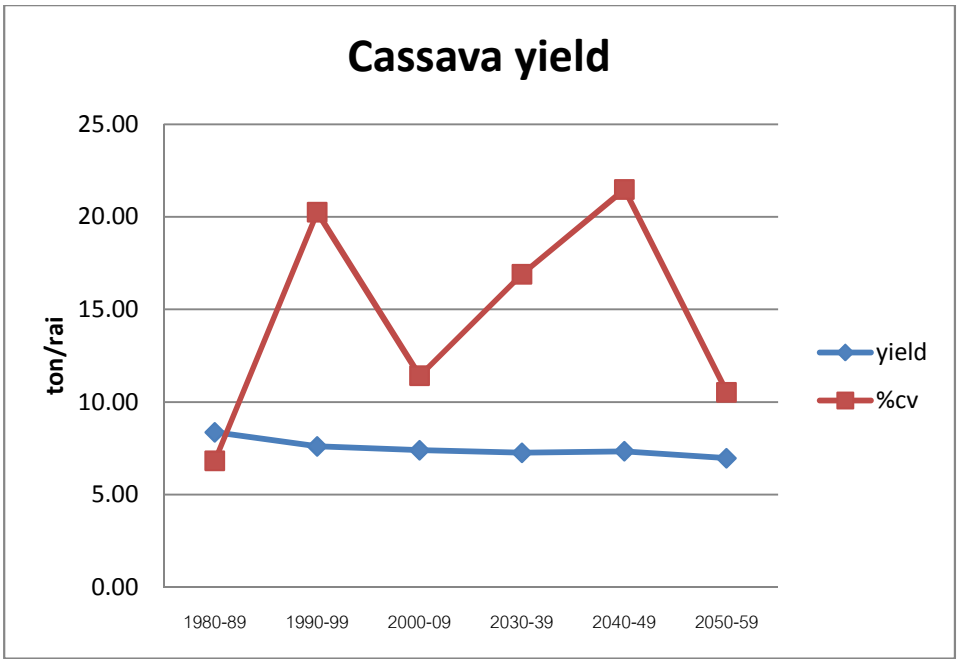


Figure 41 cassava yields in the base year and year 2030-59

Sugarcane During year 1980-2009 (base year), Sugarcane yield (K84 variety) are 55.6, 58.0 and 59.22 tons per hectare in the year 1980-1989, 1990-1999 and 2000-2009 respectively. The percentage of coefficient of variation is 5.5, 9.4 and 11.6 respectively. While in the year 2030-2059, upland rice yield are 52.2, 56.5 and 51.7 tons per hectare in the year 2030-2039, 2040-2049 and 2050-2059 respectively. The percentage of coefficient of variation is 20.1, 17.8 and 20.9 respectively **(Figure 43).** It is shown that sugarcane yield has a trend to few decrease in the future and has coefficient of variation more than the base year.

Pineapple During year 1980-2009 (base year), pineapple yield (Patavia variety) are 58.3, 53.4 and 53.1 tons per hectare in the year 1980-1989, 1990-1999 and 2000-2009 respectively. The percentage of coefficient of variation is 2.6, 2.9 and 2.0 respectively. While in the year 2030-2059, upland rice yield are 49.3, 48.3 and 49.0 tons per hectare in the year 2030-2039, 2040-2049 and 2050-2059 respectively. The percentage of coefficient of variation is 3.4, 4.9 and 3.6 respectively **(Figure 44).** It is shown that pineapple yield has a trend to few decrease and more coefficient variation in the future.

Under climate change during year 2000 to 2059 in BCI tenasserim in Thailand, Crop production of 4 main crops have trend to decrease. Decreasing and coefficient variation of crop yield in each crop is different. Coefficient variation of cassava and maize yield is more fluctuate than upland rice and sugarcane. However, coefficient variation of sugarcane yield has trend to more increase in the future.

