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Impact, Vulnerability Assessment and Adaptation to Climate Change: The Case Study of Rice Farming in Ba Phnum District, Prey Veng Province

Chea Navin

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Impact, Vulnerability Assessment and Adaptation to Climate Change: The Case Study of Rice Farming in Ba Phnum District, Prey Veng Province

Chea Navin

December, 2015

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Table of Contents

List of Abbreviations

ACAPS	:	Assessment Capacities Project
ECB	:	The Emergency Capacity Building
IPCC	:	Intergovernmental Panel for Climate Change
MAFF	:	Ministry of Agriculture, Forestry and Fisheries
MOE	:	Ministry of Environment
MOWRM	:	Ministry of Water Resources and Meteorology
NAPA	:	National Adaptation Programme of Action to Climate Change
PRECIS	:	Providing Regional Climates for Impacts Studies
RGC	:	Royal Government of Cambodia
SRES	:	Special Report on Emissions Scenarios
UNDP	:	United Nations Development Programme
UNFCCC	:	United Nations Framework Convention on Climate Change

List of Figures

List of Tables

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Abstract

The effects of climate change include flood, drought, pest and disease outbreak, and are likely to become more prevalent and more intense in the future. Rice is the backbone of the economy in Cambodia, and rural people rely on rice cultivation for their livelihood. Ba Phnum district is located in Prey Veng province, and is the district that is ranked the highest in vulnerability to flooding and second most vulnerable to drought.

This study aims to achieve the following objectives, i) to identify past and future climate trends in Prey Veng Province ii) to assess the impact of climate change and vulnerability of rice cultivation in target areas iii) to propose adaptation options for rice farmers.

The research used the Providing Regional Climates for Impacts Studies (PRECIS) climate modeling downscaling for rainfall and temperature from Southeast Asia System for Analysis, Research and Training (START) Regional Center, and obtained climate data from water resources and meteorology in Prey Veng Province. The study gathered trends based on 31 years of data on rainfall (from 1984 to 2014), and 18 years data of data gathered on temperature (from 1997 to 2014). Both the rainfall and the temperature data were projected to predict trends for 2030 and 2050. Additionally, this research used household interviews to consolidate the key findings.

According to observed climate data, over the past 31 years the average rainfall was 1421.116 millimeters (mm) annually. The Special Report on Emissions Scenarios (SRES) A2 projection indicates that rainfall will decrease 97.504 mm by 2030 and increase 41.51 mm by 2050 in the target area.

The maximum temperature is 33.02 degrees Celsius (^oC) according to SRESA2, and could show an increase of 0.60 ^oC by 2030 and of 1.12 ^oC, by 2050, while temperature in SRES B2 shows an increase 0.41 ^oC by 2030 and 1.32 ^oC by 2050. The mean annual minimum temperature is 23.55 ^oC. The projection shows that temperature could increase 0.46 ^oC by 2030 and increase 1.03 ^oC by 2050 using the SRESA2 scenario. For SRESB2 the minimum temperature could increase 0.46 ^oC by 2030 and increase 1.19 ^oC by 2050.

Household survey data indicates that rice is very vulnerable to the impact of climate change due to lack of irrigation, changes in climate, and challenges due to the market demand. Farmers from the selected area were aware of the impact of climate change, but some have little financial ability to cope with it. Farmers in Ba Phnum district have selected a short-term variety of rice seed variety to supply the market demand (Nambong - a Vietnamese variety of rice seed). Though they face challenges and are aware the seed they are currently cultivating is not tolerant to flood, drought, and pests they accept the risks related to climate change and use it to meet the market demand.

1. Introduction

1.1. Background of the Study

Billions of people, particularly in developing countries, are predicted to face shortages of water, and food, and impacts to their health and lifespan as a result of climate change over the next few decades (UNFCCC, 2007).

Many countries in Asia have declines crop yields due to increasing temperatures and extreme weather events. The frequency in the occurrence of climate-induced diseases and heat stress (Cruz *et al*, 2007) translates to area-averaged annual mean warming of approximately 3°C in the decade of the 2050s and 5°C in the decade of the 2080s (Lal *et al*, 2001).

The Kingdom of Cambodia is highly vulnerable to climate change and ranks the 9th most vulnerable in the world due to high exposure and the lack of coping mechanisms (ECB & ACAPS, 2011) and low adaptive capacity due to widespread poverty and lack of financial means (Thomas *et al.*, 2013). Many people are poor or are vulnerable to poverty in the face of shocks and crisis (ECB & ACAPS, 2011; Worldbank, 2009). Cambodia's mean surface temperature has increased by 0.8°C since 1960. The mean monthly temperature indicates an increase between 0.013°C and 0.036°C per year by 2099 (RGC, 2013).

Rice is the dominant crop in Cambodia's agricultural sector. It occupies more than 80 percent of cultivated land and is the most important agricultural export commodity (Yu & Diao, 2011). In 2010, the government released a policy on the promotion of rice production and milled rice exports, with the goal of exporting one million metric tons of milled rice by 2015 (MoE, 2002; Thomas *et al.*, 2013).

Flood and drought have become key influences over the production of rice in Cambodia (ACIAR, 2009; Mainuddin *et al.*, 2010; MoE, 2011). Production loss due to the occurrence of climate hazards such as flood, drought, and windstorms are very common throughout Cambodia (NGO Forum, 2014).

Since the 1960s there have been more than seven serious floods. When a huge flood arrived in 2000, about 370,000 hectares (ha) of farmland were inundated and 6,081 houses were destroyed, affecting the lives of 3.44 million people in 132 districts (MoWRM, 2012).

In 2009, 13 out of 24 provinces were affected by severe drought. 57,965 ha of rice crops were affected and 2,621 ha were destroyed. In 2010, 12 provinces out of 24 provinces were affected by severe drought. 14,103 ha of transplanted rice were affected with 3,429 ha of transplanted rice seedlings and 5,415 ha of subsidiary crops damaged. In 2011, drought affected 3804 ha of rice fields and destroyed 53 ha. In 2011, floods affected 350,000 households (over 1.5 million people) and 52,000 households were evacuated. In 2011, 18 out of 24 provinces in Cambodia were affected by flooding, with 4 provinces along Mekong River and Tonle Sap the worst hit, 250 people lost their lives and 23 people sustained injuries, 431,000 ha of transplanted rice fields were affected and 267,000 ha of rice fields were damaged. In 2012, drought hit 11 out of 24 provinces; affected 14,190 hectare of rice fields and destroyed 3151 hectares (ADRC, 2014).

The 2011 floods caused an estimated loss of 630 million USD. As the primary crop, rice covers 84 percent of Cambodia's total cultivated land area. Between 1996 and 2001 more than 70 percent of the national rice production losses were due to flooding. In comparison, approximately 20 percent were due to drought and another 10 percent due to pests and disease (NGO Forum, 2014).

From 1987 to 2007 drought and flood hit almost the entire country affecting millions of people. Damage incurred on infrastructure, property and crops totaled over USD 440 million (MoE, 2006; NGO Forum, 2014).

Options to adapt to climate change in the agricultural sector include new high yielding varieties of rice, improvement of crop management, development of capacity to adapt to current extreme climate events such as early warning systems for flooding and maps delineating the rice growing areas of provinces prone to flood and drought, development of irrigation facilities in low land areas, increasing the planting index in suitable areas, and diversification of crops (MoE, 2002).

In Prey Veng province, rice farming is a major source of livelihood and income (MoE, 2006; Ros et al., 2011). Without designing proper adaptation techniques, the agricultural sector will be highly vulnerable to climate change impacts especially due to the effects of flooding and drought (MoE, 2002; NGO Forum, 2014).

1.2. Research Rationale

In Cambodia, the 2000 floods affected 30 percent of the population, killed 347 people, and destroyed more than 7,000 homes and almost 350,000 hectares of rice. Between 2000 and 2003 more than 80 percent of the land area in Prey Veng province was inundated by flooding (Iran *et al*., 2003). While some of the impacts of climate change in Cambodia have been documented in the literature, there is a shortage of information regarding on-the-ground observations made by people themselves who are facing the challenges and deal with these issues every day. They have been adapting to the changes in climate patterns long before climate change became the hot issue it is today.

This study in Prey Veng province helps to fill this knowledge gap by documenting farmer’s insights about the issues commonly related to climate change. The research provides a valuable record of the practical implications of climate change on people’s daily lives, and identifies adaptive measures that are already being implemented by people and which may be replicated or improved. A deeper understanding of the impact of climate change and the farmers’ vulnerability will also help improve future rice production. Moreover, the information obtained from this research can assist policymakers, non-governmental organizations (NGOs) and other climate change actors to better understand the level of awareness and coping mechanisms of farmers, so it can be incorporated into action plans for improving food security and poverty alleviation.

1.3. Research Objectives

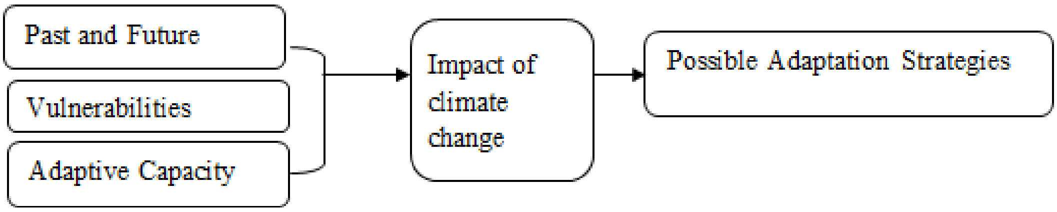
- To identify past and future climate trends in Prey Veng province
- To assess the impact of climate change and vulnerability of rice cultivation in the target areas
- To propose adaptation options for farmers and rice cultivation

1.4. Scope and Delimitations

- What trends can be identified from the record of climate data in Prey Veng province? And what future climate trends can be predicted from this data?
- What climate projection can be made for the cultivation of rice in the target areas?
- What is the level of vulnerability for rice cultivation in the target areas?

- What are the possible adaptation strategies for farmers to improve rice cultivation in the future? And what current coping mechanisms are the farmers utilizing?

1.5. Research Hypothesis



1.6. Conceptual Framework

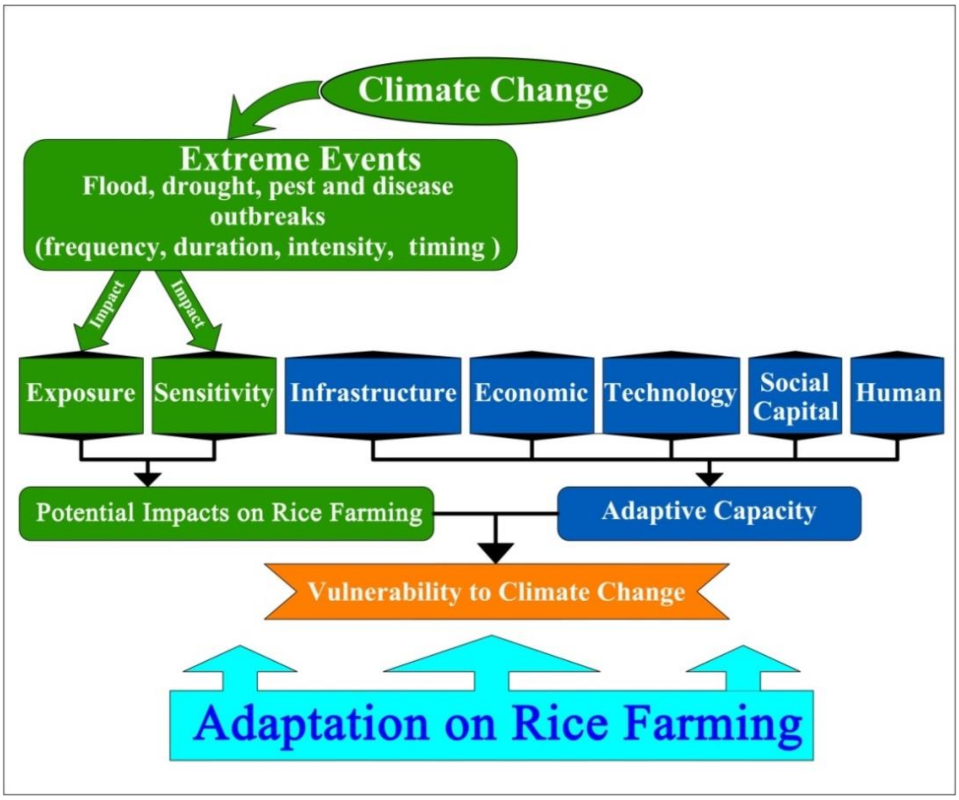


Figure 1: Research Conceptual Framework

Exposure: *The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected* (Intergovernmental Panel for Climate Change (IPCC), 2014).

