Southeast Asia START Regional Center

Risk and Vulnerability of Rain-fed Farmers in Lower Mekong River Countries to Climate Change: Case study in Lao PDR and Thailand

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Abstract:

Climate change in the lower Mekong River region may cause shift and change in rainy season pattern that would directly affect the rain-fed rice cultivation, which is the most important agricultural activity that involves large number of population in the region. This research studied changes in future climate pattern by developing regional climate scenarios under different CO_2 concentration conditions, using regional climate modeling technique. Vulnerability of rain-fed farmer was assessed based on the analysis of changes in rice productivity under different climate scenarios and how it may affect farmer's livelihood and risk condition to climate impact. The case study in Lao PDR shows that farmer in Lao PDR is resilience to climate impact as more than 80% of them is in low risk category throughout all climate impact scenarios, even though substantial amount of population may be considered vulnerable under some conditions. In Thailand, climate change has favorable impact on rice cultivation, but it cannot cover the influence of potential extreme climate event. Only about one-third of the farmer in Thailand are considered low risk to climate impact and substantial amount of population are vulnerable from impact of climate change under influence of extreme climate event. The assessment shows that vulnerability to climate change impact of the farmers in the lower Mekong River region vary from place to place, according to degree of climate impact as well as socio-economical and physical condition in each location.

Keywords:

Climate change, climate impact, vulnerability, rain-fed agriculture, farmer livelihood, Mekong River region

Introduction: Impact of Climate Change on Vulnerability of Rain-fed farmer in Lower Mekong River region

Climate change caused by the Greenhouse Effect is a long-term shift or alteration in the climate of a specific location or regional or globally. Such shift or alteration may be upon various features associated with climate, particularly the temperature, wind pattern, precipitation. Climate change also includes change in the variability of climate. One of the main drivers for this phenomenon is the rising of Greenhouse Gas in the Earth's atmosphere, particularly Carbon dioxide (CO_2) that has been rising sharply since the industrial revolution era. It has the potential to alter the ability if the Earth's physical and biological systems to provide good and services essential for sustainable economic development. Among various systems that may be at stake from the impact of climate change is the agriculture system, particularly the rain-fed agriculture as it mainly relies upon climate condition. (IPCC, 2001 a, b).

Agriculture is one of the most important activities in the Lower Mekong River region, particularly Lao PDR and Thailand. For Lao PDR, agriculture products accounted for 47.2% of total GDP of US$2.8 billion in the year 2003 (The World Bank) and 76.3% of total population of 5.7 million people are in the agricultural system (UN-ESCAP). For Thailand, agriculture product accounted for 9.9% of total GDP of US$41.8 billion in the year 2003 (The World Bank), however, 44.9 % of total population of 63.1 million people are in the agricultural system (UN-ESCAP). Majority of the agricultural activity in this region is based on the rain-fed system as irrigated area is limited, which only accounted for 19% and 30% of total harvested area in Lao PDR and Thailand respectively (Barker et al, 2004). Among various crops, rice is considered as one of the most important crop as it is main source of food for the countries in the region, therefore, impact of climate change on rain-fed rice cultivation, may cause wide-scale impact to the socio-economic condition in these countries.

The rain-fed farmer in the lower Mekong River region could be among the most vulnerable group as their livelihood depends heavily on their annual on-farm productivity, particularly the rice cultivation, which is directly exposed to climate risk. In addition, household economic condition of these farmers is also considered to be in the poor group in the society, thus may cause them to have limited resource or other capacity to cope with impact of climate variability and change. However, risk profile and vulnerability of the farmers may vary from place to place due to different degree of climate change impact and also according to the socio-economic condition as well as lifestyle of each community. In addition, the surrounded natural environmental condition that may contribute to the coping capacity of the farmer in the study areas also is important factor to the risk and vulnerability to the climate threat of the community (IPCC 2001, b). This paper covers the study of farmers in 2 countries, where socio-economic condition is greatly different, which can be indicated by the Gross National Income (GNI) figures of the two countries. In the year 2003, Lao PDR's GNI per capita was $380, while Thailand's GNI per capita was $2,550 in the same year (The World Bank).

This paper is the result of the study under the research project: Assessment of Impact and Adaptation to Climate Change, regional study AS07 and prepared by following the concept in Adaptation Policy Framework for Climate Change of United Nations Development Programme (UNDP, 2004). It would give overview of changing in climate pattern in the lower Mekong River region and its impact on rain-fed rice productivity at the study sites. This paper also includes analysis result from quantitative approach assessment to explain the risk and vulnerability of farmer to future climate change, which took local socio-economic condition into consideration. The framework of this study can be described by the following diagram;

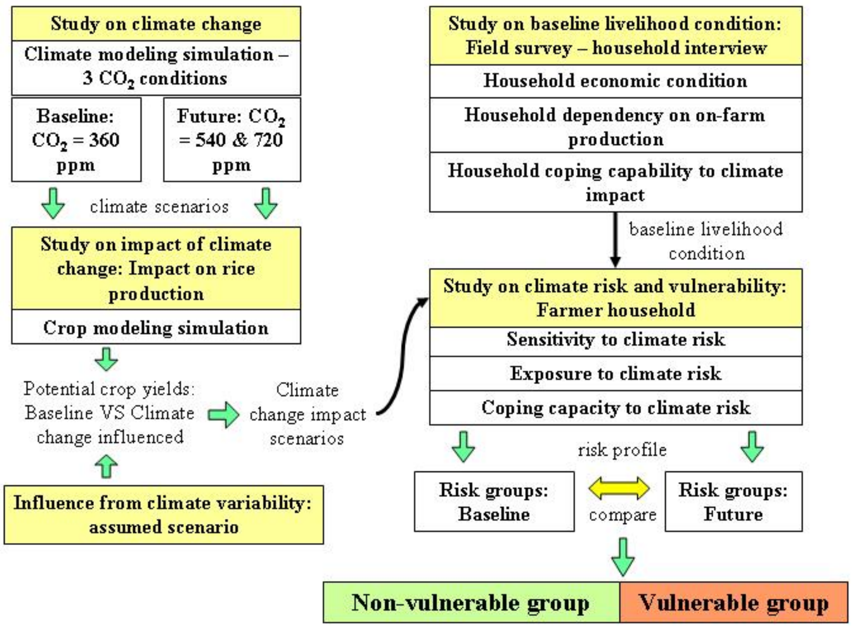


Figure 1: Framework for climate risk and vulnerability assessment

2.0 Brief description of study sites

This study of climate change in the Mekong River basin was mainly focused on 2 countries in lower Mekong River region, Lao PDR and Thailand. The selected study sites for this study are Savannakhet Province in Lao PDR and Ubonratchathani Province in Thailand as shown in the map below, figure 2.

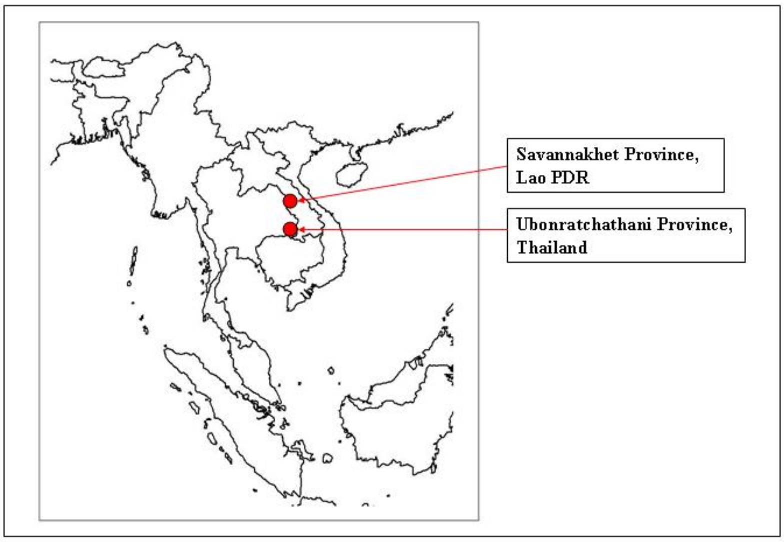


Figure 2: The study sites in Lao PDR and Thailand

2.1 Study site in Lao PDR: Savannakhet Province

Lao PDR locates in the center of the Southeast Asian peninsular, between latitude $13^{0}54'$ to $22^{0}03'$ North, and between longitude $100^{0}05'$ to $107^{0}38'$ East, with total area of 236,800 km^2. The length from north to south is approximately 1,000 km, and the width from east to west is approximately 470 km.

Savannakhet province locates in the central to southern part of Lao PDR, having a total area of 21,774 km^2 and consists of 15 districts. The topography of Savannakhet province is lowland and slope slightly from east to west toward Mekong River. Savannakhet province has the largest area of rice fields in the country, which is 139,582 ha or 19% of total rice fields in Lao PDR (Committee for Planning and Cooperation, 2003). Total population of Savannakhet province is 811,400 people or approximately 15% of the country population, which is the highest populated province in the country and mostly is farmer.

Songkhone district locates in the southwest of Savannakhet province. It is the largest district in the province, with the total area of 1, 406 km^2. The district consists of 142 villages, and 13,919 households, which makes the total population of 86,855 people. Most of the population is farmer and grow rice mostly for own consumption with minor commercial on the excess production. The rice farming system is rain-fed rice farming with single crop cycle per year.

Four villages selected as study area namely, Seboungnuantay, Lahakhoke, Khouthee, and Dongkhamphou villages. The study site has total area of 1,851 ha with the population 2,490 people in 434 households.