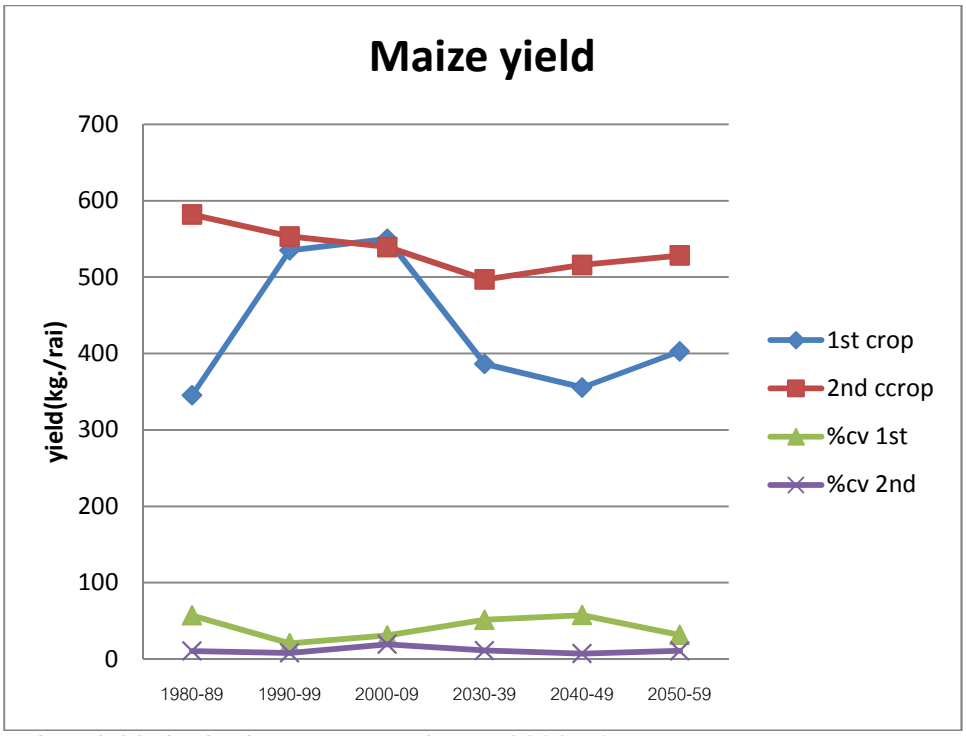


Figure 42 maize yields in the base year and year 2030-59

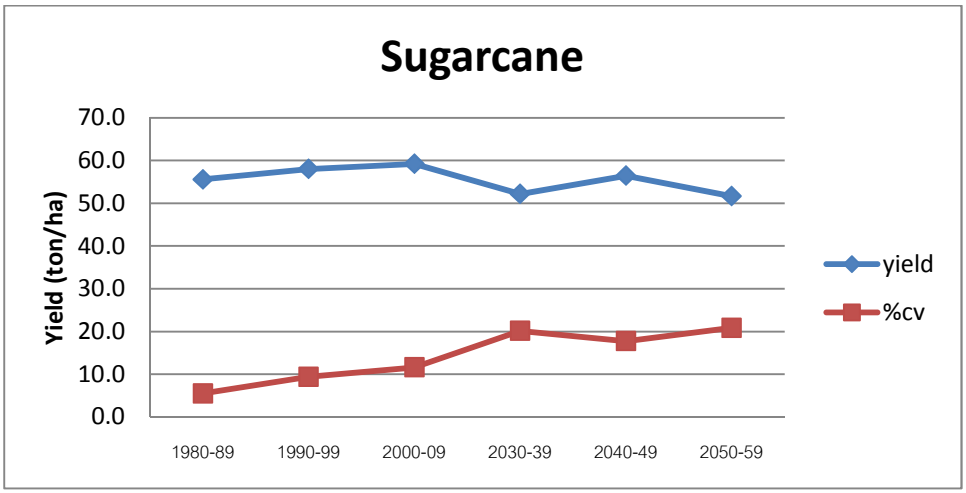


Figure 43 sugarcane yields in the base year and year 2030-59

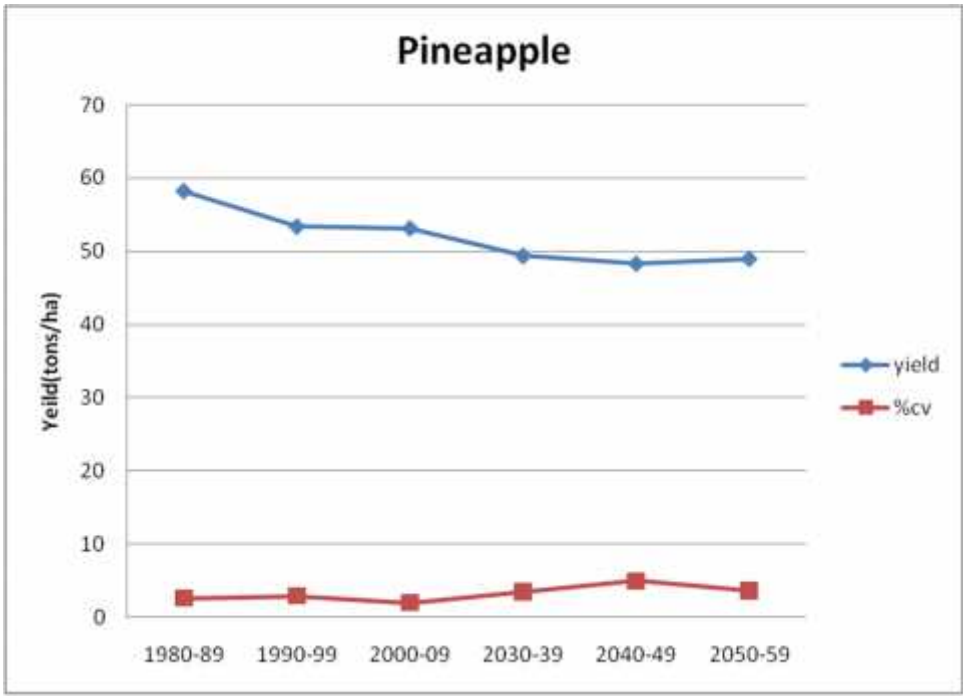


Figure 44 Pineapple yield in the base year and year 2030-59

15. Climate adaptation strategy and option

Project conducted the brainstorming workshop on climate change adaptation for agriculture sector and agricultural community in the Tenasserim BCI corridor at River kwai hotel on 19-20 January 2012. The workshop focused on discussion about future changes in the Tenasserim BCI corridor, both socio-economic change and climate change as well as the consequences on future risk of agriculture sector and agricultural community. In addition, the workshop covered brainstorming on adaptation strategy and options, which can be implemented to avoid and/or to better manage current as well as plausible future risk.

15.1 key concerns on future change in Sai Yok cluster

Agricultural system: 1) trend cassava and maize has been practicing and to continue in the future. 2) High price and demand of Para rubber in the world market is driver persuade farmer to grown this crop and expand land use change in the future. 3) Upland rice may be disappearing from this area.

Community system: 1) livelihood of villager has change from subsistence to commercial farming more than in the past. 2) Some villager who has less land for crop cultivation will migrate to a city and sale land ownership to capitalist or outsider who want to grow para rubber or do resort. 3) Conflict between people in community and government officer because of unclear boundary of Bongti subdistrict and Sai Yok national park.

15.2 key concerns on future change in Suan Phueng cluster