Table 1: Exposure Indicator

Dimension	Indicator
	Number of family members that are rice farm laborers
Population	Daily management in agriculture
	Farming activities in time
	Amount of money
Resources	Rice varieties
	Input of fertilizer and pesticide
	Rice field topography, rice farmer machinery
Property	Degree of mechanization use

Sensitivity *is the degree to which a system is affected, either adversely or beneficially, by climate- related stimuli. Climate-related stimuli encompass all the elements of climate change, including mean climate characteristics, climate variability, and the frequency and magnitude of extremes. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)* (McCarthy *et al.*, 2001).

Farmers are exposed to and sensitive to the impacts of a range of climatic and non-climatic forces which do not act in isolation of each other (Li *et al.*, 2010).

Table 2: Sensitivity Indicator

Dimension	Indicator
	Labor cost
Market	Market price of produce
	Marketing channel
	Cost of chemical fertilizer
Input	Cost of rice farming resources
	Rice insurance
	Change in crop yield
Biophysical effect	Change in availability of water

Dimension	Indicator
	Change in availability of food
	Biodiversity loss, soil fertility loss
	Shared labor in crop cultivation

Adaptive capacity: *the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences* (McCarthy *et al.*, 2001).

Table 3: Adaptive Capacity Indicator

Dimension	Indicator
Infrastructure	Availability of irrigation canals
	Total irrigated agricultural land of household
	Total available land for cultivation of crops or other use
Economic	Income per head
	Amount of remittance per year
	Income from rice production
	Percentage of income generated from non-rice farming
	Availability of finances for investment into farming
	Variety of farming livelihood channels
Technology	Ability to access information through television and radio
	Access to telephones and mobiles
	Internet connectivity level in the community
	Access to early warning systems
Social Capital	Access to capital through relatives and friends in the case of disaster
	Institutional support
	Community networks
Human	Number of laborers
	- Physical force
	Level of education
	- Highest level of school attended
	- Length of experience in farming

	- Knowledge of crop cultivation
	- Assess to information
	- Participation in training or other capacity enhancement

The research must also take livelihood into consideration because rice farming contributes to the livelihood of farmers.

Table 4: Household Livelihood Indicator

Dimension	Indicator
Household life	Family structure
	Income and expenditure
	Goal of livelihood
Labor division	Rice farming
	Other jobs
Structure of household income	Source of individual income
Available cash flow	Cash in hand
Human capital	Health of family members
	Quality of labor force
Social capital of the household	Neighborhood network, existence of saving groups

*** Household yield and income obtained from rice cultivation, the variation of yield compared with former years and extreme climate change effects on rice production.

2. Literature Review

2.1. What is Climate Change?

The term climate change has been defined differently according to different institutional requirements. This section will identify some of the most accepted concepts and definitions of climate change.

According to the Framework Convention on Climate Change (UNFCCC), the international environmental treaty which almost all countries in the world have ratified, climate change, refers to

> a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the UNFCCC, in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (IPCC, 2014).

Thus the UNFCCC makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes (IPPCC, 2014). With this definition the term of climate change refers to a time period of 100 years or longer. Looking at the concept of climate provided by the United States Environmental Protection Agency (EPA), it states:

> the average weather (usually taken over a 30-year time period) for a particular region and time period. Climate is not the same as weather, but rather, it is the average pattern of weather for a particular region. Weather describes the short-term state of the atmosphere. Climatic elements include precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, and hailstorms, and other measures of the weather.

According to the UNFCCC (2007) a rise in the burning of fossil fuels and changes in land use have emitted, and are continuing to emit, increasing quantities of greenhouse gases into the earth's atmosphere. These greenhouse gases include carbon dioxide (CO_2), methane (CH_4) and nitrogen dioxide (N_2O). The rise in these gases have caused a rise in the amount of heat from the sun withheld in the earth's atmosphere, heat which would normally be radiated back into space. This increase in heat has led to the 'greenhouse effect', resulting in climate change.

Climate change is caused by an increase in the atmospheric concentration of greenhouse gases, which inhibits the transmission of some of the sun's energy from the earth's surface to outer space. These gases include carbon dioxide, water vapor, methane, chlorofluorocarbons (CFCs), and other chemicals. The increased concentrations of greenhouse gases result in part from human activity-deforestation, the burning of fossil fuels such as gasoline, oil, coal and natural gas, and the release of CFCs from refrigerators, air conditioners etc.

2.2. What is Vulnerability to Climate Change?

There have been different definitions proposed by a number of experts on the concept of vulnerability.

Vulnerability, as proposed by Turner II *et al*, is defined as a function of exposure, sensitivity and adaptive or coping capacity. Vulnerability, broadly speaking, is the degree to which a system is likely to experience harm due to exposure to a hazard (Turner II *et al.*, 2003).

According to the Intergovernmental Panel for Climate Change (IPCC) (2014), "Vulnerability is the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt". Vulnerability is a concept that has been mentioned in a number of different research traditions (Li *et al*., 2010).

> Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. In this regard, It 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 (McCarthy *et al.*, 2001).

Defining the element of the functions of vulnerability (Exposure, Sensitivity, Adaptive Capacity) is important. Each variable of the elements is very important for research.

Assessing the impacts of and vulnerability to climate change in order to propose adaptation needs and requires high quality information. This information includes climate data, such as temperature, rainfall and the frequency of extreme events, and non-climatic data such as the current situation on the ground for agriculture and water resource (UNFCCC, 2007).

In the beginning many research studies utilizing the theory of climate change, vulnerability and adaptation, as mentioned previously, focused largely on predicting how certain biophysical systems were being affected by and would respond to climate change. After gaining a better understanding of how climate changes affects biophysical processes, the research has shifted into its implications on human activity, requiring increased attention to the human dimensions of climate change (Li *et al.*, 2010).

2.3. Adaptation to Climate Change

Based on IPCC (2014) adaptation is *"*The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects*"*.

However, to McCarthy *et al.* (2001) adaptation is the

> Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation:

- *Anticipatory Adaptation:* Adaptation that takes place before impacts of climate change are observed also referred to ask proactive adaptation.
- *Autonomous Adaptation:* Adaptation that does not constitute a conscious response to climatic stimuli but it 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.
- *Private Adaptation:* Adaptation that is initiated and implemented by individuals, households or private companies. Private adaptation is usually in the actor's rational self-interest.
- *Public Adaptation:* Adaptation that takes place after impacts of climate change has been observed

2.4. Rice Production and Climate Change Impact in Cambodia

Cambodia's climate is highly dependent upon the arrival of seasonal monsoon rains which occur from May onwards, often extending until November. Aside from these rains, however, precipitation is scarce. The total annual rainfall varies from 1,100 to 2,200 millimeters depending on the location. Average temperatures are often in the high twenties or in the lower thirties, with the hottest period occurring shortly before the onset of the rains in May (NGO Forum, 2012).

As mentioned rice is Cambodia's most important crop and the country's most valuable export crop; Agri-Consulting International (2006) estimated that rice is grown on 84 percent of all cultivated land in Cambodia rice. Cambodia must produce at least 3.5 million tons of paddy rice per year to feed its population of 14 million (Nyda *et al.*, 2013). Rice is grown in a variety of systems, dependent on difference rainfall and flooding patterns. The most common system which farmers use is to plant shortly after rains commence in rain-fed or partially irrigated systems. Another system is to plant after floods recede later in the year, especially in the low-lying areas in the Tonle Sap Lake and Mekong River areas. Both areas are prone to annual flooding which varies depending on local rainfall as well as rainfall in the wider Mekong catchment. In areas with access to annual water flows, irrigated rice is also grown from February to May (NGO Forum, 2012).

Cambodia's Ministry of Environment (MoE) (2002) concluded that rice output in Cambodia is directly correlated with climate variations. The total production of rice is highly affected by the occurrence of floods or droughts. Based on data it was concluded that floods more often lead to production losses (in 70 percent of the cases) than droughts (20 percent) and nationwide both can occur at the same time. Production losses due to pests and disease were insignificant.

In addition, it is predicted that world market prices for rice will rise by 50 percent by 2050 (NGO Forum, 2012). This will create an additional burden and impact on the health of poor and marginalized groups, most of which are farmers, as their lack of resources reduces their ability to adapt (Farming First, 2010; MoE, 2001).

Anthropogenic greenhouse gases are the main culprit of climate-change due to their role in increasing the earth's temperature, according to the IPCC report (2007). This results in changes to the climate including increasing temperature, early or late onset rainfall, increase in the frequency and intensity of droughts, precipitation, storms and the rise of the sea level (Nyda, 2013).

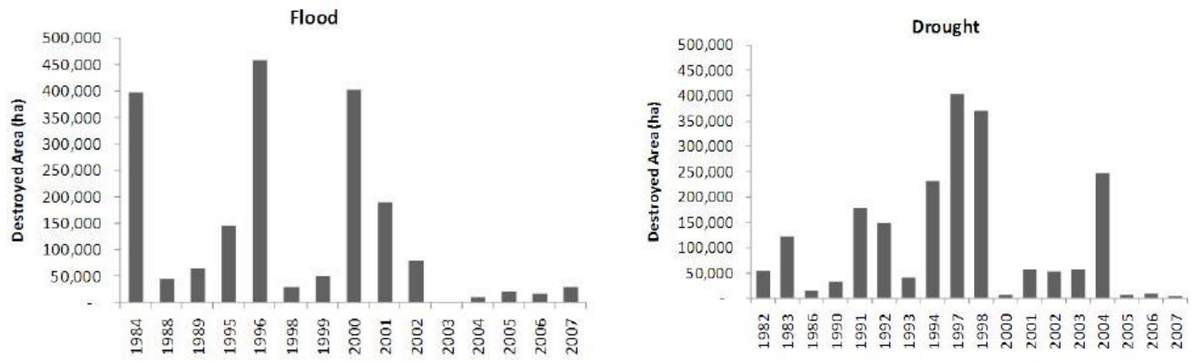


Figure 2: Rice Fields Damaged by Flood and Drought in Cambodia (1982-2007)

Source: (MAFF, 2010; Chhinh & Poch, 2012)

2.5. Climate Change Projection in Cambodia

According to the projection of climate change Cambodia's rainfall patterns will be altered in both the wet (May-November) and dry seasons (December-April). Three climate change models were used to study Cambodia's rainfall patterns and found that changes in climate will result in increased rainfall between 0 to 14 percent during the wet season and a reduction of rainfall during the dry season. Changes in rainfall intensity and frequency have already provided challenges for Cambodia's people and the development of the country. Rice production has been impacted greatly by flood and drought. The average rainfall in Cambodia is between 1,000 mm to 4,000 mm per annum. In the paddy rice production area in the flood plains, the rainfall is between 1,000 mm and 1,600 mm per annum (MoE, 2001). The study of the impact of climate change on Cambodia conducted by MoE shows that by 2100 rainfall in Cambodia will increase 3 to 35 percent from the current conditions, and the temperature increase will be in the range of 1.3 - 2.5 ^{o}C. This result was produced using two scenarios-SRESA2 (reference) and SRESB1 (policy) and General Circulation Model (GCM) developed by Center for Climate System Research (CCSR) and Commonwealth Scientific and Industrial Research Organization-Australia (CSIRO).