2.2 Study Site in Thailand: Ubonratchathani Province

Ubonratchathani province locates in the lower North-Eastern region of Thailand. The province covers area of 16,112km^2. Most of the land areas in Ubonratchathani province are highlands, about 68 meters above the sea level, with Mekong River as the border line between the province and Lao PDR, as well as high mountains as the border line between Lao PDR and Democratic Republic of Cambodia. However, the overall areas in Ubonratchathani province are highlands with slopes from eastern part, with mixed sandy soils of low fertility. Also, there is Chi River coming to merge with Mun River, before passing through Ubonratchathani province from the West to the East, and downing into Mekong River at Khong Chiam district. In 2005, Ubonratchathani maintained total population of 1,774,808 persons in 432,923 households, which mostly are in the agricultural sector (Department of Provincial Administration, Ministry of Internal Affairs, Thailand)

The study site is part of the Ubonratchathani Land Reform Area (ULRA), covers 55,000 ha of gently undulating farm land on the right (eastern) bank of the Dome Yai River. This area has three slope classes, namely; level to gently sloping, sloping to undulating; and undulating to rolling. Soils are generally sandy and of low fertility. Korat series is the major soil in this area. These soils are almost well drained and strongly acidic.

Most of the area is cultivated for paddy, with some areas for upland crops. There are small patches of degraded forests. Water is plentiful in the wet season, but severe shortage occurs in the dry season. Average rainfall is about 1,600 mm, 90 percent of which fall in the period May to October. The average temperature is from a minimum of 17.0 $^{\circ}$C in December and January to a maximum of 35.9 $^{\circ}$C in the March and April. There is no source of irrigation, except some small-scale in some harvested areas, so cropping is mainly a wet season activity (Ubonratchathani Province Administration).

The study site is divided into 5 zones as follows:

Zone	Characteristics of zone	Village selected
# 1	The area is deep sand. Cropping patterns are rice + plantation and forest. The forest trees are eucalyptus and cashew nut.	1. Ban Mak Mai 2. Ban Mek Yai 3. Ban Khok Pattana
# 2	This area lies along the Lam Dom Yai River. Soil has high fertility. It is a wet area. The dominant cropping system is rice and upland crop (field crop) such as vegetable, cassava or kenaf.	1. Ban Fung Pa 2. Ban Muang 3. Ban Bung Kham 4. Ban Bua Thaim
# 3	The area is partly upland rice. The cropping system is an encroached forest area.	1. Ban Nong Sanom 2. Ban Udom Chart 3. Ban Pa Rai 4. Ban Non Sawang
# 4	This area has an intensive rice system. Mostly commercial farming practice. There is low tree density in the area.	1. Ban Bua Ngam 2. Ban Nong Waeng 3. Ban Rat Samakee 4. Ban Non Yai
# 5	This area is similar to zone # 3 but has more lowland characteristics. Rice area is an encroached forest.	1. Ban Pa Pok 2. Ban Sok Seang 3. Ban Non Deang

Table 1: Zoning in the study site in Thailand

3.0 Projected climate change and its impact

In order to assess risk of future climate change, future climate scenarios were developed and analyzed, so future changes in climate pattern would be understood and used as foundation in the study of its impact on biophysical system. The study on impact of the future climate change in this study was focused on how future climate condition may affect rain-fed rice cultivation system because rice productivity was selected as a key proxy for the analysis of risk and vulnerability from climate impact. The study also took the opinion of farmers from the field interview regarding their concern about climate risk into consideration, which is mainly the influence of extreme climate event and incorporate it into the climate change impact scenarios, which was based on changes in rice productivity, for the analysis of farmer's risk and vulnerability to climate change.

3.1 Climate change in the lower Mekong River region

This study developed a regional climate scenario by adopted the approach of using regional climate modeling (RCM) to simulate the future climate condition for Southeast Asia region. This approach gives advantage over the widely used GCM downscaling approach as the result from the regional climate model generated at higher resolution; furthermore, the output in daily climate data is also useful for further analysis on impact of climate change on various systems. The Conformal Cubic Atmospheric Model (CCAM), which is the secondgeneration regional climate model developed specifically for Australasian region by the Commonwealth Science and Industrial Research Organization (CSIRO), Division of Atmospheric Research in Australia. (McGregor et al, 2001), was used. The model uses the principle of stretched coordinate of a global model instead of uniform latitude-longitude grid system and runs for 18 vertical levels including the stratosphere. It has also been evaluates in several international model inter-comparison exercises to be among the best climate model for Asian region.

The future climate scenarios were simulated based on the condition of different atmospheric CO_2 concentration levels. The atmospheric CO_2 concentration at 360 ppm, which was the CO_2 concentration level during the 1980s, was used for the simulating of baseline condition climate scenario. The future climate scenarios were simulated at CO_2 concentration of 540 ppm and 720 ppm (or at 1.5 time and double of baseline condition). Under SRES scenario A1FI, the world atmosphere would reach CO_2 concentration level of 540 ppm and 720 ppm at around the middle and toward the end of this century (approximately in the 2040s and 2070s respectively) (SRES, 2000). The result of the future climate simulation is the climate scenario with daily climate parameter that can then be used to assess the future impact on various biophysical systems and the output resolution was set at 0.1 degree (approximately 10 km).

The climate scenarios simulated from the CCAM model need to be adjusted to match local condition. The adjusting focused on the precipitation and was based on observed data from weather observation stations throughout the region. Statistical adjusting was based on cumulative rainfall using a non-linear function (log-log regression) to exponentially increase the daily variability. An arbitrary rainfall threshold of 3 mm/day was applied to reduce number of rainy days. The focused area of this study is the lower Mekong River Basin, however, due to the lack of sufficient data from Cambodia while this study was conducted, the climate scenario in Cambodia area has been excluded until sufficient data can be further obtained.

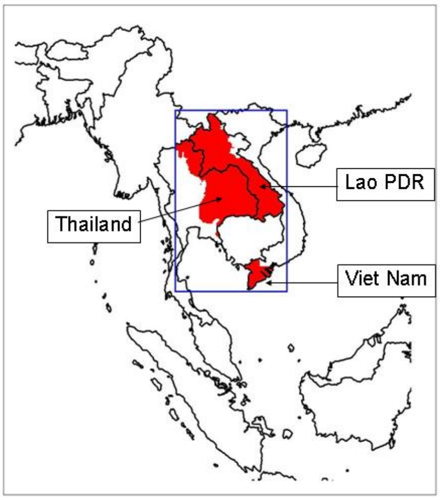


Figure 3: Geographical coverage of the analysis on climate change in the lower Mekong River basin - Most part of Lao PDR, Northeastern part of Thailand and Mekong River delta in Viet Nam

Under this simulation, the climate scenario shows that the region tends to get slightly cooler under climate condition when CO_2 concentration is at 540 ppm and would change to be warmer under climate condition when CO_2 concentration is at 720 ppm. The precipitation shows upward trend throughout the region as the CO_2 concentration raise. The precipitation will be higher throughout the region at climate condition under CO_2 concentration at 540 ppm and even higher at 720 ppm, particularly in the eastern and southern part of Lao PDR. The summarized result from the simulation is shown in the figures below:

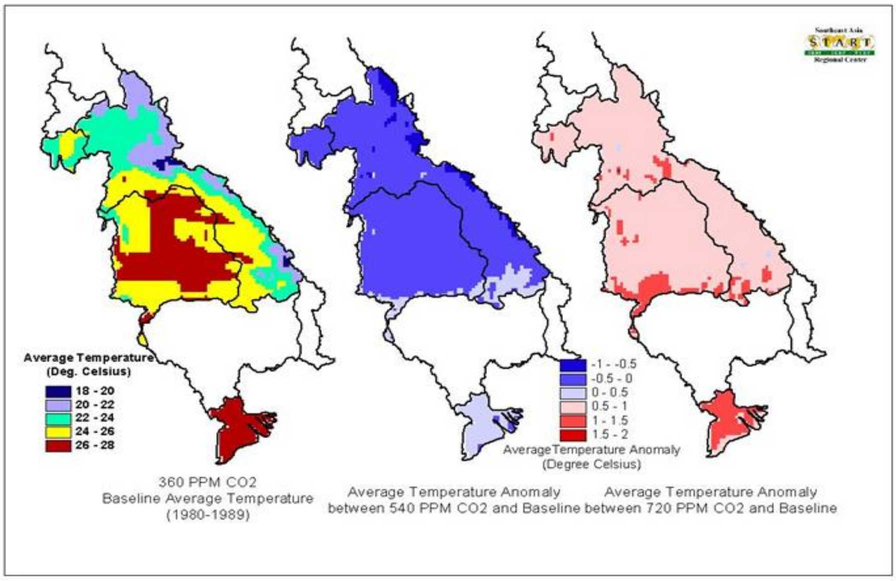


Figure 4: Average temperature in the lower Mekong River region and change in the future

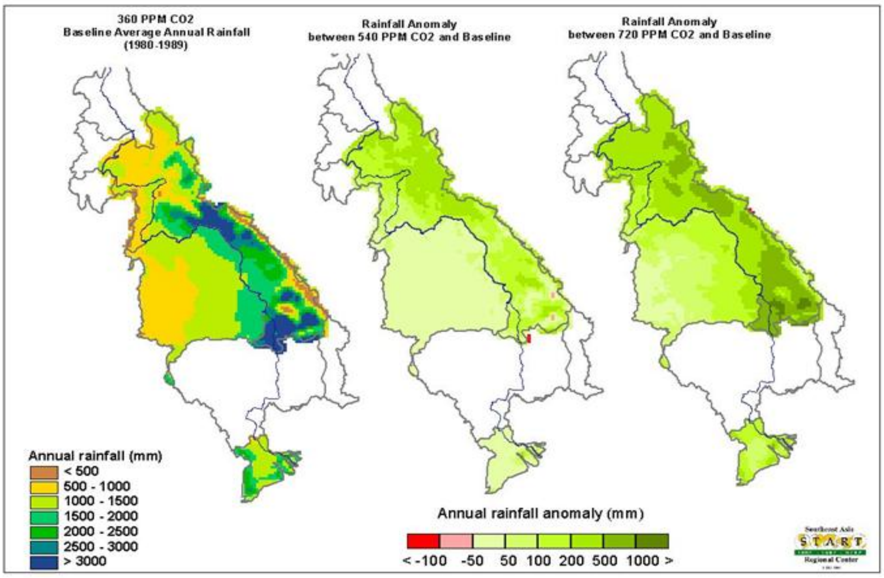


Figure 5: Average rainfall in the lower Mekong River region and change in the future

3.2 Climate change scenario in the study site areas

At the study site in Lao PDR, the Savannakhet Province, the rainy season tends to be slightly longer as the onset would shift to be approximately 10 days earlier in the climate condition under CO_2 concentration of 540 ppm, but will settle back to the same condition as baseline when CO_2 concentration rise higher to 720 ppm. Even though the rainy season will be longer in the climate condition under CO_2 concentration of 540 ppm, but there is no substantial change in the total rainfall amount, however, total rainfall will increase by about 20% in the climate condition under CO_2 concentration of 720 ppm. From the simulation, 10-year averaged annual rainfall during baseline period in Savannakhet province is 1,624 mm. and it will rise to 1,780 mm. and 2,129 mm. in the climate condition under CO_2 concentration of 540 and 720 ppm, respectively. Temperature under influence of climate change will only change within the range of +/- 1 degree C as more cloud overcastting could compensate for less temperature rise.