Agricultural system: 1) Cassava and maize cultivation have trend to decrease in the future. Sugarcane area is trend to slightly increase. 2. Land use for crop cultivation has trend to decrease. 3) Agricultural sector in this cluster has reduced important in the future.

Community system: 1) Land ownership has changing from villager in community to

capitalist who is investment resort. 2) Labor in agricultural sector move to work in service sector more than the present.

15.3 key concerns on future change in Tanaosri cluster

Agricultural system: 1) Para rubber and palm oil have trend to expand area in the future, the new crop (perennial crop) is take part a present annual crop.

Community system: 1) Land ownership has changing from villager in community to capitalist who is investment to growth perennial crop and resort. 2) Livelihood of villager in this cluster is more depend on NTFP than in the past, especially bamboo and bamboo shoot. 3) Some villager will migrate to work in service sector in outside area and or in the city. 4) Unclear boundary of community forest area and protected areas of Queen Sirikit indigenous plant study.

15.4 key concerns on future change in Ban Bueng cluster

Agricultural system: 1) Para rubber and palm oil have to replace or take part of pineapple and cassava area, Para rubber has trend to increase area in the future. 2) Vegetable cultivation has trend to increase area because in the community has strength vegetable group, market demand and irrigation system.

Community system: 1) land ownership has to change from villager to big farmer who want to growth perennial crop such as Para rubber and palm oil. 2) Villager is to growth bamboo in the land owner instead to keep it in the Chalerm Phrakiet Thai Prachan Park. 3) Ecosystem in this cluster has to recover in the future.