Several studies in South East Asia have confirmed that climate change has detrimental effects on rice production. Among the earliest studies that probed the impact of climate change on rice paddy production in South East Asia.The study predicts the impact of climate change in the decades of 2010, 2030, and 2050 and finds that an increase in maximum and minimum temperatures, rainfall, and solar radiation will lead to the reduction of about 1 percent of rice production annually in East Java (Firdaus, Latiff, & Borkotoky, 2013).

The impacts of climate change will be unprecedented, with increasing threats to life, livelihood and life-supporting systems. Cambodia is ranked among the world's top 10 countries with the highest vulnerability to the impacts of climate change, although the country's net contribution to global warming is negligible. Natural hazards such as floods, droughts and storms are likely to become more prevalent and more intense. It is also expected that changes will occur in the timing, duration and intensity of the two main seasons in Cambodia – the wet season and the dry season. The dry season will be longer and drier than before, while the wet season will be shorter and wetter. Cambodia's vulnerability to climate change is widely regarded as being due to its lack of capacity to adapt (United National Development Programme (UNDP, 2012).

2.6. Cambodia, Vulnerability to Climate Change

The frequency and intensity of floods may increase with changing climate conditions, and cause severe damage to rice harvests. Successions and combinations of droughts and floods have resulted in a significant number of fatalities and considerable economic losses. Losses arising from floods have been further exacerbated by deforestation. Floods accounted for 70 percent of rice production losses between 1998 and 2002, while drought accounted for 20 percent of losses (MoE, 2006).

Flood and rainfall patterns play a determining role in rice paddy cultivation and the absence of widespread irrigation and water harvesting schemes in Cambodia make this sector particularly vulnerable to climate change, especially due to the effects of flooding and drought.

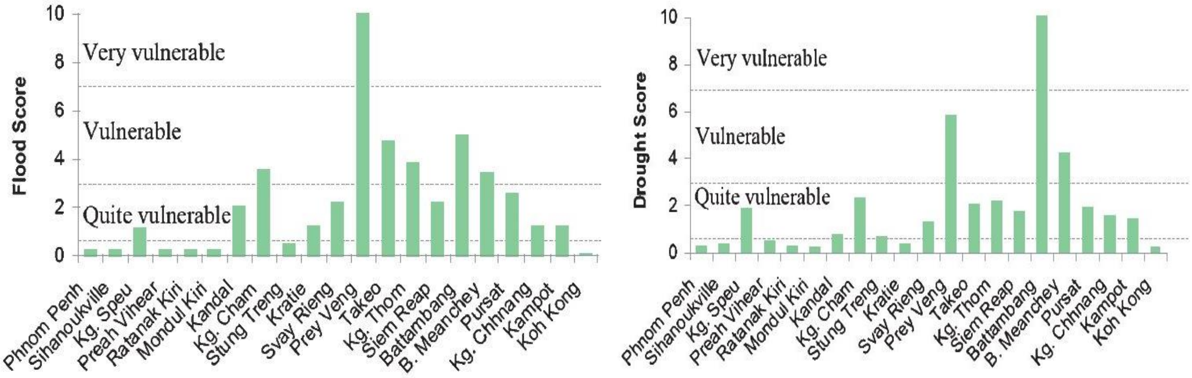


Figure 3: Vulnerability Level to Floods and Droughts by Province, Cambodia

Source: (MoE, 2006)

3. Research Methodology

3.1. Site Selection

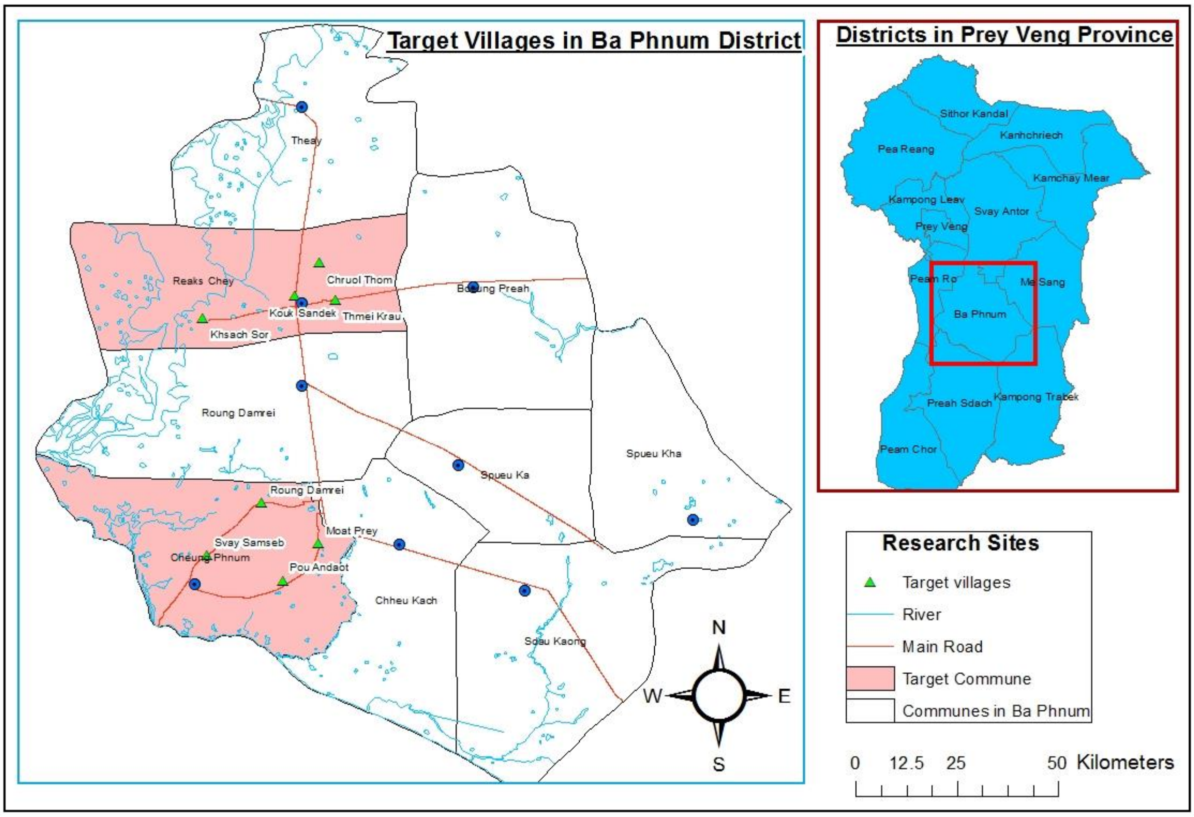


Figure 4: Map of Research Site

MoE research (2006) shows that Prey Veng province is the most highly vulnerable to flood, ranking number one among the provinces in Cambodia, and ranking number two in vulnerability to drought. People rely on agriculture, mainly the cultivation of rice, for their livelihood.

This research was limited to the Ba Phnum district in Prey Veng province. The area was selected based on the vulnerability of the agro-ecological zone, as this district is close to the river and is often faced with flood and drought. It is categorized as a 'drought prone' district. The target communities and villages were selected based on discussions with key informants from Department of Agriculture in the district, and the chiefs from the communities, who indicated that the selected areas are impacted by flood and drought frequently and should be included in this study.

3.2. Sampling Method

Sample Size

The sample size was identified based on statistical requirements using the sampling formula named "Jamane Taro" with a standard error of 10 percent. The sample size was calculated by using the formula below:

$$n = \frac{N}{1 + Ne^2}$$

(Yamane, 1967)

$$n = \frac{2306}{1 + 2306(0.1)^2}$$

n = 100

N _ total population size
e _ standard error 10%
n _sample size selected

Next, the sample size in each village was selected by using below formula:

$$n_i = \frac{n \times N_i}{N}$$

n_i = Number of household samples selected in each village for interview
N_i = Total households in each village
n = Total number of sample size selected
N = Total households in two communities

So, the number of household samples for interviews in each target village is presented in the below table:

Table 5: Number of Household Samples Selected for Interviewing

District	Community	Target Villages	Number Household	Number of sample Selected
Ba Phnum	Cheurng Phnom	Moat Prey	158	10
		Pou Andout	384	20
		Svay Samseb	415	10
		Roang Damrei	607	20
	Reaks Chey	Kouk Sandaek	291	10
		Khsach Sor	151	10
		Thmei Krau	184	10
		Chruol Thum	116	10
Total			**2306**	**100**

3.3. Method of Data Collection

This research utilized two types of research methods: Providing Regional Climates for Impacts Studies (PRECIS) climate modeling and conducting household interviews. The data was collected from both primary and secondary sources following the procedure below:

Secondary Data Sources: Secondary data was collected from various sources through desk review. .Documentation was collected on government policies related to climate change from the Ministry of Environment, on rice cultivation from the Ministry of Agriculture, Forestry and Fisheries, and the Ministry of Water Resources and Meteorology. In addition, data from the provincial Department of Agriculture and Department of Water Resources and Meteorology in Prey Veng were utilized for this research.

Secondary was also collected from research articles and research papers of NGOs and research institutions. The documents include previous studies related to climate change issues and helped to identify the research area and to design appropriate techniques. The desk review was conducted before the field work start.

Primary Data Sources: Primary data was also collected from a variety of sources to strengthen the research results

- **Household survey:** The participants were farmers who had been involved in rice cultivation for at least 20 years in the target areas. The selection was based on random selection. The selected villages were identified and mapped with the village chief prior to data collection.
- **Key informants interview:** Interviews were conducted with the head of the provincial Department of Agriculture in Prey Veng, head of the Department of Water Resources and Meteorology in Prey Veng province, head of the Department of Agriculture in Ba Phnum district, and the chiefs from selected communities.
- The interviews aimed to gain a deeper understanding of the status of climate in Prey Veng province, and the extent of the area of land that has been damaged by flood, drought and other climactic events. Topics covered included the existing legal framework, action plans, the availability of stakeholder support for climate change issues, and the climate change adaptation strategies of local line agencies along with the challenges being faced in order to assist farmers to adapt to climate change.
- **Field Observations:** During data collection, field observations were carried out to better understand the living situation of the target groups. The researcher observed the practice of rice farming and irrigation techniques, the social and economic aspects of the village, and the climate and geography of the target area.

Providing Regional Climates for Impacts Studies (PRECIS) climate modeling: The PRECIS regional climate model was used for the projection of climate scenarios. The researcher downscaled climate data from the Southeast Asia (SEA) START Regional Center (RC) from 1984 to 2014 for rainfall patterns, and from 1997 to 2014 for maximum and minimum temperatures. The researcher also obtained observed climate data from the provincial Department of Water Resources and Meteorology on rainfall levels and the maximum and minimum temperatures. Data on climate in the district was gathered from the district Department of Water Resource and Meteorology.