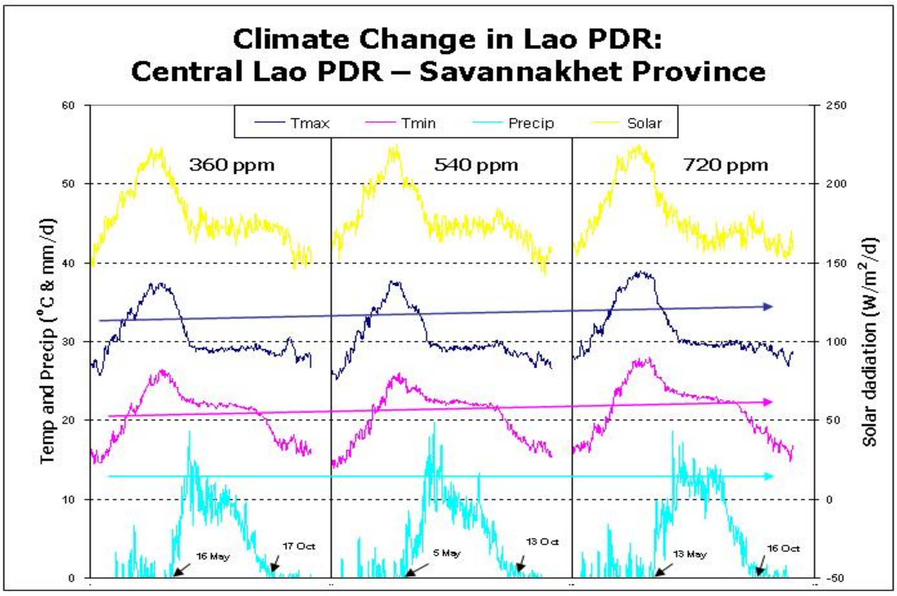


Figure 7: Summary of climate change at the study site in Lao PDR

In Thailand, at Ubonratchathani Province, the climate change may cause onset of the rainy season to start much earlier, by about 20 days, at both climate conditions under CO_2 concentration of 540 and 720 ppm. From the simulation, 10-year averaged annual rainfall during baseline period in Ubonratchathani province is 1,688 mm. and it will rise to 1,734 mm. and 1,901 mm. in the climate condition under CO_2 concentration of 540 and 720 ppm, respectively. In addition to that, the mid-season dry spell at climate condition under CO_2 concentration of 540 ppm seems to be more prominent. The temperature in the area would remain almost unchanged, which is the same condition as the study site in Lao PDR, perhaps because more cloud overcastting could compensate for less temperature rise and make the temperature fluctuate within the range of +/- 1 degree C

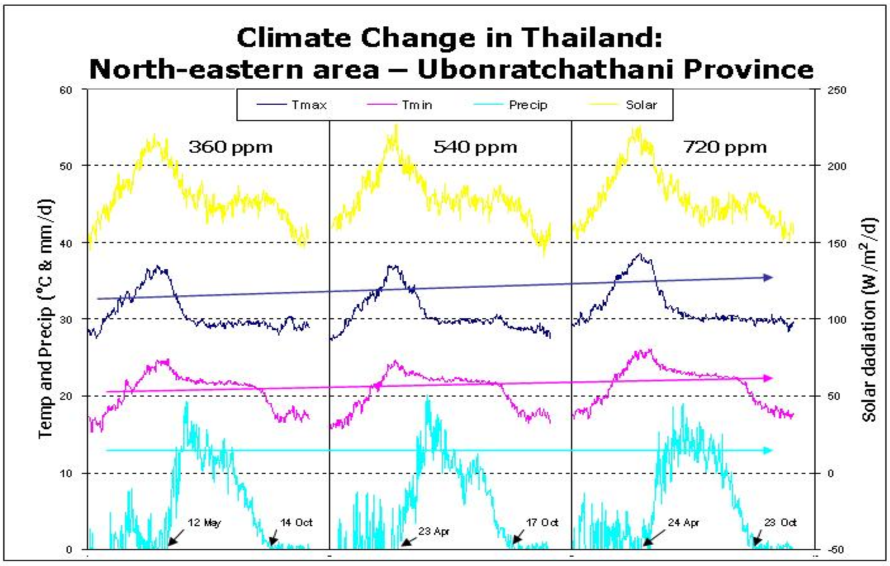


Figure 8: Summary of climate change at the study site in Thailand

3.3 Impact of climate change: rain-fed rice cultivation

Rain-fed rice cultivation system in both Lao PDR and Thailand is single crop cycle per annum due to the length of the rainy season and the productivity depends upon distribution and amount of rainfall. In order to understand how climate change may affect the rain-fed rice cultivation in the region, this study used crop model to simulate future potential yield of rice cultivation in the study sites under different climate scenarios. The simulation used Decision Support System for Agro Technology Transfers (DSSAT version 4.0) crop modeling software (Hoogenboom et al, 1998) with the climate scenarios generated from the CCAM climate model as input. The crop modeling software used daily climate data, including maximum and minimum temperature, precipitation, solar radiation, etc. and coupled with crop management scheme and soil property of the study sites to calculate the yield of rice cultivation. By using daily climate data for the simulation process, this study is able to capture the impact of climate change on rain-fed rice productivity not only in terms of the change in degree of intensity of each climate parameter, e.g. increase or decrease in rainfall or temperature, but also change in temporal aspect too, e.g. shifting of the onset or changing on the length of rainy season or change in the pattern of mid-season dry spell period, etc.

The crop management scheme used in the simulation under this study assumed homogeneous practice in each site. Crop managements comprised of crop cultivars, planting field, initial condition of the field before planting, planting detail (method and plant density), water management, and both organic and inorganic fertilizer application.

The impact of climate change, according to these climate change scenarios as per simulation by the CCAM climate model, shows slight negative impact on the rain-fed rice production in Lao PDR. The simulated yield of rice productivity in Savannakhet province would reduced by nearly 10% under climate condition at CO_2 concentration of 540 ppm, but will rise back to almost the same level as the baseline condition under the climate condition when CO_2 concentration rise to 720 ppm.

In Thailand, the simulation of rice productivity at the study sites in Ubonratchathani province shows that the climate change has positive impact on the rice production in the area. The crop simulation shows the upward trend in the yield of rice production under future climate condition when CO_2 concentration rises from 360 ppm through 540 ppm to 720 ppm. The increase in productivity vary from zone to zone, ranged from slightly increased by approximately 1% to 7% under climate condition at CO_2 concentration of 540 ppm to higher percentage under future climate condition when CO_2 concentration rises to 720 ppm, which would increase by approximately 1.5% to 15%.

The result from crop model simulation is shown in the table below;

Change in rice cultivation productivity under different climate scenarios					
					Remark: Rice yield shown in kg/ha
Location	**Climate condition under different atmospheric CO_2 concentration**			**Change in % compare to baseline period**	
	360 ppm (Baseline)	**540 ppm (1.5xCO_2)**	**720 ppm (2xCO_2)**	**540 ppm**	**720 ppm**
Lao PDR					
Savannakhet Province					
Songkhone District	2,534.90	2,303.20	2,470.10	-9.14%	-2.56%
Thailand					
Ubonratchathani Province					
Zone 1	1,154.39	1,235.14	1,330.85	7.00%	15.29%
Zone 2	1,919.61	2,002.15	2,072.04	4.30%	7.94%
Zone 3	2,363.70	2,407.62	2,438.92	1.86%	3.18%
Zone 4	2,542.32	2,575.03	2,591.89	1.29%	1.95%
Zone 5	3,024.18	3,051.44	3,068.82	0.90%	1.48%

Table 2: Simulated yield of rice productivity at the study sites under different climate scenarios

The result from the simulation is still somewhat differ from the actual yield that has been recorded from field interview, perhaps due to the assumption in the crop management and accuracy of other dataset, particularly soil property, which were used for the simulation. However, these figures are only meant to be indicator for the future trend and degree of climate impact on rice productivity in the study sites for further risk and vulnerability assessment.

3.4 Future climate risk: Farmer's concerns

In addition to the changes in climate pattern that may affect the agriculture system, the extreme climate event is also an important climate risk that farmer highly concern. Interview with the farmer in the study sites had revealed that nowadays the farmer has already been threatened by impact of climate variability in many ways; of which combined impact should be incorporated in the risk and vulnerability assessment process.