15.5 Key concerns on future changes and drivers of change in the Tenasserim BCI corridor study area:

Socio-economic change and its consequences:

1. Trend of intensive commercial farming, base on mono cropping, has been widely practiced over the years and expected to continue into the future. This drives livelihood of villager to rely on market condition. Villager is pushed to higher production and may have tendency to intrude into conservation zone.
2. Market situation of pararubber, high demand in international market and high price, drive land-use change in the study area. Farmer switches crop system from annual crop to perennial crop in response to higher income potential as well as to avoid impact of climate variability on more sensitive annual crops.
3. Changing land ownership due to lack of understanding on right of different type of land title certificate as well as lack of monitor and control and ambiguous and unclear boundary of village and conservation zone.
4. Expansion of tourism activity in the area may offer more off-farm income potential for villager.

Climate change and its consequences:

1. In Kanchanaburi Province, future climate projection shows plausible future increasing temperature, both daytime and night time temperature, while average monthly rainfall is likely to be more or less the same as present but dry spell during rainy season could be more fluctuate. See **figure 45.**

2. In Ratchaburi Province, future climate projection shows plausible future increasing temperature, both daytime and night time temperature. Average monthly rainfall during early rainy season could be slightly less than present but dry spell during rainy season could be less severe. See **figure 46**.

3. Even though, according to future climate projection, climatic pattern on average may not change so much but extreme weather event, such as storm or heavy rain caused by tropical storm, could be more severe in the future, according to IPCC Forth Assessment Report.

4. In summary, future climate change may raise concern in changing future climate risk as **Figure 39**.

5. These changes in climate pattern may have consequences on productivity of major crops in the Tenasserim BCI corridor as follows:

1) Upland rice: the simulation result shows trend of decreasing yield with almost no year-to-year fluctuation as **Figure 40**.
2) Cassava: the simulation result shows trend of slightly decreasing yield, but with high year-to-year fluctuation as **Figure 41.**
3) Maize: the simulation result shows fluctuation in yield of future productivity of first crop (early rainy season planting) from decade to decade with slight change in year-to-year fluctuation. Second crop (mid-rainy season planting) may have decreasing trend of future productivity with almost the same year-to-year fluctuation as present as Figure 42.
4) Sugarcane: the simulation result shows trend of slightly decreasing yield, but with high year-to-year fluctuation as **Figure 43.**
5) Sugarcane: the simulation result shows trend of decreasing yield with slightly increase year-to-year fluctuation as **Figure 44.**

16. Risk and adaptation strategy assessment

Farmer group in Tenasserim BCI corridor divided to 6 groups; 1) Upland rice famer 2) Maize farmer 3) Cassava farmer 4) Perennail crop-Para rubber farmer 5) Vegetable farmer and 6) NTFP dependent group. Risk and adaptation strategy assessment are digest on farmer group and coping capacity in future, risk and adaptation strategy are different depend on farmer group. Summary on risk and adaptation strategy assessment shown in **Table 12**

17. Adaptation options planning and key supporting agencies

Adaptation option planning of agricultural system is consider from key strategy and option, benefit now and future, enabling factor, critical success factor and key agency to drive supporting policy shown in **Table 13.**