3.4. Method of Data Analysis

The climate projections used two types of data; historical data which was obtained from the SEA START RC and observed data that was gathered from the Department of Water Resources and Meteorology in Prey Veng province, and in Ba Phnum district. This data was analyzed using two scenarios, SRESA2 (Reference scenarios), and SRESB2 (Policy scenarios). The method of modeling is provided in the figure below:

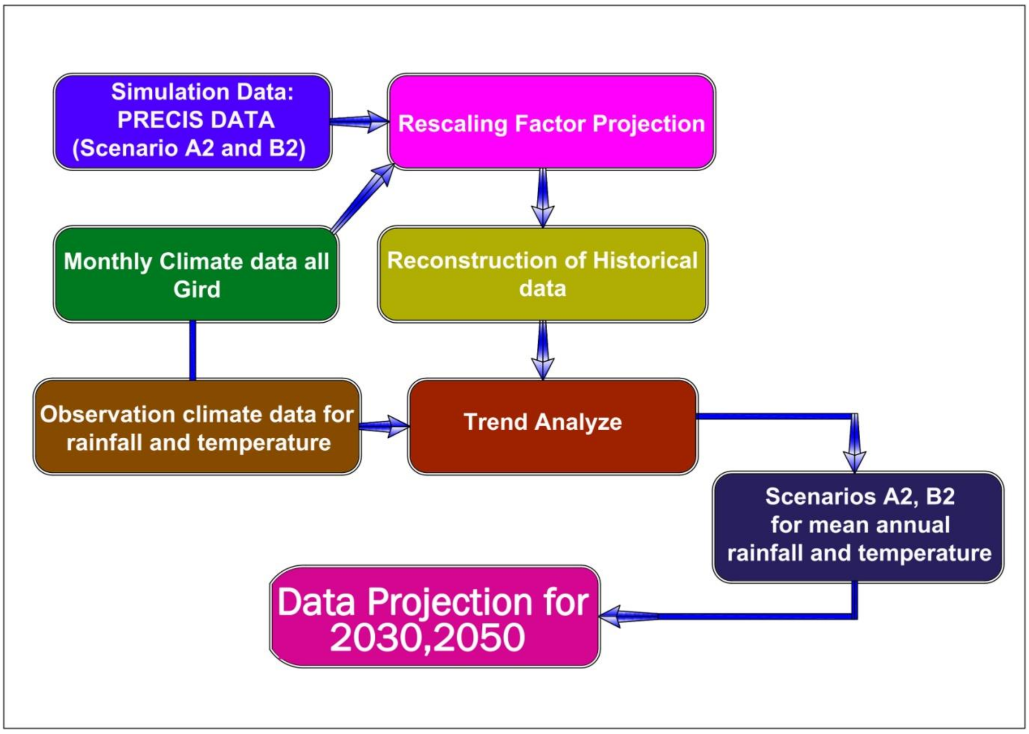


Figure 5: Climate Data Analysis

The data collected from the field survey was cleaned and descriptive statistics like mean, standard deviation, percent and frequency were calculated. Data entry and analysis used the Statistical Package for Social Science (SPSS) and Microsoft Excel computer software

4. Results and Discussion

4.1. Past and Future Climate in Prey Veng Province

- **Past rainfall in Prey Veng Province**

The climate in Prey Veng province is a monsoon climate divided into two seasons, a wet season and a dry season. The average annual rainfall from the last 31 years (1984 to 2014) based on observed climate data is 1421.116 mm annually (Figure 6). This can be compared with SRES A2 model which shows that the average annual rainfall is 1574.70 mm annually (see Figure 6).

Comparing the observed climate data with SRES B2, indicates that the average rainfall is 1583.13 mm annually for the period 1984 to 2014 (see Figure 7).

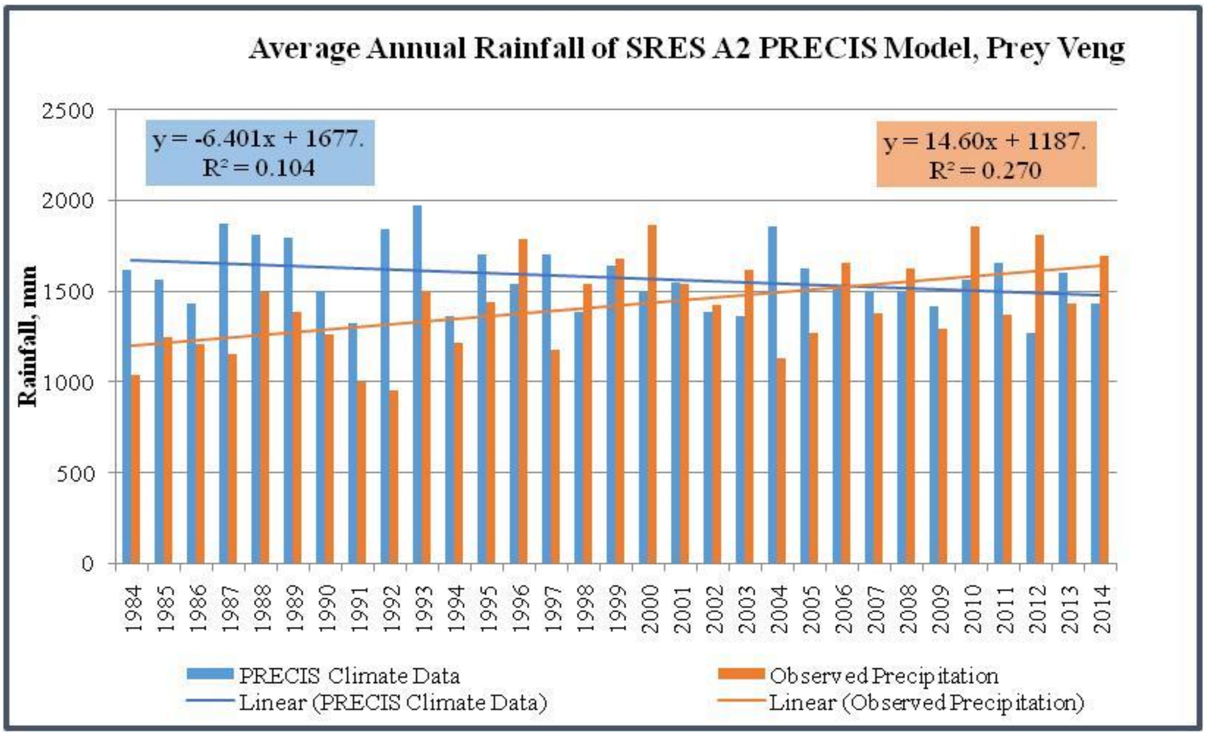


Figure 6: Average Annual Rainfall from 1984-2014 from SRES A2 PRECIS Model, Prey Veng

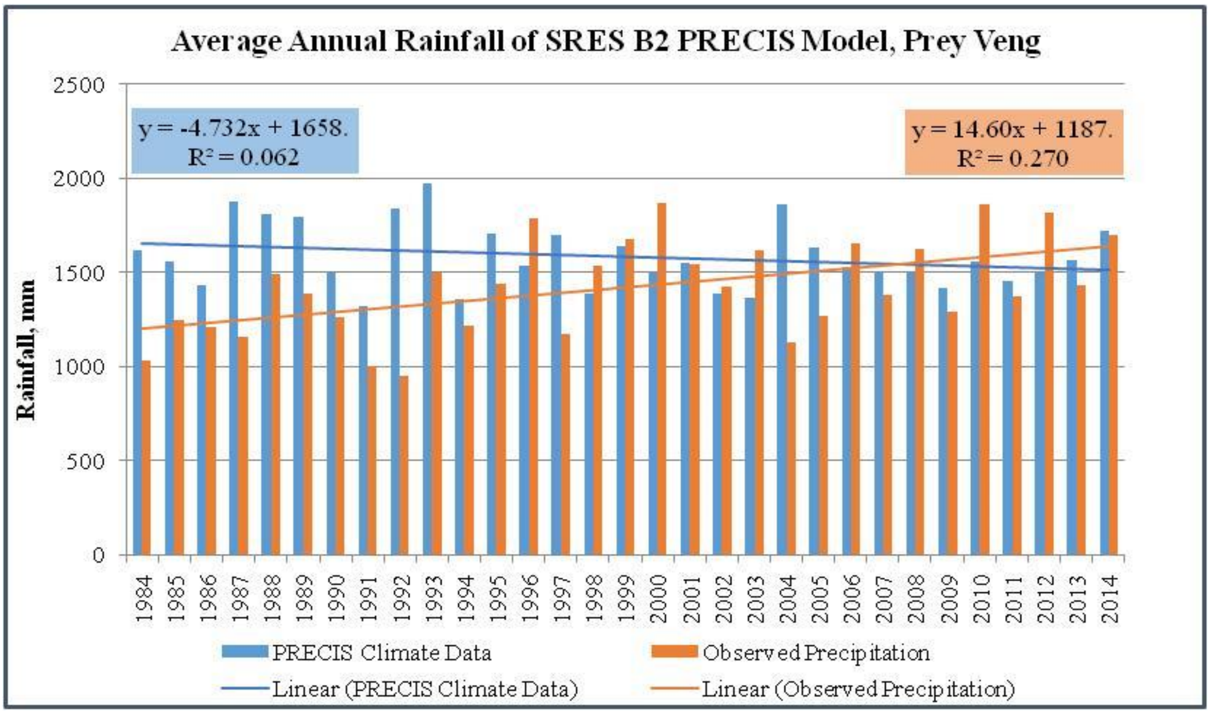


Figure 7: Average Annual Rainfall from 1984-2014 from SRES B2 PRECIS Model, Prey Veng

- **Past Temperature in Prey Veng Province**

The observed climate data reveals a maximum temberature of 33.02 ^{o}C and for SRES A2, the average maximum temperature is 35.56 ^{o}C in the 18 year period from 1997 to 2014 (Figure 8). SRES B2 shows that the maximum mean temperature was 35.60 ^{o}C (Figure 9) .