Some of the extreme climate events that threaten the rain-fed rice cultivation in the study areas may include prolonged mid-season dry-spell, which usually occurs after the rice planting or transplanting, that can damage young planted rice and cause higher cost of production in replanting or additional cost in water procurement to maintain the rice plant while waiting for the rain. In worse case, if the mid-season dry-spell is prolonged over long period of time, the farmer may loss production opportunity in that crop season as it would be too late for the replanting and rainy season will end before the rice is mature.

On the other hand, heavy rainfall also cause flood in the area, which is also high threat to the rice cultivation in the farmer's opinion. Floods in this area do normally occur around the month of October and November, which is during middle of the crop season or toward the end of the crop season, prior to the harvesting. In most cases, flood had caused severe damage to the rice production, which is difficult to recover as it is too late in the rainy season to replant the rice. Late ending rainy season may also damage the harvesting or cause higher cost in the additional drying process.

While impact of averaged changing in climate characteristic on future yield of rice productivity can be simulated using crop modeling technique with the available climate scenarios, however, the impact of future fluctuation in climate variability on rice cultivation would need the study on the pattern and probability of future extreme climate anomaly. Such study would require climate scenario simulation that cover longer period of time than the scenarios generated under this study in order to understand the probability on frequency and magnitude of potential extreme climate event in the future.

For the purpose of developing future climate change impact scenarios that incorporate the influence of climate variability, which would be used for the risk and vulnerability assessment, this study adopted the conclusion from the group discussion with farmer and community leaders in the study sites in selecting degree of impact from extreme climate that represent the concerns of farmer. In most cases, loss in rice productivity from approximately one-third of the season production or higher is considered as severe situation, which would significantly affect farmer's livelihood or push them to react to the situation. Therefore, the loss in rice production by 30% was used as proxy of extreme climate event from future climate variability impact.

4.0 Assessing climate risk and vulnerability: Rain-fed farmer

The assessment on risk and vulnerability to climate impact in this study was based on multiple criteria and each criterion was assessed by multiple indicators as the nature of risk and condition of livelihood is a complex issue beyond the capacity of any single indicator or criteria to describe. The three criteria selected for this study in the assessing farmer's risk to climate impact are as follows;

- Household economic condition, which was used to measure the sensitivity of the farmer household to climate impact.
- Dependency on on-farm production, which was used to measure the exposure of the farmer household to climate impact.
- Coping capacity to climate impact, which was used to measure the coping capacity of the farmer household to climate impact.

These criteria when combined together would indicate the degree of risk of rain-fed farmer to climate impact. The concept in evaluating risk profile and risk grouping as well as determining risk group is described in the diagram below;

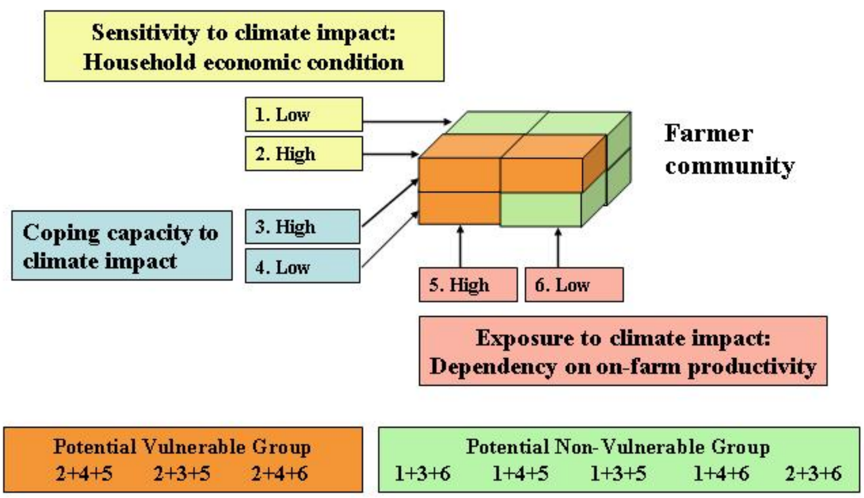


Figure 8: Framework for the climate risk analysis - Multi-criteria approach

According to this conceptual framework, the farmer households which may be at risk and has high potential to be vulnerable to impact of climate change / variability are those who are poor or have unstable or non-sustained household economic condition and highly rely on rice production to maintain their livelihood, in addition, they may also have limited coping capacity to cope with climate impact too.

In order to determine the risk profile of farmer household from these 3 criteria, a set of indicators was put up to evaluate the condition of each criterion as follow:

Criteria	Indicator	Measurement	Scoring	Min score	Max score
Household Economic condition	Household sustainability condition	Total household production (or total household income) / Total household consumption (or total household expenditure)	>1=0, 1-0.7=1, <0.7=2	0	2
	Household production resource condition (1)	Farmland own / rent	Own = 0, Rent = 1	0	1
	HH production resource condition (2)	Farmland/capita (ha) - use 0.8ha for Lao PDR and 0.65 for Thailand as threshold in analysis (size of farmland that can produce productivity to support annual food consumption for one family member)	>= 0.8 = 0, < 0.8 = 1 (Thailand >= 0.65 = 0, < 0.65 = 1)	0	1
			Sub-total	**0**	**4**
Household Dependency on On-Farm Production	Ability to use non-climate sensitive income to support household livelihood	Total household consumption / Income from livestock + Fixed off-farm income	>1=0, 1-0.7=1, <0.7=2	0	2
	Dependency on rice production to sustain basic needs	Total rice production / Total food expenditure (or Total household fixed expenditure)	=1=0<1-0.7=1<0.7=2	0	2
			Sub-total	**0**	**4**
Coping Capacity	Ability to use non-farming income to maintain livelihood	Total household consumption + Total cost of production / Total household saving + Total off-farm income + Income from livestock + Extra income	<=1 = 0, >1-1.3 = 1, >1.3 = 2	0	2
	Ability to use non-farming income to maintain household basic needs	Total food expenditure (or Total household fixed expenditure) / Total household saving + Total off-farm income + Income from livestock + Extra income	<=1 = 0, >1-1.3 = 1, >1.3 = 2	0	2
			Sub-total	**0**	**4**
			Total		**12**

Table 3: Indicators used in evaluating farmer's risk to climate impact

This assessment took under consideration the contribution of rice production to the household's livelihood condition into the analysis. The information from household interview would be analyzed according to the table above and farmers would then be grouped together according to their risk scoring, which would be categorized into 3 groups:

- The household which risk score is between 0-4 is classified as low risk category.
- The household which risk score is between 5-8 is classified as moderate risk category.
- The household which risk score is between 9-12 is classified as high risk category.

Social vulnerability is a negative state endured by groups or individuals. In the broadest sense, vulnerability occurs because livelihood and social systems are exposed to stress and are unable to cope with that stress (Adger et al, 2001). Vulnerable populations may be defined as those whose livelihood is sensitive to climate impact and expose to the climate risk with only limited capacity to protect themselves from environmental hazards, in particular from extreme climate events, such as flood. In this study, change in rice productivity was used to represent climate stress that would affect the household economic condition as well as degree of household dependency on on-farm production to maintain livelihood condition, which would affect the household risk to climate impact at the end. In this study, the vulnerable household is defined as those whose risk score under climate change impact is changed from baseline condition.

The calculation on household risk to climate change impact was based on change in rice productivity of each household according to climate impact scenarios, which derived from the simulation and also coupled with influence of climate variability in the case of impact from extreme climate event, as states in the table below;

Changes in rice productivity under climate change impact

	Climate condition under CO_2 concentration 540 ppm		**Climate condition under CO_2 concentration 720 ppm**	
	Normal condition	**Extreme climate event**	**Normal condition**	**Extreme climate event**
Lao PDR:				
Savannakhet Province				
Songkhone District	-9.14%	-39.14%	-2.56%	-32.56%
Thailand:				
Ubonratchathani Province				
Zone 1	7.00%	-23.00%	15.29%	-14.71%
Zone 2	4.30%	-25.70%	7.94%	-22.06%

Zone 3	1.86%	-28.14%	3.18%	-26.82%
Zone 4	1.29%	-28.71%	1.95%	-28.05%
Zone 5	0.90%	-29.10%	1.48%	-28.52%

Table 4: Climate change impact scenarios - changes in rice productivity

The field assessment was conducted by field interview that covered 560 farmer households in Thailand and 160 farmer households in Lao PDR. The field assessment activity in Thailand was conducted by team of researchers from Faculty of Agriculture, Ubonratchathani University during the month of May - July 2004. The assessment in Lao PDR was conducted by researcher from National University of Laos during the month of September 2004.

4.1 Baseline risk of farmer household to climate impact

From the assessment, the information from household survey was summarized and analyzed according to the table 3. The analysis shows that farmer in Lao PDR are highly resilience to climate risk as most of the surveyed population, which is more than 80%, is classified in the low risk group and only less than 5% of the population is high risk to climate impact. However, on the contrary, farmer in Thailand is riskier to climate impact as only about one-third of the surveyed population is classified as low risk and approximately 15%-25% are in the high risk category. The moderate risk group is the largest group of the population, which in some study sites is as many as half of the total surveyed population.