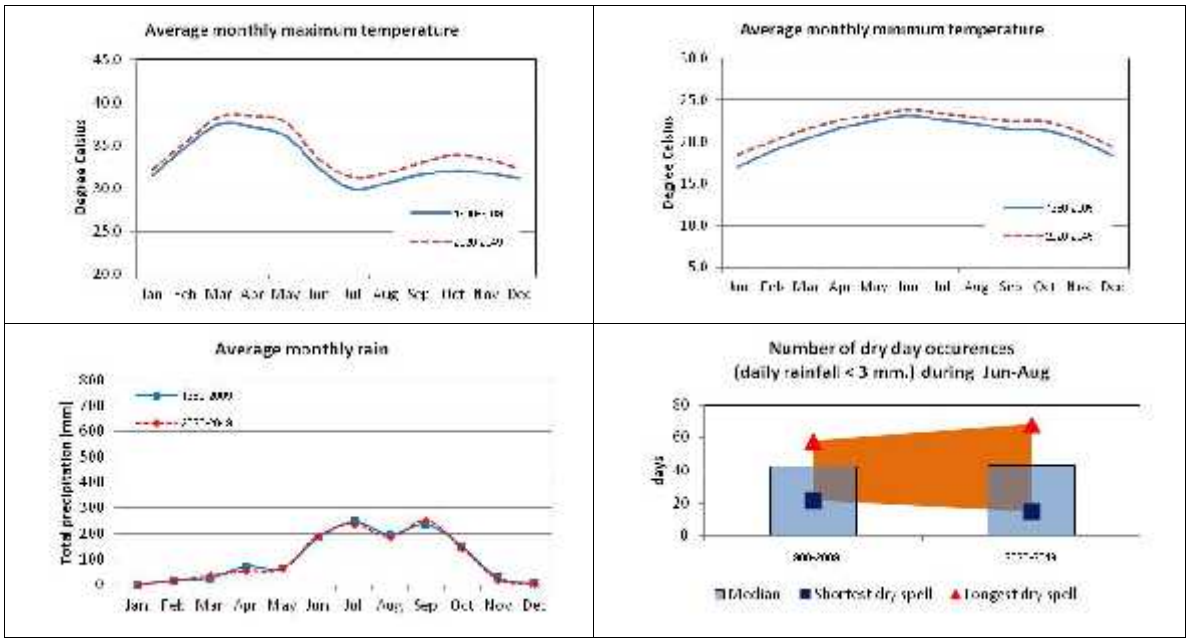


Figure 45 Future climate projection in Kanchanaburi province

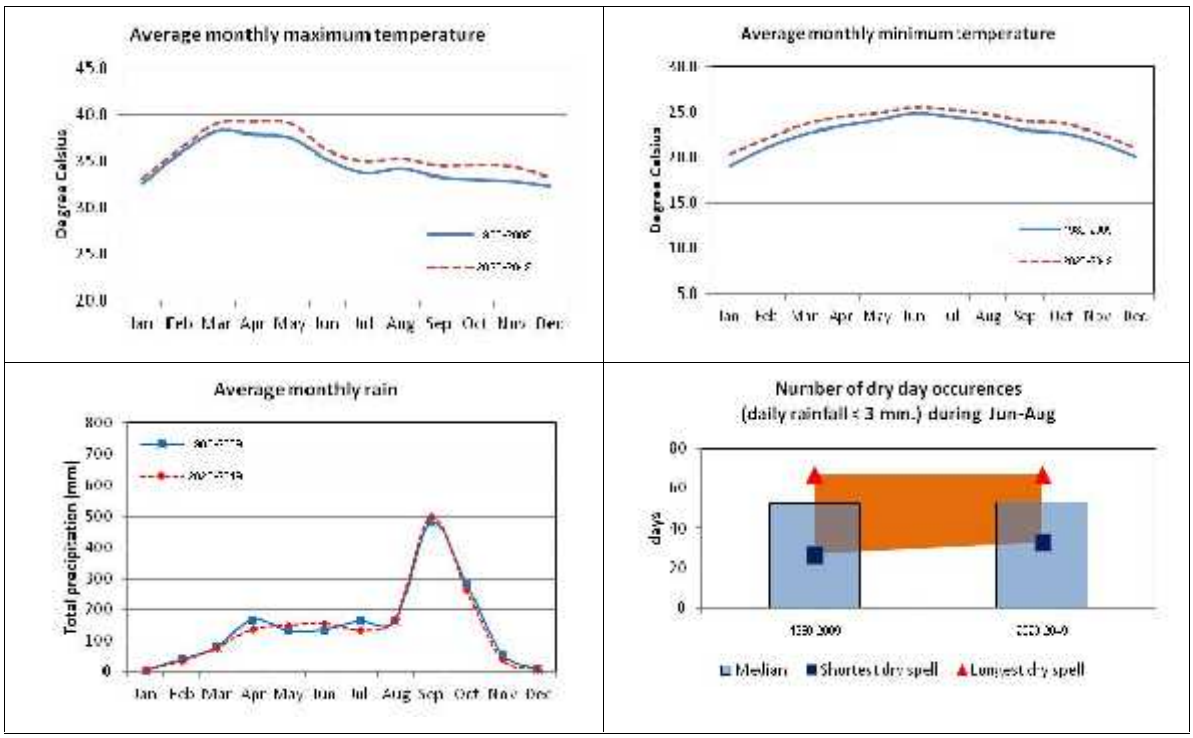


Figure 46 Future climate projection in Ratchaburi province

Table 12 Risk and adaptation strategy assessment

Farmer group	Current risk	Future risk	Key issues on coping capacity in future	Adaptation strategy
• Upland rice	• Dry spell during rainy season • Fluctuation of rainy season on-set	• Higher fluctuation of rainfall pattern during rainy season • Soil degradation, leads to lower productivity	• Cost for soil fertility improvement • Limitation in crop planning, which is based on local wisdom	Crop production planning based on better information
• Maize	• Early rainy season crop risk dry spell and fluctuation of rainfall distribution • Mid-rainy season crop risk heavy rain and flood before harvesting period	• Soil degradation, which leads to lower productivity	• Use hybrid seed, but high cost • Drought tolerance variety from Ministry of Agriculture is more affordable, but with limitation in seed production and distribution • Some areas switch to pineapple, but may have lower productivity under future climate change influence	Low cost drought tolerance variety seed (Continue maize production to serve high domestic demand, but focus on early rainy season crop by switch to variety with higher drought tolerance)
• Cassava	• Dry spell • Pest (pink mealybug)	• More severe pest situation • Higher intensity rainfall may damage production	• Need better and eco-friendly pest control	New technique in pest control – using parasitic wasps to control pink mealybug
Perennial crop – rubber *Note: The study site shows strong trend of shifting from annual crop farming to rubber*	• Rubber tapping day reduce in prolonged dry period during summertime • Starting rubber tapping reduces	• Rubber tapping day may reduce if summertime may become longer and drier • Lack of labor force	• Using foreign labor force, but may have legal issue – depends on • Rubber wood may become important	• Proper zoning and sizing for rubber plantation

Farmer group	Current risk	Future risk	Key issues on coping capacity in future	Adaptation strategy