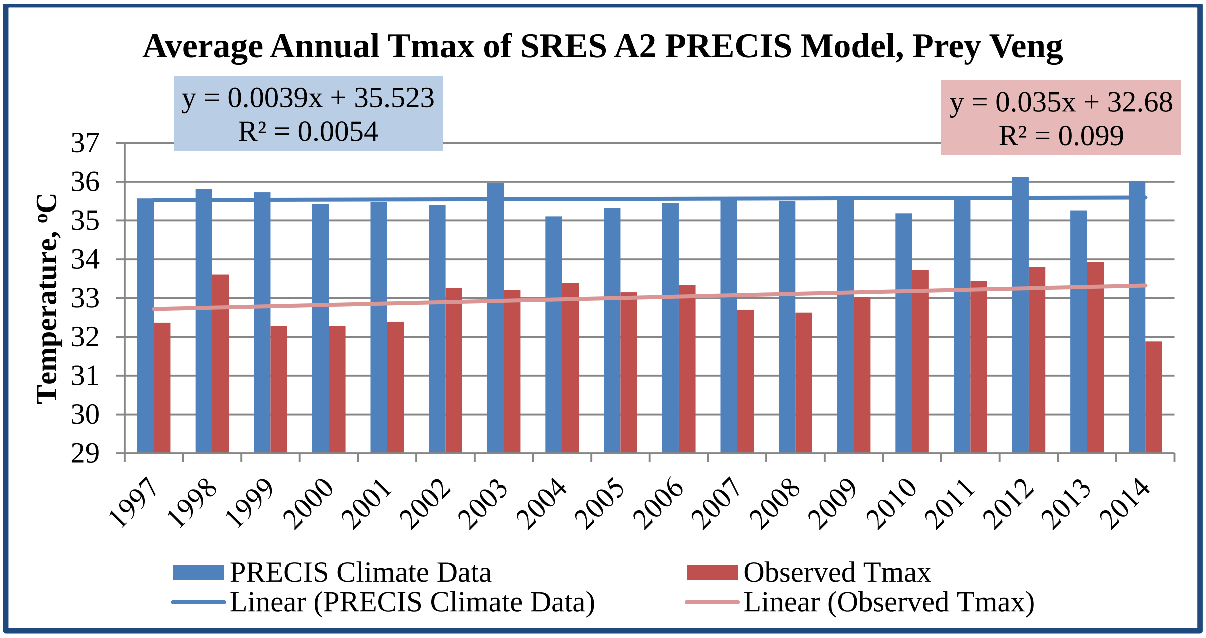


Figure 8: Average Annual Tmax from 1997-2014 of SRES A2 PRECIS Model, Prey Veng

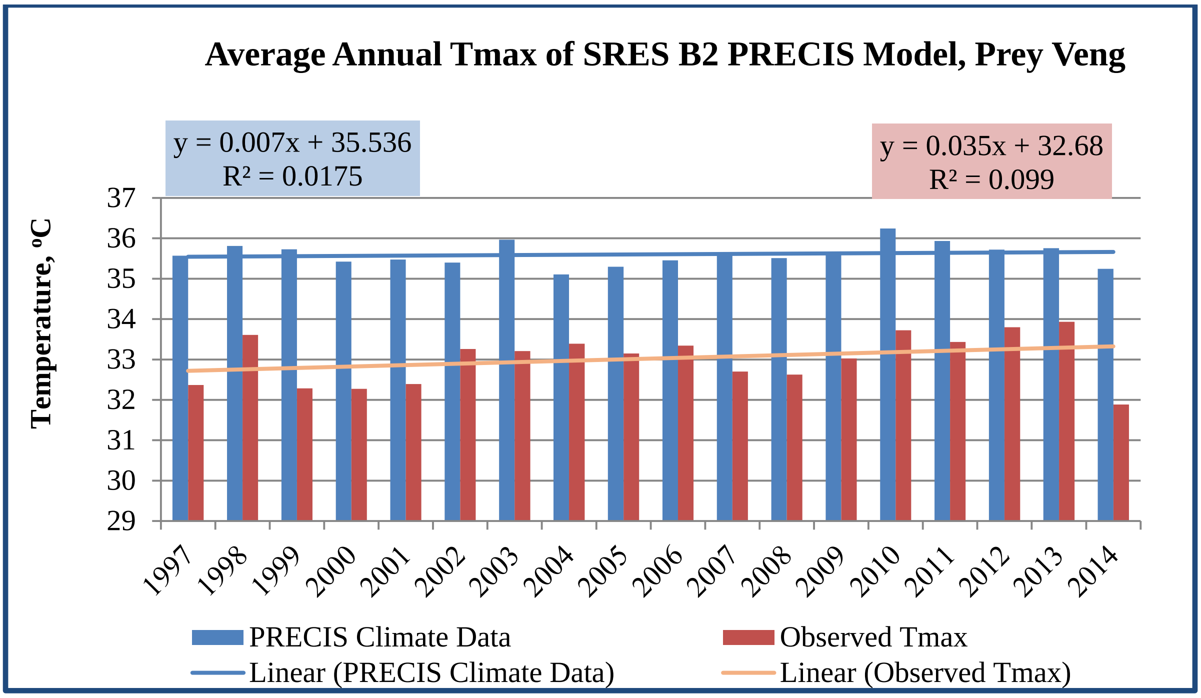


Figure 9: Average Annual Tmax from 1997-2014 of SRES B2 PRECIS Model, Prey Veng

In the 18-year period from 1997 to 2014, the minimum mean temperature was 23.55 °C, according to baseline data. Scenario A2, (Figure 10) indicates that the minimum mean temperature was 25.90 °C annually during the same period. The minimum mean temperature was 25.88 °C annually according to policy scenario B2 (Figure 11).

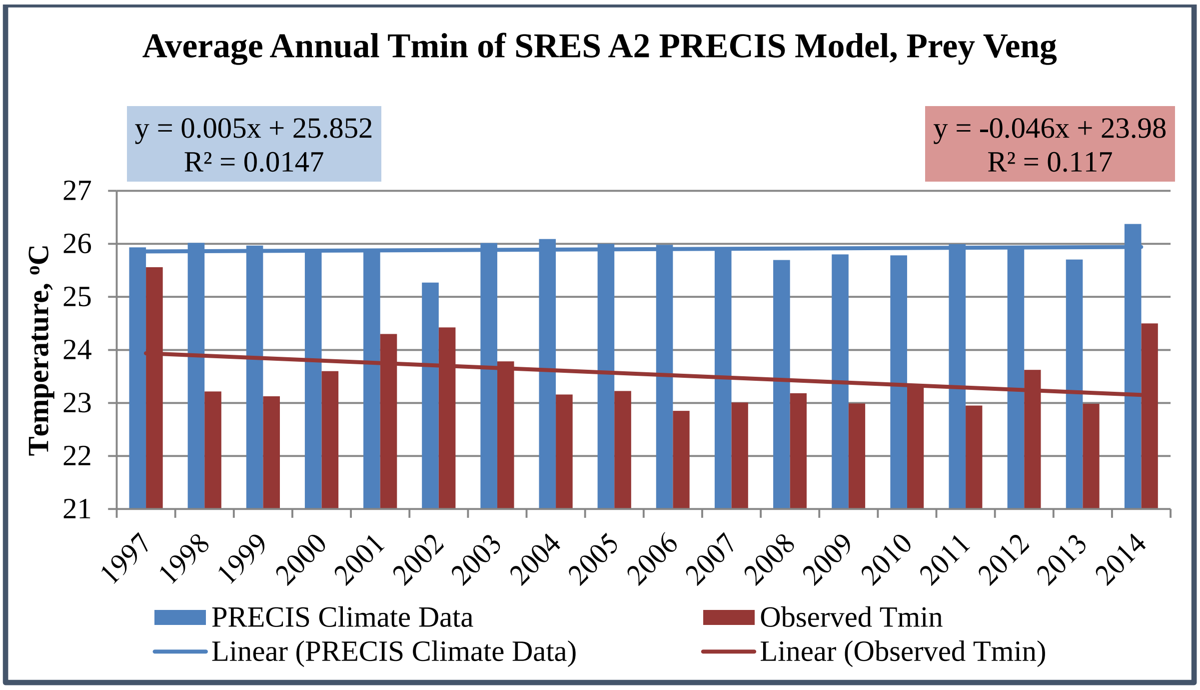


Figure 10: Average Annual Tmin from 1997-2014 of SRES A2 PRECIS Model, Prey Veng

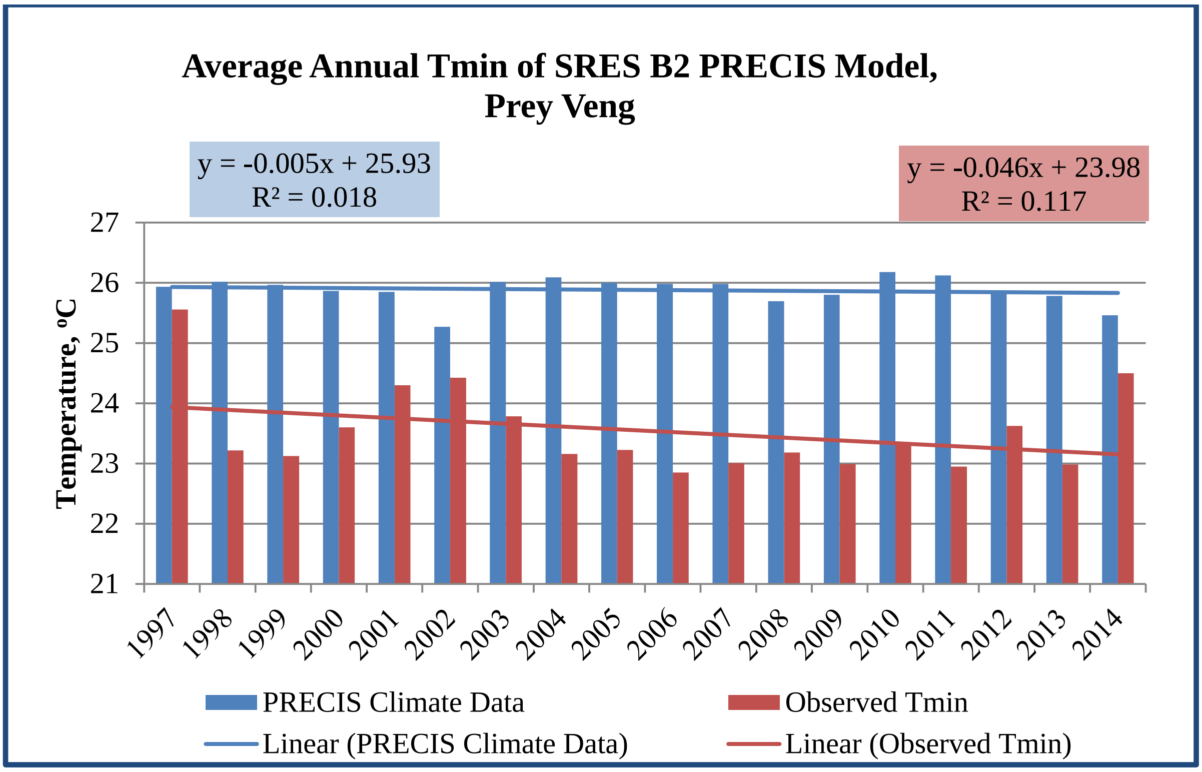


Figure 11: Average Annual Tmin from 1997-2014 of SRES B2 PRECIS Model, Prey Veng

4.2. Future Climate in Prey Veng Province

- **Future Rainfall in Prey Veng**

The projections of average annual rainfall from 2015 to 2050 used the PRECIS climate model for scenarios SRESA2 and SRESB2. In Figure 12, the projection for annual rainfall using emission scenario SREA2 shows that average rainfall could decrease 97.504 mm annually by 2030 and could increase 41.51 mm annually by 2050.

Using analyzed data from downscaling PRECIS climate model for the period of 1984 to 2014 (31 years), the monthly rainfall projection from 2015 to 2050 for scenarios SRESA2 reveals that during the rainy season (from mid-May to mid-November) in 2030 the rainfall increases in August when compared with observed data and slightly decreases in September and October. However, in 2050 from June to October, the rainfall increases when compared with observed climate data.

For SRESB2, monthly rainfall projection indicates that in 2050 the level of rainfall could increase from July to October if compared with observed climate data and the projection to 2030.

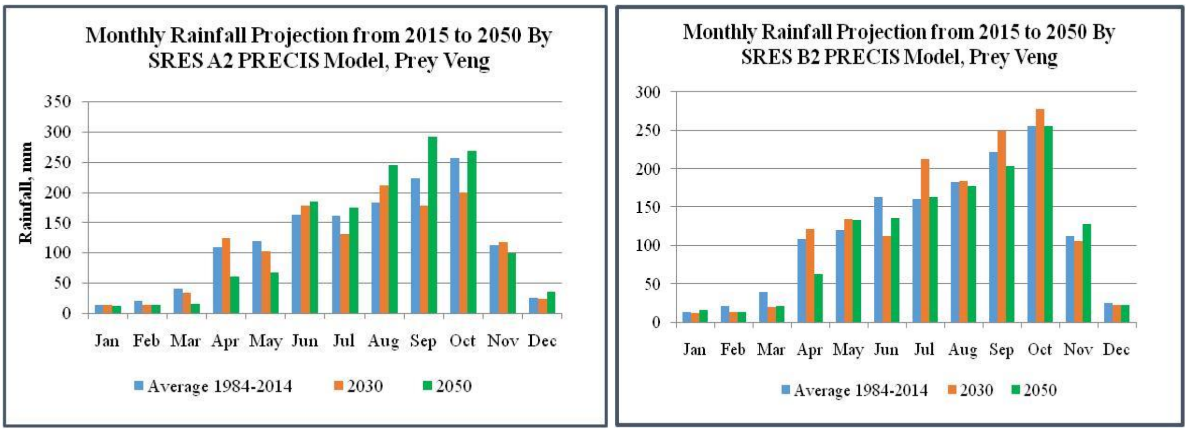


Figure 12: Monthly Rainfall Projection from 2015 to 2050 by SRES A2, B2 PRECIS Model, Prey Veng

- **Future Temperature in Prey Veng Province**

The observed climate data average annual maximum temperature from 1997 to 2014 is 33.02 ^{o}C. The projection to 2030 and 2050 based on scenario SRESA2 indicates that the annual maximum temperature could increase by 0.60 ^{o}C in 2030 and 1.12 ^{o}C in 2050. Scenarios SRESB2 showed that it could increase 0.41 ^{o}C in 2030, and 1.32 ^{o}C in 2050.