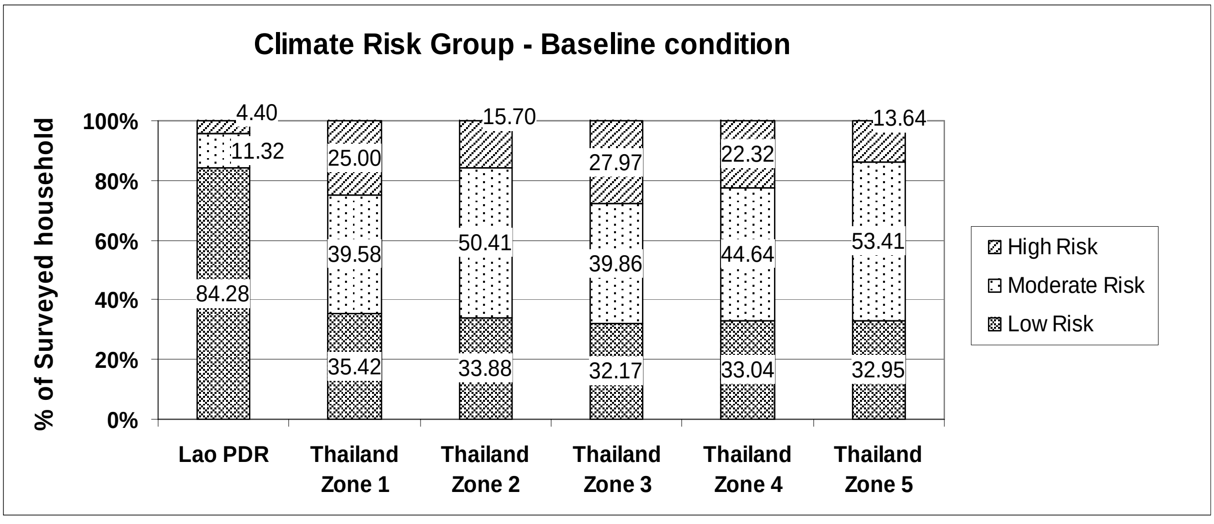


Figure 9: Risk groups to climate impact in each study sites

From the assessment, the analysis shows that the low risk groups in every location are highly resilience to climate impact and their risk profile is substantially differ from the moderate and high risk group. Their risk score is low in every criterion. In most cases, the risk score of the riskier groups differ significantly in the areas of the exposure to climate impact and the lack of coping capacity to climate impact, particularly the cases of the moderate and high risk groups in Thailand. On average, total risk score of the low risk groups in both Lao PDR and Thailand are approximately around 2 points, while the total risk score of the moderate and high risk group are around 7 and 10 points, respectively. The risk profile of each risk group in each location is shown in the chart below;

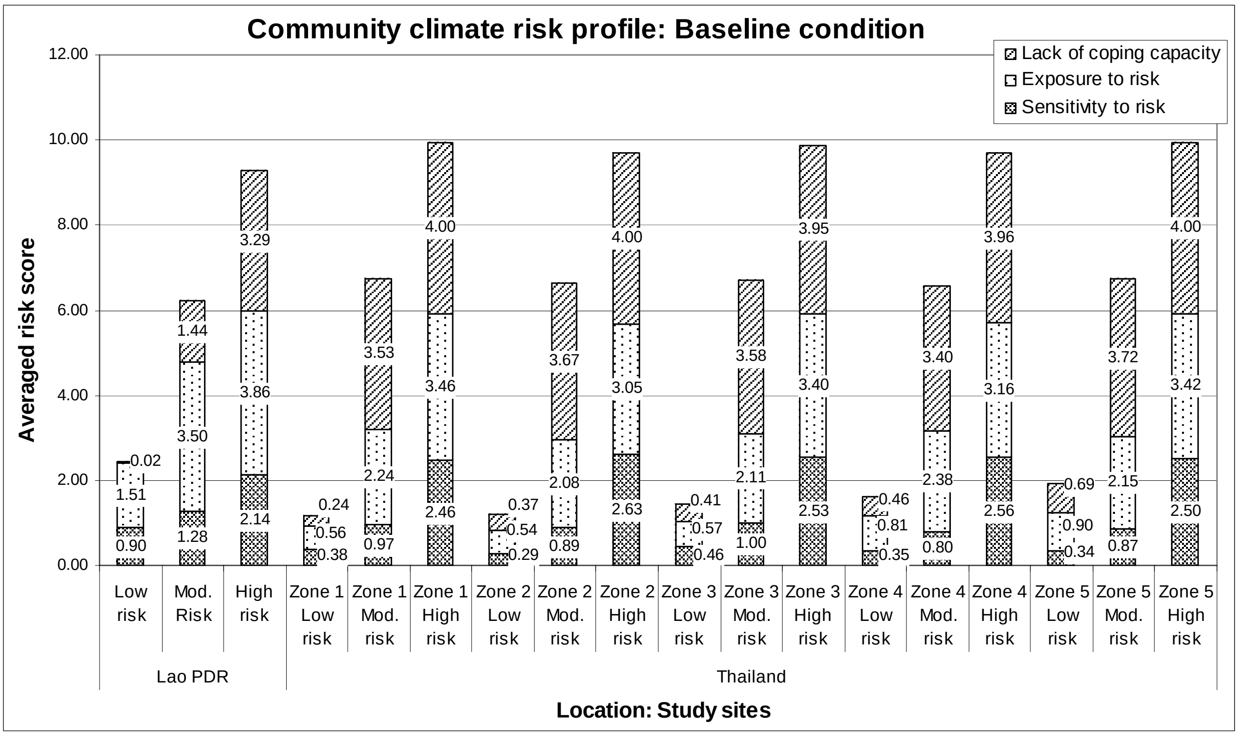


Figure 10: Profile of risk to climate impact of each group in each study site

The rain-fed farmer in Lao PDR is considered well sustained, partly because their household productivity is diversified over various activities, both on-farm and off-farm sources. As per interviewing with farmer in the study site, the rice production does not dominate the household productivity, as it only accounts for less than one-third in the total household productivity of the vulnerable group and it is even lower in the non-vulnerable group. Another advantage of these farmers for living in the rural area of Lao PDR is that, due to the low population, the natural system still be able to provide sufficient products to be alternate source of food as well as excess product that can be converted to or exchange for other products required for daily necessity or even cash. In addition to relying on natural ecosystem as coping mechanism, both non-vulnerable and vulnerable groups of farmers in Lao PDR also have other savings in form of reserved rice and cash convertible livestock to help them cope with impact from climate threat, even though cash saving is almost non-exist. On the other hand, the debt level of the farmer in Lao PDR is also virtually none, partly due to the limited availability of source of loan or other institutional lending mechanism, as well as social norms that is against indebting (Boulidam, 2005).

From the field survey, the interviewed data revealed that the farmer in Thailand has very limited coping capacity, by having little saving and also high debt. In addition, according to the survey data, the farmer in Thailand also highly relies on income from rice production with little diversification. These conditions may cause them to be riskier to climate impact.

4.2 Climate risk and vulnerability to climate change: Climate condition under CO_2 concentration 540 ppm

By taking changes in rice productivity as proxy of impact of climate change into the analysis by recalculating the risk scoring of each surveyed household based on climate change impact scenarios as stated in table 4, the analysis results shows that the profile of the risk groups has changed slightly.

In Lao PDR, most population, which is more than 80%, still are under low risk category. Approximately 10% is in moderate risk and slightly over 5% is in high risk categories. There is no substantial different between the situation under normal condition and also the condition with influence of extreme climate event.

In Thailand, there is no substantial change in the risk groups, which the moderate risk group is still the largest group in most cases, except in Zone 3 under influence of extreme event which the high risk group has become the largest group in the community. However, in case of the influence in extreme climate event, even though the low risk groups only slightly change in every zones, but there are noticeable changes in the moderate and high risk group, where there are number of household that move from moderate to high risk group (also see Appendix 1: Climate risk groups by study sites).

The risk group to climate change in climate condition under CO_2 concentration of 540 ppm is shown in the chart below;

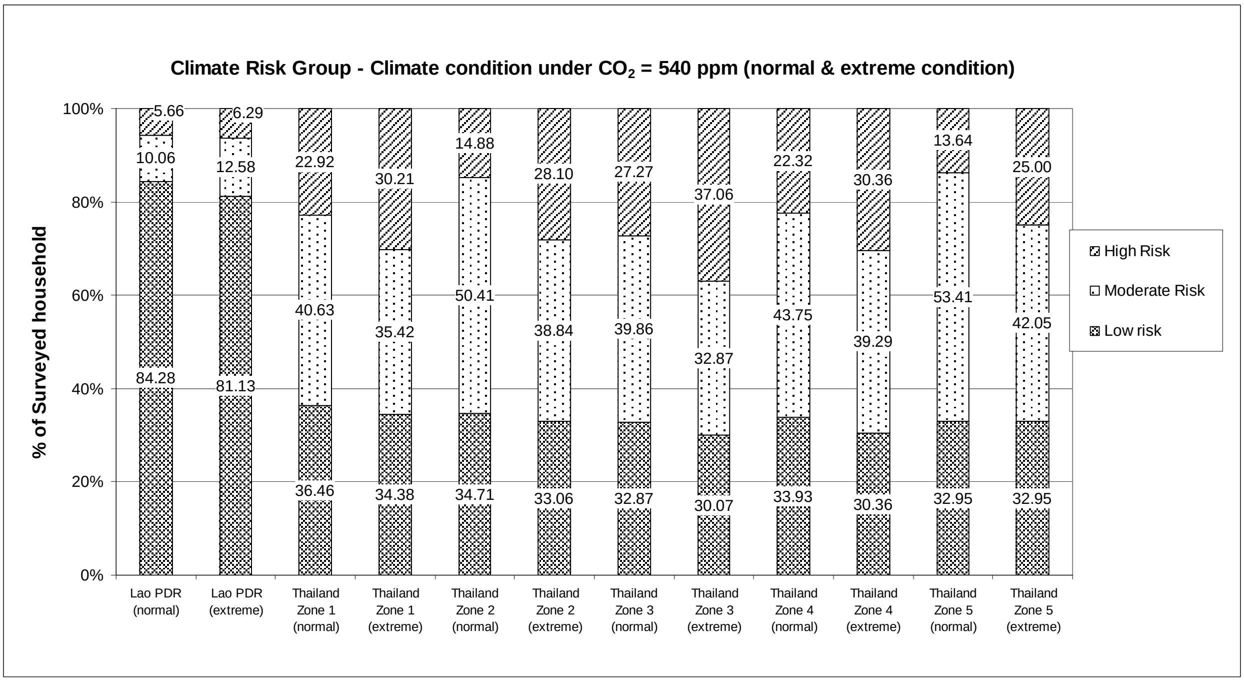


Figure 11: Risk groups under impact of climate change – Climate condition under CO_2 = 540 ppm

When compare to the baseline condition, the impact of climate change under normal condition would cause almost one-fifth of the population in Lao PDR to be vulnerable and more than half of the population would be vulnerable under the influence of future extreme climate event coupled with climate change impact. However, in Thailand the impact of climate change is favorable to some households in the study sites and would make them to be less risky to climate impact, particularly in Zone 1. But the positive impact of climate change cannot cover the influence of extreme climate event, which causes large number of population, ranged from about 30% in Zone 1 to almost 50% in Zone 5, to be vulnerable.