plantation with some annual crops while rubber tree is still young (e.g. pineapple)	overall tapping period	in rubber tapping • Future market situation may change if supply will significantly increase from various countries (e.g. PRC / Lao PDR / Vietnam)	commodity to compensate lower price of rubber, but unclear land entitlement and conservation zone may prohibit wood production from rubber plantation	
Vegetable	• Dry period during summertime (March – April) • Flash flood during rainy season	• Warmer and drier summertime may affect productivity during summertime • Higher risk from flashflood in the rainy season	• Using water contained by dyke in natural river may not be sufficient • Cooperative among farmer to handle logistic and marketing does help producer in better access to market	Preparation for alternate source of water supply
NTFP dependent group *Note: Primarily bamboo basket weaving – bamboo shoot / mushroom.*	• Dry summertime affect NTFP availability • Forest fire	• Drier summertime in future • More severe forest fire	• Limitation in harvesting NTFP in conservation area	Grow bamboo to support commercial / household-scale industrial usage

Table 13 Adaptation options planning and key supporting agencies

Agricultural system	Key strategy and options	Benefit now and future	Enabling factor	Critical success factor	Key agency to drive supporting policy
Upland rice	Crop production planning based on better information	Reduce production damage	• Seasonal weather forecast *Note: Applicable to all crop, especially annual crop*	• Comprehensive information • Efficient information dissemination channel	• The Thai Meteorological Department • Department of Agriculture Extension • Local Administration Organization
Maize	Low cost drought tolerance variety seed	Reduce production damage	• Sufficient seed production from government • Reproduce seed in village	• Effective seed distribution channel • Knowledge – know how transfer	Department of Agriculture to produce initial seed and Department of Agriculture Extension to establish seed reproduction facility in the village. Note: Seed development task in Department of Agriculture had been revoked, which should be reestablished.
Cassava	New technique in pest control – using parasitic	Reduce production damage	• Know-how transfer • Early warning on	• Local reproducing facility for parasitic warp	Department of Agriculture / Department of