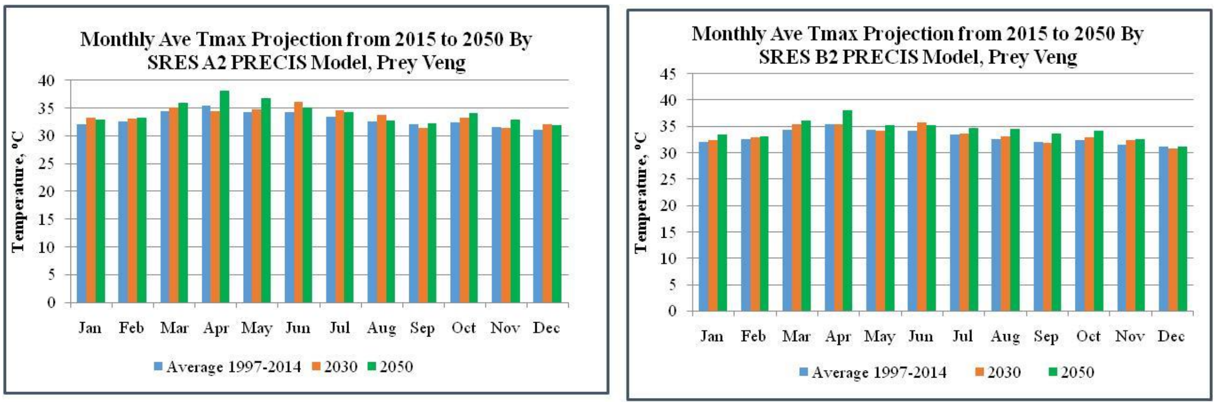


Figure 13: Monthly Ave Tmax Projection from 2015 to 2050 by SRES A2, B2 PRECIS Model, Prey Veng

According to baseline data from the 18-year period, of 1997 to 2014, the minimum mean temperature was 23.55 ^{o}C. The PRECIS model climate projection of emission scenerio SRESA2 reveals that the minimum mean temperature could increase 0.46 ^{o}C by 2030 and could increase 1.03 in 2050 from the current conditions. Using scenarios SRESB2, it could increase by 0.46 ^{o}C in 2030 and by 1.19 ^{o}C in 2050 (Figure 14).

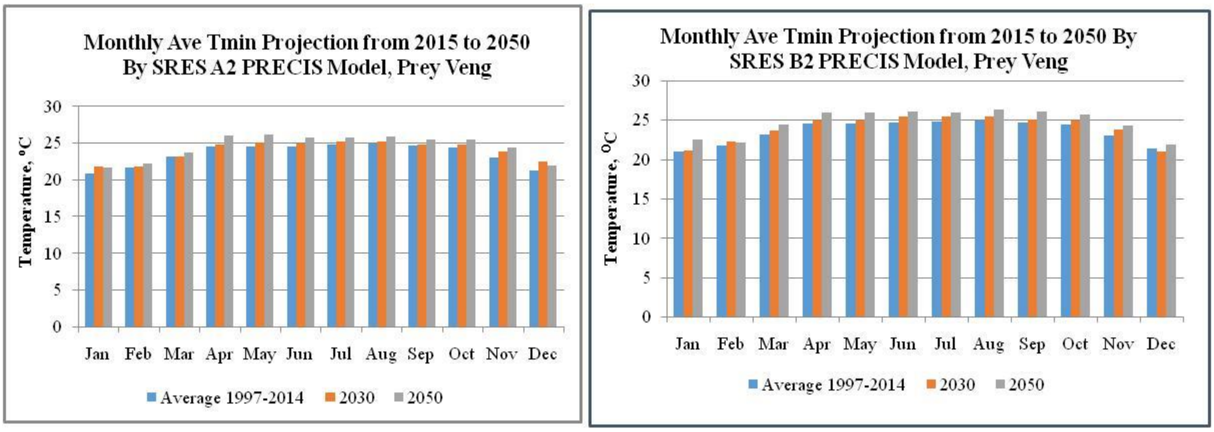


Figure 14: Monthly Ave Tmin Projection from 2015 to 2050 by SRESA2, B2 PRECIS Model, Prey Veng

4.3. Household Profile-Education Level

The majority of the respondents (50 percent) in the research had completed only primary school (Figure 15). This result is very high and the low level of education attained is a concern. The findings indicate that 23 percent of respondents were illiterate. When key actors have only a low level of education it is a sign of risk that needs to be taken into consideration. Knowledge of rice farming has links with educational background, as an important foundation which can have an effect of either increasing or decreasing the production of rice.

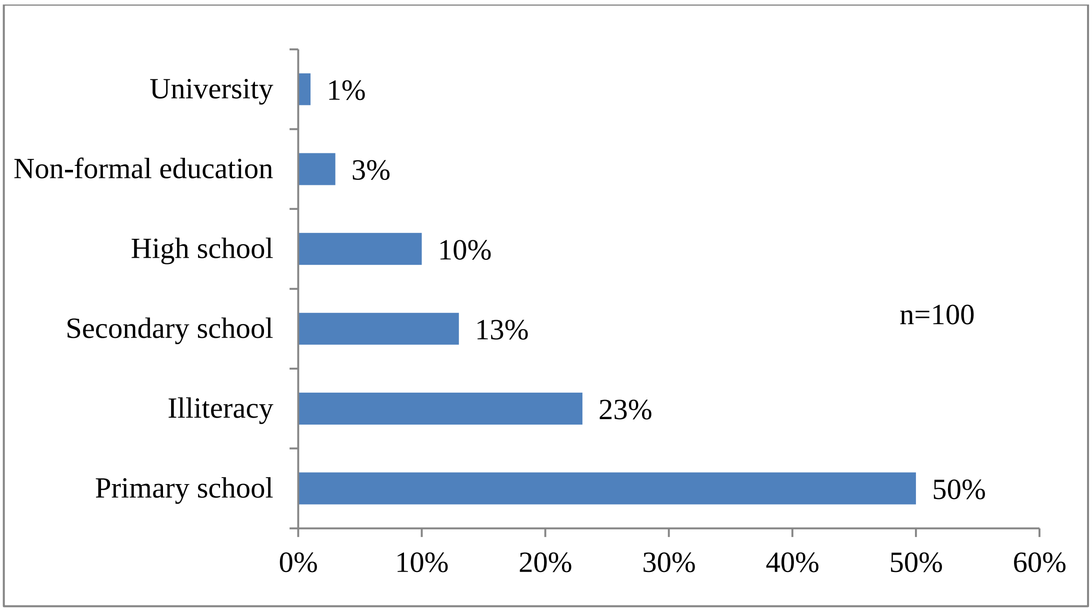


Figure 15: Education Level of Respondents from both Communities

4.4. Economic Profile

4.4.1. Household Main Occupation

Rice cultivation plays an important role in the household of the farmers. More than 88 percent of respondents from both communities (Cheung Phnum and Rakschey) emphasized that rice cultivation was the main occupation of their households. Rice cultivation is the back-bone of their livelihood in addition to being their staple food.

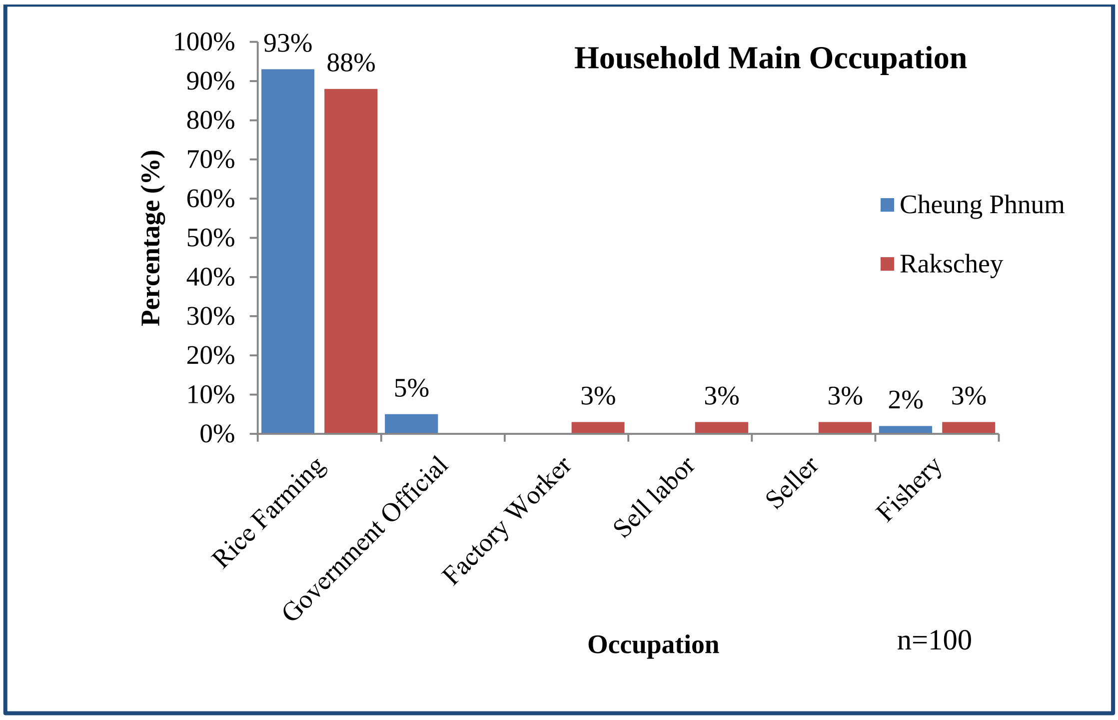


Figure 16: Household Main Occupation

4.4.2. Household Job Diversification

Job diversification is a very important factor for adaptation options. From both communities, 100 percent of family members were engaged in the cultivation of rice, followed by animal husbandry at 32 percent, and labor 28 percent. Table 6 shows that some families had more than one source of income; however in others the farmer had the only one job in their household. In addition to interviewing the respondents, it was observed that job diversification also depended on the number of household members and whether the state of their health allowed them to engage in multiple jobs and also the available opportunities.

Table 6: Household Job Diversification

Job Diversification	Percentage
Rice cultivation	100
Animal husbandry	32
Factory worker	27
Laborer	28
Informal vendor/ small business owner	26
Fishing	11
Vegetable cultivation (vegetables with short-term harvest such as cucumber or cabbage)	10
Cash crop (such as maize, sugarcane, watermelon, soybean, peanut)	6
Government official	9
NGO/company staff	5
Fish farming	1

4.5. Household Rice Farming

4.5.1. Total Land Ownership for Rice Cultivation

From the research findings, 51.7 percent of farmers in Cheung Phnum owned less than one ha of land for rice cultivation, while 45 percent owned more than one ha. In Rakschey, 67.5 owned one ha of land for rice cultivation, while only 32.5 percent had more than one ha. There was not much difference in the size of land owned for rice cultivation between the two communities. Additionally, the plots of land were not in one place; with farmers owing four plots of paddy rice field each on average

Table 7: Ownership of Land for Cultivation of Rice

Rice Field Land (hectare)	Cheung Phnum		Rakschey	
	N°	%	N°	%
< 0.50	12.0	20.0	7.0	17.5
0.50-1	19.0	31.7	20.0	50.0

Rice Field Land (hectare)	Cheung Phnum		Rakschey	
	N°	%	N°	%
1-2	15.0	25.0	6.0	15.0
2-4	11.0	18.3	4.0	10.0
4-8	3.0	5.0	3.0	7.5
		n=100		

4.5.2. Land for Wet-season Rice and Dry-season Rice

There is a difference in the distribution of cultivated land between the rainy season and the dry season, as seen in Table 8 According to the results of interviews, a total of 86 of the respondents utilize rice fields for cultivation in the rainy season, whereas 14 of the respondents cultivate rice only in the dry season. 73 percent of respondents in Cheung Phnum and 97 percent in Rakschey cultivate rice on less than one 1 ha during the rainy season.

Table 8: Rice Land Size Can Grow Rice in Rainy Season

Wet-season Rice Land (hectare)	Cheung Phnum		Rakschey	
	N°	%	N°	%
< 0.50	12	22	7	23
0.50-1	28	51	23	74
1-2	10	18	1	3
2-4	5	9	0	0
4-8	0	0	0	0
		n=86		

Only 33 percent of respondents from both communities reported having access to water resources with 53 percent dependent mainly on rainfall. Farmers that did have access to water resources reported the main sources as a small river (61 percent), or a lake (27 percent), with access gained through the utilization of pumps.