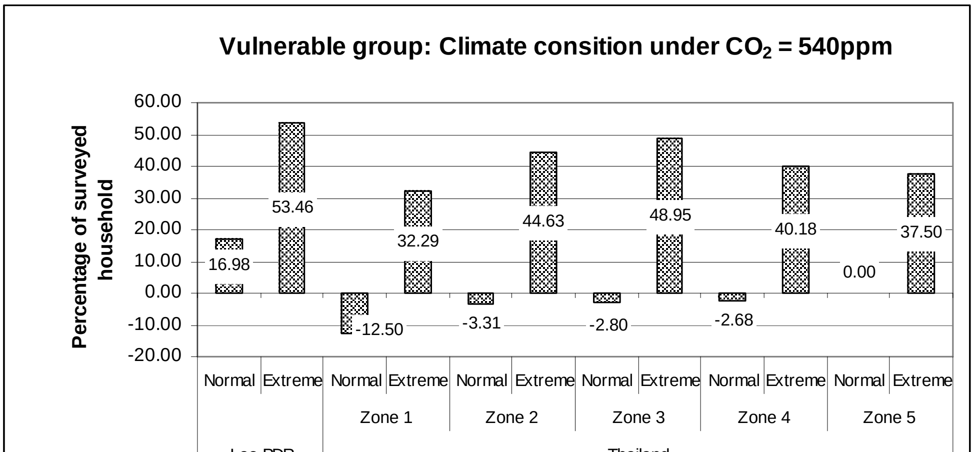


Figure 12: Vulnerable groups under impact of climate change – Climate condition under CO_2 = 540 ppm

4.3 Climate risk and vulnerability to climate change: Climate condition under CO_2 concentration 720 ppm

Under the impact of climate change when atmospheric CO_2 concentration rises to 720 ppm, the change in rice productivity cause only slight change to the risk groups, when compare to the condition under climate condition when CO_2 concentration is 540 ppm, as degree of climate change impact on rice productivity is not substantially differ. The risk groups in Lao PDR changed slightly and almost unchanged in case of study sites in Thailand when compare to the impact of climate change under climate condition when atmospheric CO_2 concentration is at 540 ppm (also see Appendix 1: Climate risk groups by study sites).

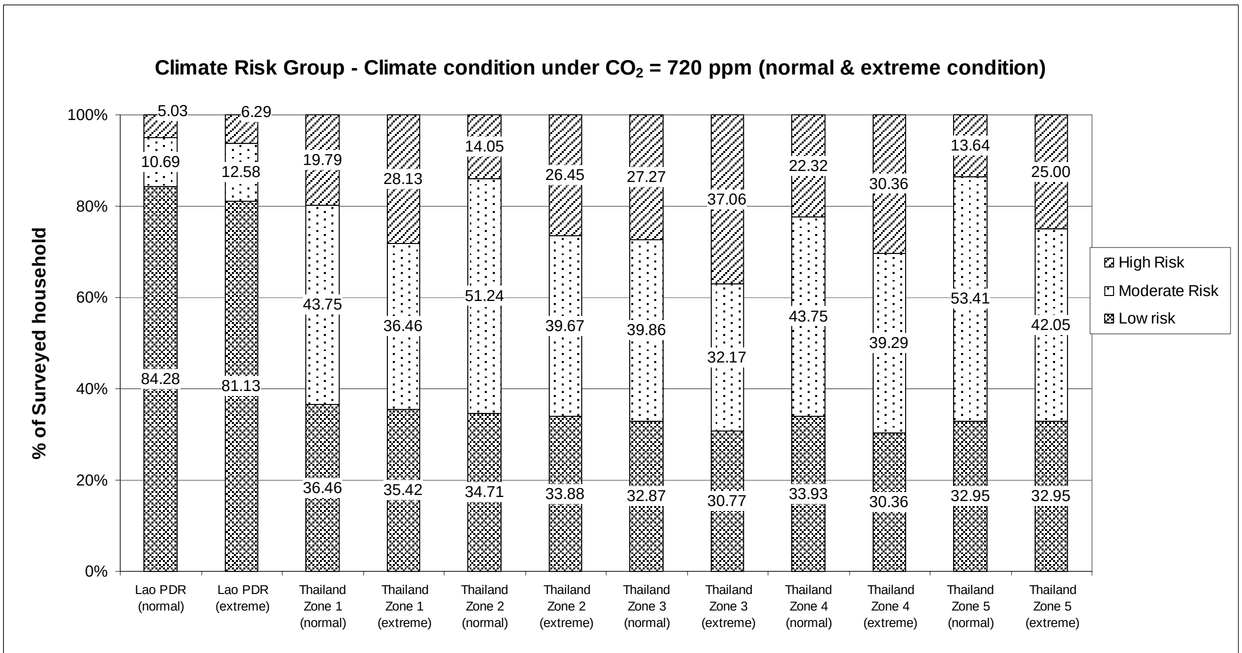


Figure 13: Risk groups under impact of climate change – Climate condition under CO_2 = 720 ppm

Under impact of climate change at climate condition under CO_2 concentration of 720 ppm, less population in Lao PDR is vulnerable when compare to the climate condition under CO_2 concentration of 540 ppm. In Thailand, about one-fifth of the population in Zone 1 is less risky to climate impact and this is also the case for small number of population in other areas. In the case of influence from extreme climate event on climate change impact, high numbers of population in most areas are vulnerable, where the worse case is in Lao PDR and the least vulnerable is Zone 1 in Thailand, as summarized in the chart below;

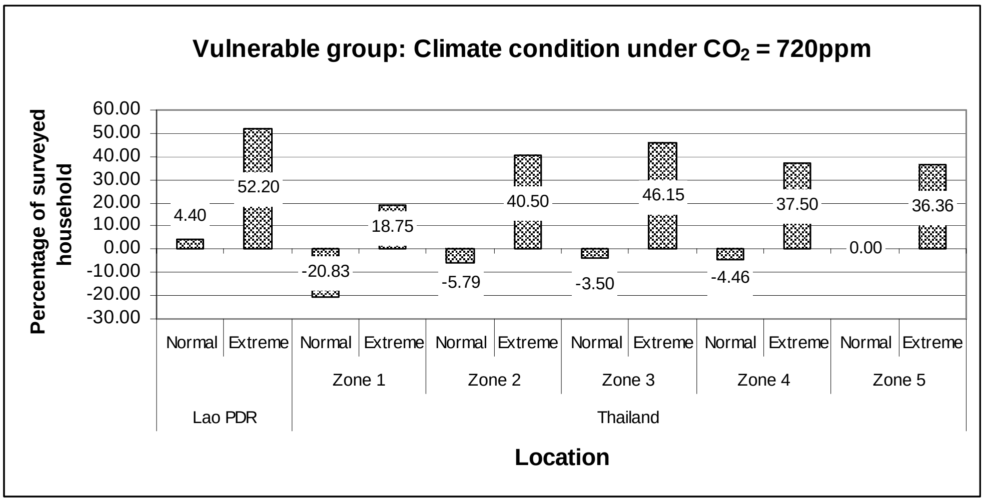


Figure 14: Vulnerable groups under impact of climate change – Climate condition under CO_2 = 720 ppm

5.0 Conclusion

This paper provides an overview of the climate change and how the farmers in the lower Mekong River region would be vulnerable to the future impact of the changes in climate pattern through regional climate scenarios and quantitative approach assessment on impact and risk analysis.

From the assessment in this study, the analysis showed that vulnerability is a place-based condition, which depends upon the degree of impact as well as socio-economic condition and physical condition of each location. The profile of risk to climate change impact would differ from community to community and climate risk seems to be more serious from the impact of climate variability in the future, which impact of climate change that is favorable to some locations may not be able to cover. The local context that contributes to the livelihood of the society is also key factor to the vulnerability condition of the household in the community to climate change impact. In addition, the vulnerable society may not be high risk to climate impact, at least under definition of this study.

This study is an effort in developing of quantitative approach for the vulnerability assessment process that also capture local context into the analysis, such as household expenditure that may vary from household to household and from community to community as well as from society to society. However, as this study is one of the pilot studies on the subject in this region, there still are many gaps in the process that need to be further improved for the future study activity. First of all, this study did not cover other non-climate stresses particularly the changes in socio-economic condition, which may have influence on farmer's livelihood. The future socio-economic condition, e.g. cost of living, inflation, market structure and market condition, national and regional development policy, etc., could be greatly differ from current situation, especially in the timescale of climate change study. These non-climate factors are important drivers that may have significant influence on the future vulnerability and risk of any social group in the society to climate change impact. Therefore, appropriate socio-economic change scenarios should be developed and also be used in the risk analysis along with the climate change impact scenarios. In addition, single proxy of climate stress as used in the analysis of risk and vulnerability to climate change may be insufficient. Secondly, this study also did not cover the analysis on the threshold of farmer's tolerance to climate impact, particularly in the categorizing of the risk groups. In addition, the accumulative impact to the household livelihood in the case of multi-year or consecutive year occurrence of extreme climate event should also be taken under consideration.