Agricultural system	Key strategy and options	Benefit now and future	Enabling factor	Critical success factor	Key agency to drive supporting policy
	wasps to control pink mealybug		pest situation	• Efficient information dissemination on pest situation	Agriculture Extension (Pest Management Center) to support the know-how transfer and establishment of local pest control facility Also need cooperation from private sector, e.g. support from cassava processing plant
Perennial crop – rubber *Note: The study site shows strong trend of shifting from annual crop farming to rubber plantation with some annual crops while rubber tree is still young (e.g. pineapple)*	• Proper zoning and sizing for rubber plantation	• Higher tolerance to fluctuation of weather pattern • Yield higher income compare to other annual crops – but there is concern on uncertainty of future market condition	• Initial investment for transforming annual crop farming to rubber plantation • Source of income during transforming period	• Precise zoning map and land use planning to ensure plantation in private land and no intrusion of rubber plantation into conservation zone, so rubber tree can be used for lumber	Royal Forest Department / Department of National Parks, Wildlife and Plant Conservation / Military Unit / Local Administrative Organization to define zoning and land use plan Office of the Rubber Replanting Aid Fund to assist in

Agricultural system	Key strategy and options	Benefit now and future	Enabling factor	Critical success factor	Key agency to drive supporting policy
					initial investment of rubber plantation
Vegetable	Preparation for alternate source of water supply	Production continuity	Investment in farm scale irrigation	Physical condition of farm – availability of underground water / surface water	Department of Land Development / Department of Water Resource
NTFP dependent group *Note: Primarily bamboo basket weaving – bamboo shoot / mushroom.*	Grow bamboo to support commercial / household-scale industrial usage	Production continuity	• Clear policy and regulation in NTFP harvesting and reproduction • Define agro-forestry zone to allow bamboo planting and other NTFP harvesting	• Precise zoning map and land use planning • Monitoring and control land-use and harvesting	Royal Forest Department / Department of National Parks, Wildlife and Plant Conservation / Military Unit / Local Administrative Organization to define zoning and land use plan Community Development Department to support community in weaving technique and market access

18. Policy context on future adaptation:

Key policies that need to be addressed at national level with strong linkage with local level in order to allow the agriculture system and agricultural community in the BCI corridor to better cope with risk from future change may be focused on the following issues:

18.1 Land-use planning in the BCI corridor

The main focus needs to address clarification of the locations of community as well as area which is required to support livelihood of the villager and the conservation zone. This needs to be clearly mapped out and revised by taking into consideration social dynamic of the population and settlement as well as future climate change in the area. Proper land utilization on different zones needs to be revised and planned out, jointly among various government agencies, e.g. Royal Forest Department, Department of National Parks, Wildlife and Plant Conservation, Department of Land Development, Military Unit and Local Administrative Organization. To a certain extent, the utilization of buffer area between village and conservation zone, which have yet to be further defined and designed, need to be compromised. Understanding of right on different class of land entitlement needs to be further educated to villager. Close monitoring mechanism on activity in land utilization and control mechanism on illegal change in land ownership needs to be put in place to guaranty no intrusion into the conservation area by the villager and external investor as well as to ensure that integrity of the ecosystems will be maintained.

18.2 Livelihood strategy of the people in the BCI corridor

For the fact that communities in the Tenasserim BCI corridor are located in the narrow corridor between the conservation zones and there is limitation in expansion of land utilization, therefore, development plan that addresses this unique condition needs to be developed and revised on periodically basis with target to sustained livelihood condition of the villagers. This needs be carefully and realistically planned so lifestyle and livelihood of the villager will be immune to the influence of commercially driven lifestyle and integrity of the ecosystem will not be further threatened by human activity. Such strategy development requires close collaboration and cooperation between Community Development Department and other conservation agencies, e.g. Royal Forest Department / Department of National Parks, Wildlife and Plant Conservation

18.3 Agriculture system

The current intensive farming system and the response of farmer to climate variability need to be revised in the climate change context. Sustainable farming system strategy, probably with focus on mixed farming, needs to be further enhanced in order to come up with cropping system that fit with ecosystem and yet profitable to practice and be able to provide livelihood security for villagers. Moreover, pressure from future climate change need to be factored into the strategic planning process.

19. Conclusion: Gap in adaptation policy planning

The key issue which needs to be further studied is that how and to what direction and to what extent the pressure from future social and economic dynamic as well as climate change, which includes the way villagers response to climate variability and change, may affect land utilization in the Tenasserim BCI corridor and surrounding area. The knowledge on this issue will lead to proper planning for adaptation to future change that addresses balanced coexistence between community settlement and conservation zone in the BCI area.

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