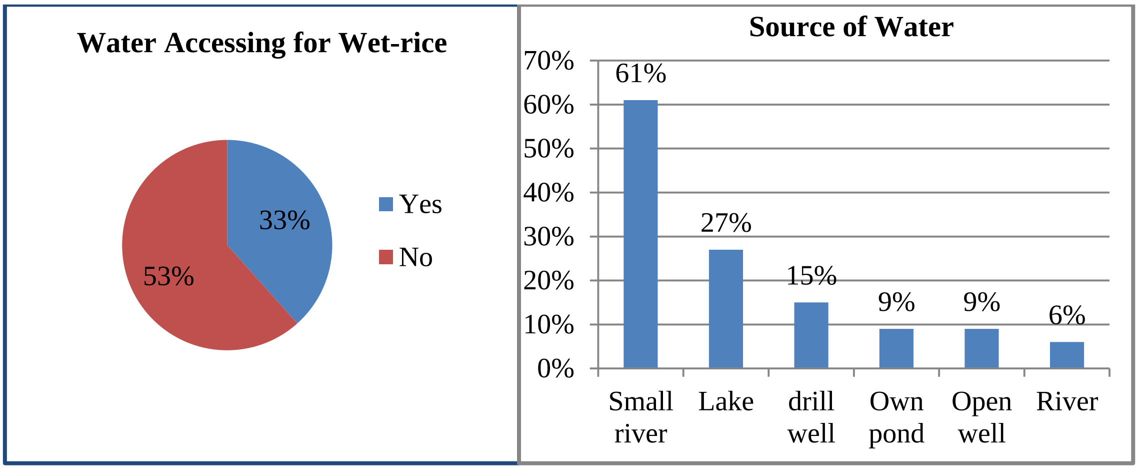


Figure 17: Water Access for Wet-rice and Source of Water

From the interviews with the farmers and the observations of the researcher it was noted that rice can be cultivated in the dry season. 52 persons had the ability to cultivate rice in the dry season, with farmers producing on average 3.50 ton/ha in both the rainy season and the dry season.

Table 9: Land Size for Cultivation of Rice in Dry Season

Dry-season Rice Land (hectare)	**Cheung Phnum**		**Rakschey**	
	N°	%	N°	%
< 0.50	4	12	4	22
0.50-1	11	32	7	39
1-2	13	38	5	28
2-4	5	15	2	11
4-8	1	3	0	0
		n=52		

4.6. Past and Future Climate from Farmers Perspective

4.6.1. Temperature

The research findings reveal that all farmers from both communities have noticed changes in temperature for affecting rice cultivation within the last 20 years. Respondents mentioned that the temperature had become noticeably hotter during the last 20 years, and that temperature is increasing from year to year. They provided evidence that this year, in 2015, the temperature had increased and they had not started the growing rice, as would be normal practice. Rice is normally planted in May, but due to the temperature change at the time of the interviews, in July they were not yet able to begin growing rice.

Table 10 shows that when cultivating rice, 94 percent of farmers indicated they looked at temperatures from the previous five years, with 80 percent estimating future temperatures for the one to five years in the future. This means that, farmers base decisions on their experience in the cultivation of rice and observations of temperatures.

Table 10: Use of Past Temperature for Prediction

Number of Past Years Used for Prediction		**Number of Years in the Future for Prediction of Temperature**	
Number of years	%	Number of years	%
1 year	48	1 year	34
2 years	13	2 years	21
3 years	21	3 years	18
4 years	2	5 years	7
5 years	10	10 years	2
10 years	3	20 years	3
More than 20 years	3	Can't estimate	15

In both communities, 83 percent of the farmers estimated that temperatures would increase over the next five years, 10 years, 20 years or 30 years. This is also a sign of their concerns regarding the future of rice growing (Figure 18). While it must be noted that this is only the predictions of farmers and they cannot attest to its veracity, the majority of the farmers believed that temperatures would increase within those years and only 3 percent mentioned the temperature would decrease.

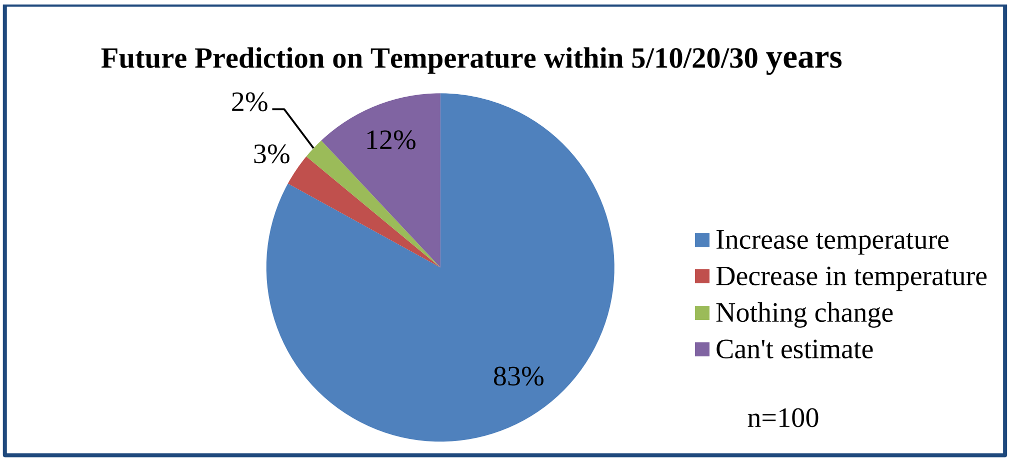


Figure 18: Future Predictions on Temperature from Farmers' Perspectives

4.6.2. Precipitation

The research finds that all farmers from both the communities have noticed changing rainfall patterns affecting the cultivation of rice within the last 20 years. They noticed a decrease in the rainfall resulting in drier conditions within the last 20 years. They also provided evidence that this year, the rainfall is delayed. Rainfall levels are decreasing and for example in this year of 2015, they not started the cultivation of rice cultivation. Normally, they start growing rice in May, but due to the variation of rainfall at the time of interviews in July, they still could not begin to grow rice. 93 percent of the farmers indicated that they used the past five years or less to plan their next crop of rice. In addition, 73 percent predict rainfall patterns from one to five years into the future. However, 26 percent responded that they could not estimate future rainfall (Table 11).

Table 11: Rainfall Patterns from Farmer's Perspective

Number of Past Years Used for Prediction		**Number of Years in the Future for Prediction of Rainfall Patterns**	
Number of years	%	Number of years	%
1 year	42	Next 1 year	29
2 year	17	Next 2 year	17
3 year	26	Next 3 year	23
4 years	4	Next 4 years	2
5 years	4	Next 5 years	2

Number of Past Years Used for Prediction		Number of Years in the Future for Prediction of Rainfall Patterns	
6 years	4	Next 2020	1
10 years	3	Can't estimate	26
		n=100	

Based on the farmers experience in the cultivation of rice and their local predictions, 65 percent stressed that rainfall levels would decreased in five, ten, twenty or thirty years (Figure 19). This will change the rice growing calendar and the farmers will face challenges. Only 22 percent felt they could not estimate future rainfall patterns because the changes are unpredictable.

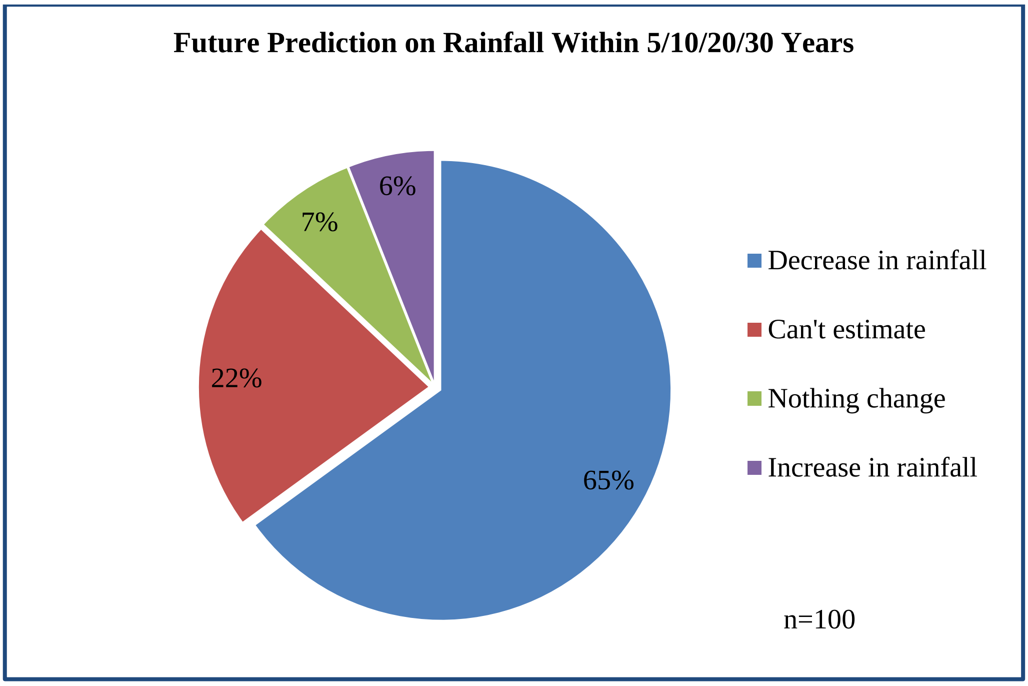


Figure19: Prediction on Rainfall Levels for the Next 5, 10, 20 or30 Years

4.7. Impact of Climate Change on Rice Cultivation

From the research findings, farmers have already experienced the impacts of flood, drought, pest and disease on their rice cultivation. More than 79 percent mentioned impacts from those climate hazards, while less than 21 percent said that their rice had not been impacted by climate hazards in the past 20 years.