The issue of accumulated risk and vulnerability condition may be a serious matter, especially in the case of farmer in Thailand, whose coping capacity is low with limited resource to buffer the serious climate impact on their on-farm productivity until the next cropping season. In addition, most of the households also have debt, which in many cases the debt is even higher than the annual income. The impact from multi-year climate threat, especially the extreme climate event that may occur in consecutive years, may drive them into very serious difficult economic condition. The vulnerability of farmer may accumulate over the threshold; they not be able to repay their debt and end up in losing their most important production resource, which is their farmland, and finally be forced to change their way of life or social status from being independent farmer to be hired farm labor or permanently move away from the sector to work in other economic sector. Future study may include the annual household cash flow analysis over period of time under different scenarios in order to understand household financial condition which is the result of multi-year climate stress.

The focus on the understanding about vulnerability and adaptation to climate change of farmer in the lower Mekong region may need to be set on impact of climate variability over number of years, particularly the case of extreme climate anomaly that may increase in its frequency and magnitude in the future as result of climate change, especially in the case of serious extreme climate in consecutive years. This may help in the better understanding of how vulnerability could be accumulated and how farmer would be vulnerable to climate change.

References

Adger, W. Neil, Kelly, P. Mike, Nguyen Huu Ninh, 2001. Living with Environmental Change: Social vulnerability, adaptation and resilience in Vietnam, Routledge, London

Barker, R., Molle, F., 2004. Evolution of Irrigation in South and Southeast Asia. Comprehensive Assessment Secretariat, Colombo, Sri Lanka.

Boulidam, S., 2005. Vulnerability and Adaptation of Rainfed Rice Farmer to Impact of Climate Variability in Lahakhok, Sebangnuane Tai, Dong Khamphou and Koudhi Villages of Songkhone District, Savannakhet Province, Lao PDR. Mahidol University, Nakhon Pathom, Thailand.

Committee for Planning and Cooperation, 2003. Statistical Yearbook 2002. National Statistical Center, Vientiane, Lao PDR.

Department of Provincial Administration, Ministry of Internal Affairs, Thailand [Online] Available at: http://www.dopa.go.th/xstat/p4834_01.html

Hoogenboom, G., P.W. Wilkens, and G.Y. Tsuji (eds.). 1999. DSSAT version 3 v4. University of Hawaii, Honolulu, Hawaii.

IPCC, 2001 a. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK.

IPCC, 2001 b. Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK.

McGregor, J.L., and M.R. Dix, 2001: The CSIRO conformal-cubic atmospheric GCM. In IUTAM Symposium on Advances in Mathematical Modelling of Atmosphere and Ocean Dynamics, P.F. Hodnett (Ed.), Kluwer, Dordrecht, 197-202.

Shukla, P.R., Ravindranath, N.H., Garg, Amit, Battacharya, Sumana, 2003. Climate Change and India: Vulnerability Assessment and Adaptation, University Press, India.

SRES, 2000. IPCC Special Report on Emission Scenarios. Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

The World Bank [Online]
Available at: http://www.worldbank.org/cgi-bin/sendoff.cgi?page=%2Fdata%2Fcountrydata%2Faag%2Flao_aag.pdf

The World Bank [Online]
Available at: http://www.worldbank.org/cgi-bin/sendoff.cgi?page=%2Fdata%2Fcountrydata%2Faag%2Ftha_aag.pdf

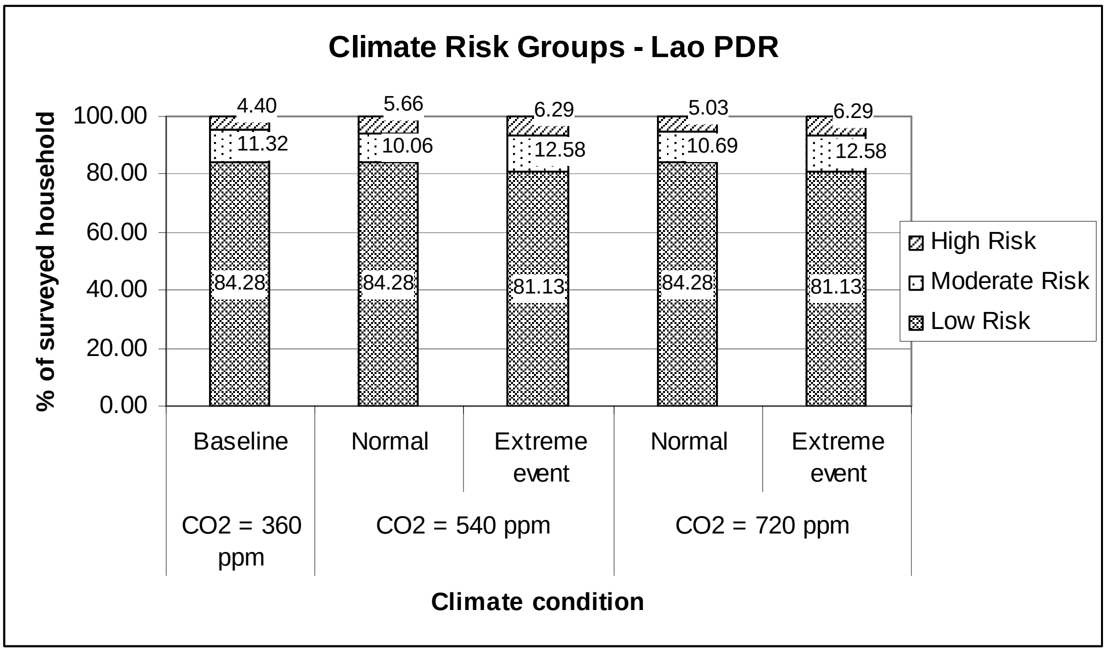
Ubonratchathani Province Administration [Online]
Available at: http://www.ubonratchathani.go.th/

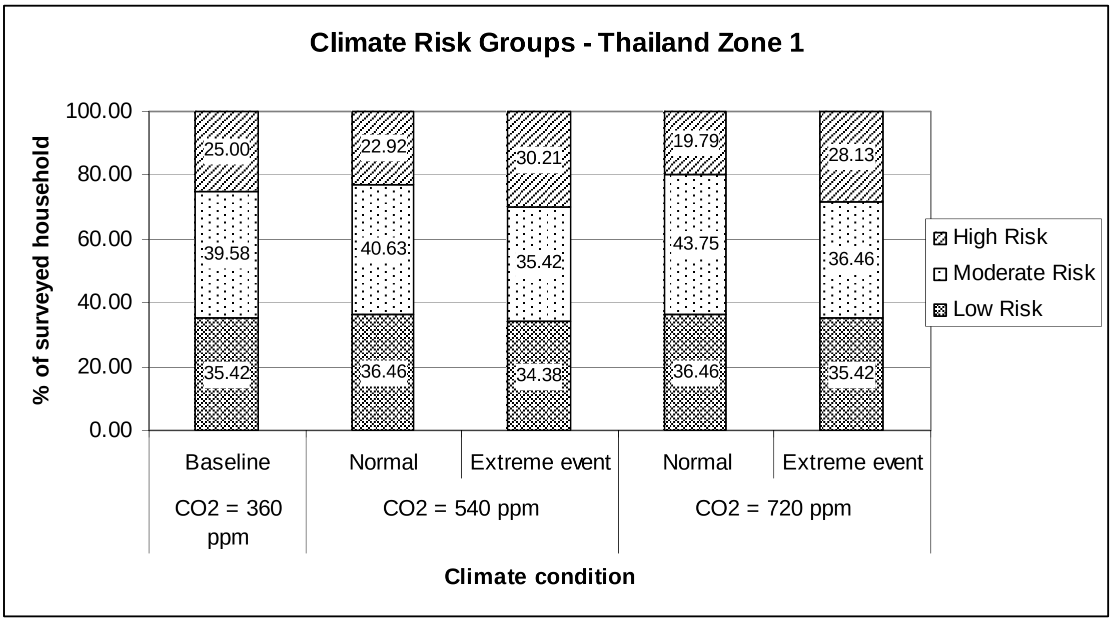
UNDP, 2004. Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. Cambridge University Press, Cambridge, UK.

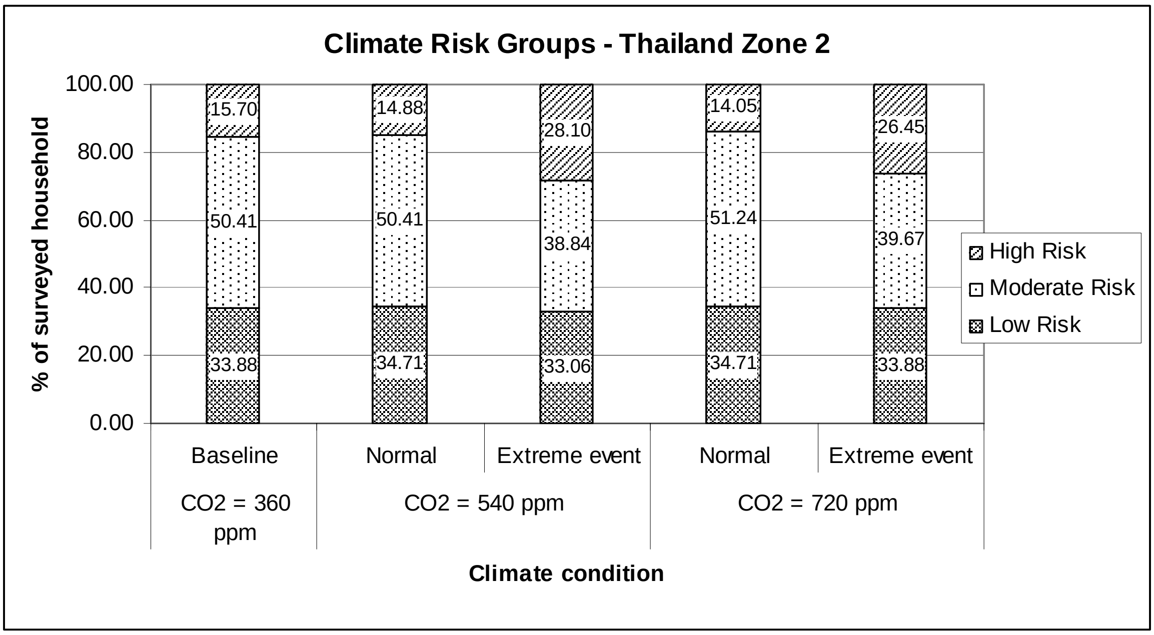
United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP) [Online]
Available at: http://unescap.org/stat/data/goalIndicatorArea.aspx

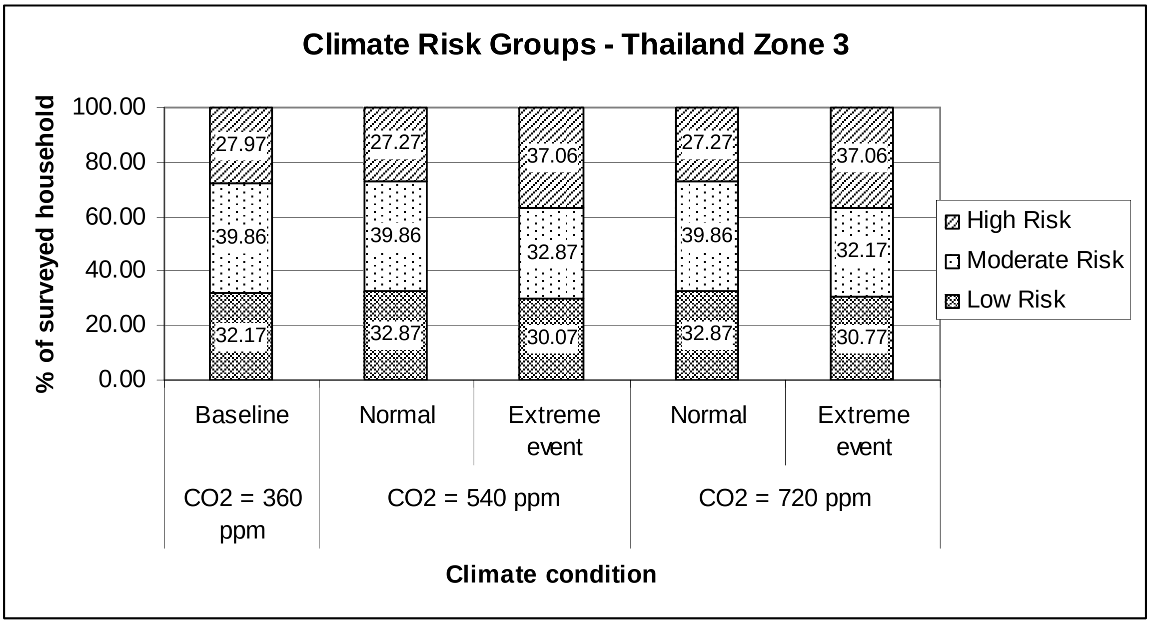
Wang, Yuqing, Leung, L. Ruby, McGregor, John L., Lee, Dong Kyou, Wang, Wei-Chyung, Ding, Yihui, Kimura, Fujio, 2004. Regional Climate Modeling: Progress, Challenges, Prospects. *Journal of Meteorological of Japan.*

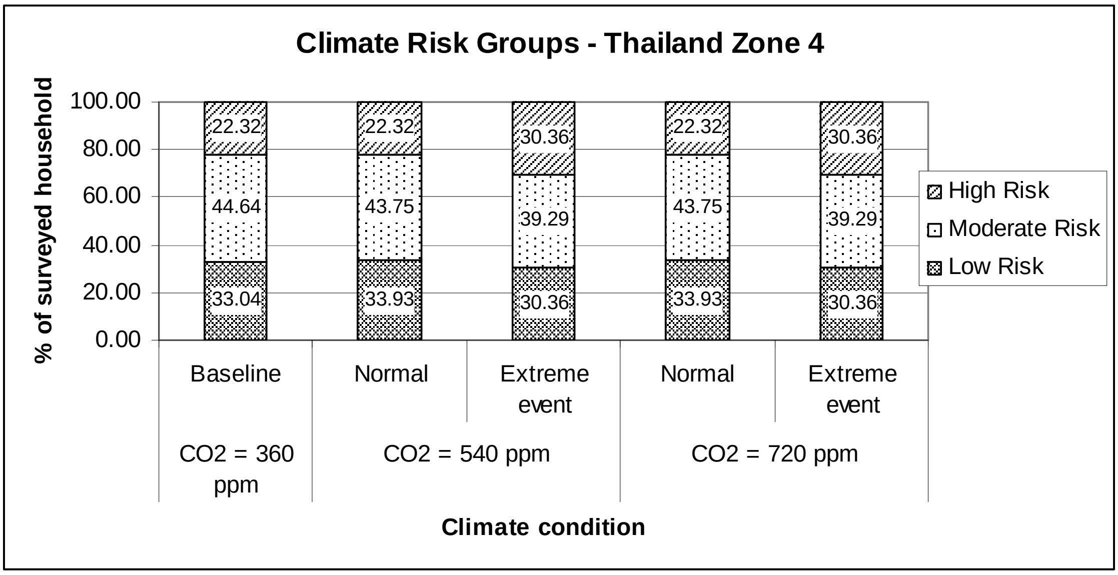
Appendix 1: Climate risk groups by study sites

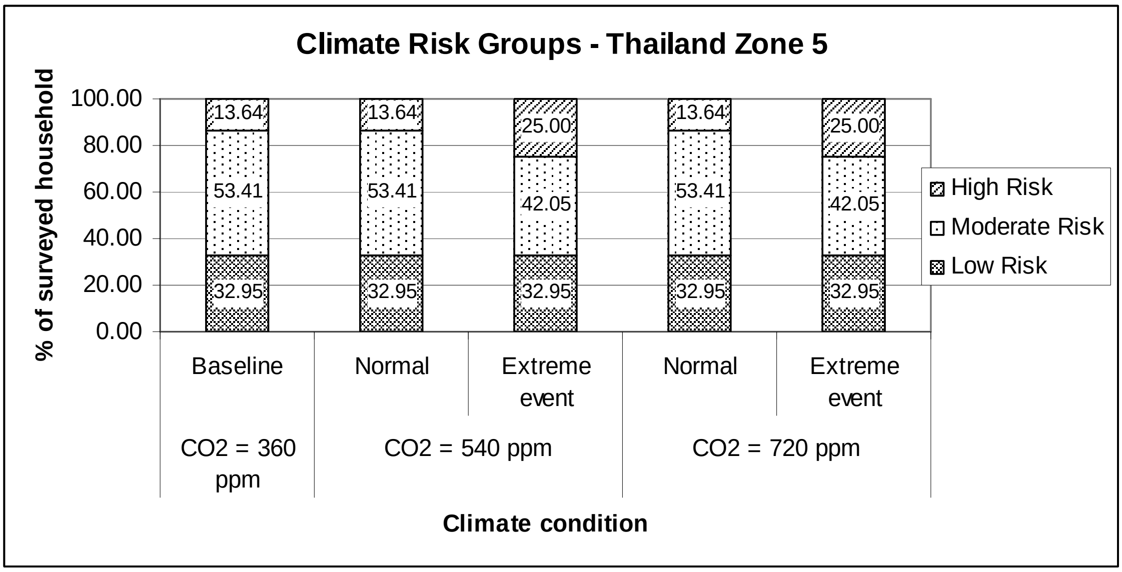





Climate Risk Groups - Thailand Zone 2
100.00
80.00
60.00
40.00
20.00
0.00
% of surveyed household
15.70
50.41
33.88
14.88
50.41
34.71
28.10
38.84
33.06
14.05
51.24
34.71
26.45
39.67
33.88
High Risk
Moderate Risk
Low Risk
Baseline
Normal
Extreme event
Normal
Extreme event
CO2 = 360 ppm
CO2 = 540 ppm
CO2 = 720 ppm
Climate condition


Climate Risk Groups - Thailand Zone 3
100.00
80.00
60.00
40.00
20.00
0.00
% of surveyed household
27.97
39.86
32.17
27.27
39.86
32.87
37.06
32.87
30.07
27.27
39.86
32.87
37.06
32.17
30.77
High Risk
Moderate Risk
Low Risk
Baseline
Normal
Extreme event
Normal
Extreme event
CO2 = 360 ppm
CO2 = 540 ppm
CO2 = 720 ppm
Climate condition


Climate Risk Groups - Thailand Zone 4
% of surveyed household
100.00
80.00
60.00
40.00
20.00
0.00
22.32
44.64
33.04
22.32
43.75
33.93
30.36
39.29
30.36
22.32
43.75
33.93
30.36
39.29
30.36
High Risk
Moderate Risk
Low Risk
Baseline
Normal
Extreme event
Normal
Extreme event
CO2 = 360 ppm
CO2 = 540 ppm
CO2 = 720 ppm
Climate condition


Climate Risk Groups - Thailand Zone 5
% of surveyed household
100.00
80.00
60.00
40.00
20.00
0.00
13.64
53.41
32.95
13.64
53.41
32.95
25.00
42.05
32.95
13.64
53.41
32.95
25.00
42.05
32.95
High Risk
Moderate Risk
Low Risk
Baseline
Normal
Extreme event
Normal
Extreme event
CO2 = 360 ppm
CO2 = 540 ppm
CO2 = 720 ppm
Climate condition