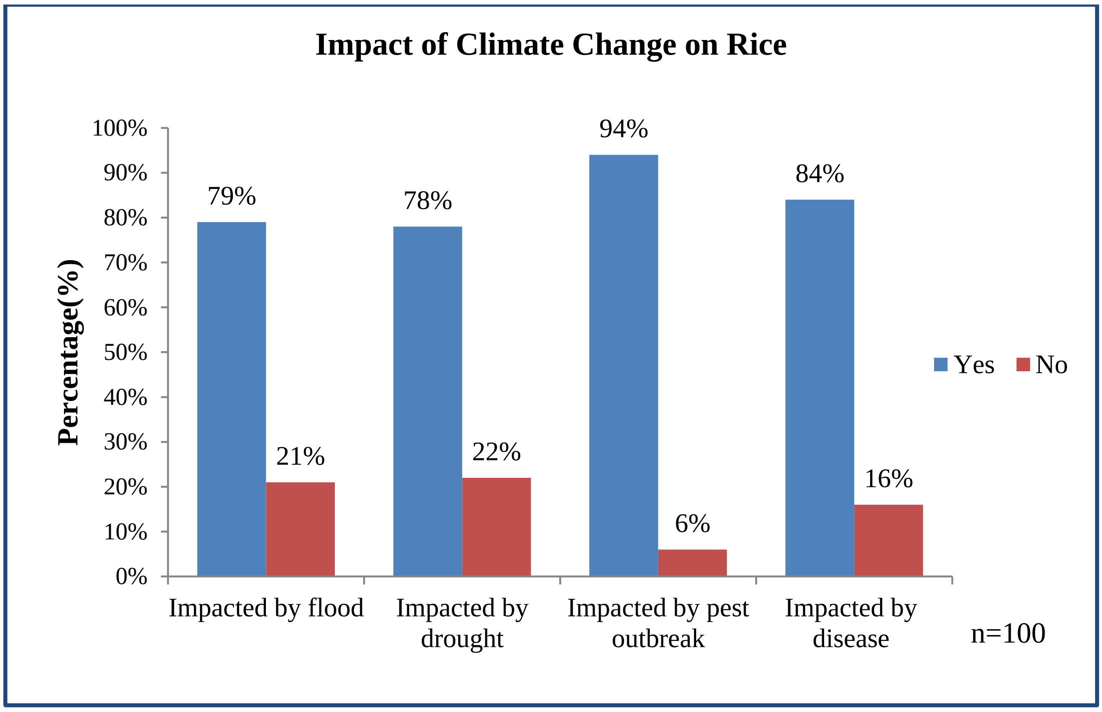
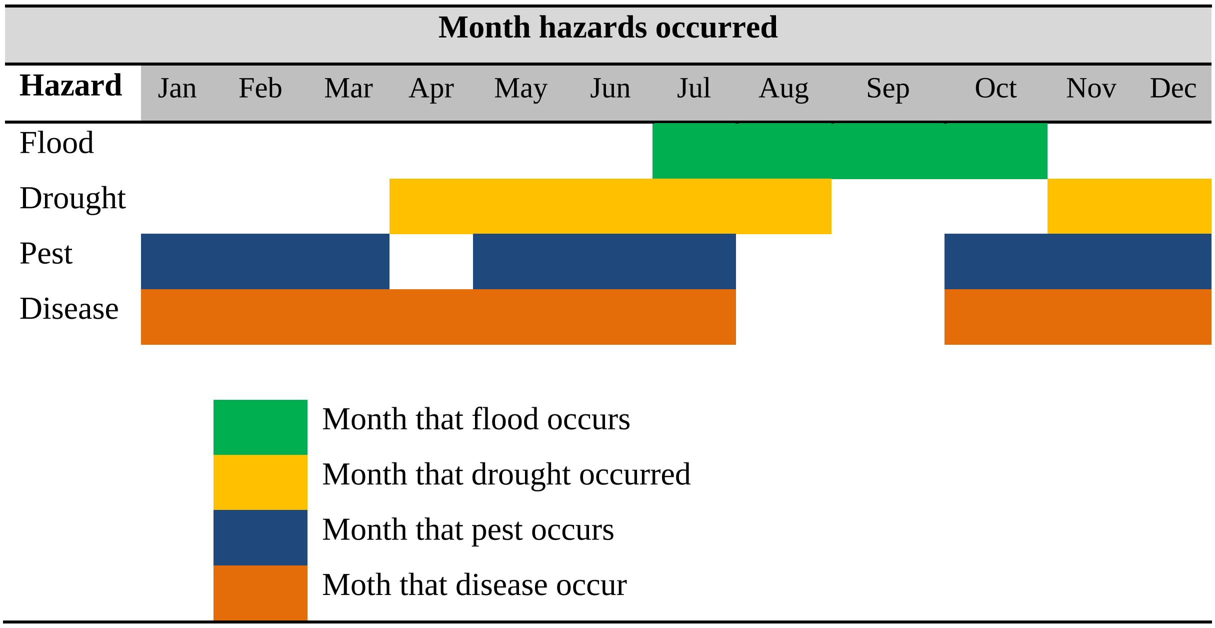


Figure 20: Impact of Climate Change on Rice Cultivation

Farmers observed that they had experienced climate hazards and had been impacted, on average, by flood seven times in 20 years, by drought six times in 20 years, by pests 16 times in 20 years, and by the outbreak of disease 15 times in 20 years. Table 12 shows that the month of occurrence is not the same, however, farmers indicated that floods occurred most frequently in September. Droughts seemed to occur in different months. The intensity and duration of rainfall varies.

As previously mentioned, the farmers stated that due to changes in the rainfall patterns they were not yet able to grow rice at the time of the interviews in the month of June. The duration of the drought was longer than normal, resulting in damage to some of the rice crops that would have to be replanted when the rains began. This indicates that the farmers planted rice after a first rain in May; however a drought followed damaging the rice. The farmers also stated the same circumstances occurred in 2015. During the time the interviews were being conducted, some farmers had already twice planted rice only to have it damaged by severe drought, causing increased expenditures on rice seed. Damage due to disease and pests, on the other hand, occurred year round, with its magnitude dependent on the variety of rice and the climate.

Table 12: Occurrence of Climate Hazards



4.8. Rice Management

The respondents clearly stressed that the management of rice farming plays an important role in their livelihoods. Most farmers described managing rice yields through the use of pesticides and regularly checking the growth of the rice. Both communities reported high levels of pesticide use to control aquatic animals such as crabs or snails. For instance in the last three years, farmers were faced with an outbreak of the golden apple snail (*Pomacea canaliculata)*, and the pesticide used to control it was costly. Without the use of pesticides, farmers reported that yields were too low, and insufficient for household consumption and market demand.

In addition to high rates of pesticide use, high rates of chemical fertilizer were reported due to the low fertility of the soil. Farmers reported the usage of natural fertilizer only at a very low rate.

Water management was important to the farmers, and they checked regularly- every one or two weeks. For minor flooding there was drainage to control it, however for more serious flooding there was no solution. However, farmers could replant after the water receded.

In the case of drought, the farmers with wells, pond, or whose fields were close to a water source, had opportunity to save their rice field. Farmers who depend on rainfall are vulnerable to drought. As previously mentioned, farmers will replant after the damages caused by a serious drought if it is early enough in the season. According to the findings, in both communities only 50 percent of farmers have enough money in reserve to replant, while the other 50 percent do not the financial resources to handle climate hazards.

Table 13 indicates that in the past IR 66 was the most popular rice seed that farmers chose to cultivate, followed by Koun Srov, Kro Sang Teap, Banla Ppdoa, Srov Ouk (traditional varieties of seeds). IR 66 was a variety of seed that the government of Cambodia introduced to farmers. However, it had special characteristics that made it susceptible to brown plant hopper, flood and drought but it is tolerant to the strip stem borer.

Table 13: Variety of Rice Seed in Past and Current Usage

Variety of Rice Used in the Past	%	Variety of Rice Used in the Past	%
IR 66	56	Sleuk Chek	3
Koun Srov	45	Phkar Krahorm	3
Kro Sang Teap	45	IR 504	2
Banla Phdao	67	Srov Sme	2
Srov Ouk	30	Chmar Prum	2
Kanntombi	9	Kantuy Domry	2
Neang Nu	8	Sticky Rice	2
Phka Rumduol	8	Chmar Prum	1
Chul Sa	7	Phkar Sor	1
Somali	7	BH85	1
Sen Pidoa	5	Srouv Sra Aem	1
Kgnoak Pong	5	Pro Pey Sor	1
Srov Snheng	5	Neang Menh	1
Raing Chey	4	Srov Toy	1
Bikat	4	Sleuk Chek	1
Koun Damnerb	4	Somaly	1
Pro Pey Khmao	4		

IR 66 appears to be highly used in the past, but currently the farmers have switched to other varieties. Currently, Nambong (a Vietnamese variety) is very popular in the target areas. It is short-term rice variety, with a harvest time of with less than three month. The main reasons the farmers chose this variety is because of the very short-term growth period, a high yield, and market demand. However, this variety is not tolerant of pest or disease, and farmers have to use high of levels of pesticide and chemical fertilizer to increase the yield. Farmers still invest in this variety of seed because their markets depend on the demand of the Vietnamese market and traders.

Table 14: Current Rice Seed Usage

Current Rice Seed Usage (2015)	**%**
Nambong (Vietnamese variety)	64
Kon Srov	23
IR 66	22
Banla Pdao	7
Domneub	5
Phka Rumduol	4
BH85	2
Kgnoak pong	2
Krorsang Theap	1
Phka Khney	1
Tae Neang	1
Phkar Sor	1
Phka Krohom	1

4.9. Adaptive Capacity

The adaptive capacity of the farmers for cultivation indicated that:

Infrastructure: For the last three years, the Cheung Phnum community has irrigation infrastructure from Chinese investment. However, farmers have to pay to use this water supply, and the research finding show that only 33 percent can access the water supply. 53 percent of the farmers are still dependent on arrival of rainfall because they are located too far from the water source and have no access to the irrigation. Rakschey, however, still has a weak irrigation system.

Economic: Farmers are mainly reliant on the cultivation of rice for their livelihood, which increases vulnerability to extreme events. While some farmers have one more than one job, other employment is small scale and results in little benefit to their family.

Technology: Almost every household from both of the communities had access to electricity and owned either a television or radio; however the access to information through those media is still very low. From the observations of the researcher, the farmers gained information mainly by word of mouth. The early warning system in the communities is not widespread, and sometimes news about climate hazards is received very late.

Social capital: Every household is involved in social activities and has connections with other people. In the event of climate hazards, the farmers could get assistance from relatives, and rice management techniques were shared between contacts.

Human: Every farmer had a strong background and experience in the cultivation of rice. However, they had attained only a very low level of education, which made it difficult to access new farming techniques or information.

4.10. Long-Term Adaptation to Climate Change

4.10.1. Adaptation to Flood

From their experiences of floods, farmers have switched to using a short-term variety of rice which can allow them to harvest prior to the arrival of a flood or to re-grow after the flood recedes. Their rice growing techniques have already been altered in response to climate hazards by a switch from transplanting to rice broadcasting. If the timing of the flood changes, they cope by harvesting the rice before the arrival of water if they receive early warning, and the growing period has also been shifted to cope with flooding (see Table 15).

Table 15: Adaptation to Flood

Adaptation to flood	%
Use short-term variety of rice seed	53
Harvest rice quickly	21
Change crop calendar	8
Don't know	14
Reserve money	5
Seed broadcasting	4
Water management (digging pond)	4
Use long-term variety of rice seed	2
Use flood-tolerant variety of rice seed	2
Use medium-term variety of rice seed	1
Don't know	1
Rice transplanting	1

4.10.2. Adaptation to Drought

There appeared to be different types of adaptation in response to drought, most farmers used short-rice rice varieties and dug wells. From observation, the farmers were aware of the adaption strategies for drought such as digging a pond or well, but were faced with financial constraints. Farmers with a large holding of rice land with plots that were not far from each other started to invest in drilling wells. However, farmers without the financial means and with a very small holding of land did not have capacity to dig ponds or drill wells. Even respondents that did not actually provide the answer of changing to use a short-term rice seed, indicated through other communications or complaints that they had switched to using a short-term variety of rice, changed the crop calendar and/or switched from transplanting to broadcasting.

Table 16: Adaptation to Drought

Adaptation to Drought	%
Use short-term variety of rice seed	34
Drilling a well	25

Adaptation to Drought	%
Drilling a well if they had the ability	22
Digging a pond	12
Changing the crop calendar	9
Water management	10
Use traditional method	17
Use-short-term variety of rice seed	12
Use pest-tolerant variety of rice seed	3
Seed broadcasting	1
Water management	1
Migration	1
Use long-term variety of rice seed	1

5. Conclusion and Recommendations

The Prey Veng province has an average annual rainfall of 1421.116 mm, while the PRECIS climate model SRESA2 average rainfall is 1574.70 mm and SRESB2 is 1583.13 mm in the period of 1984 to 2014. According to the rainfall projection using climate scenario SRESA2, rainfall could decrease by 97.504 mm and increase by 41.51 mm by the year 2050.

The annual maximum temperature in Prey Veng province is 33.02 ^{o}C, and according to the climate scenario SRESA2 the mean maximum temperature is 35.56 ^{o}C, while the SRESB2 average is 35.60 ^{o}C, in the period of 1997 to 2014. By 2030, scenario SRESA2 projected that the maximum temperature could increase 0.60 ^{o}C by 2030 and 1.12 ^{o}C by 2050, and for SRESB2 it could increase 0.41 ^{o}C by 2030 and 1.32 ^{o}C by 2050.

The mean annual minimum temperature is 23.55 ^{o}C. Scenario SRESA2 reveals a mean minimum temperature of 25.90 ^{o}C, while SRES B2 of 25.88 ^{o}C in the last 18 years. The SRESA2 projection of minimum temperature showed an increase 0.46 ^{o}C by 2030 an increase 1.03 ^{o}C by 2050. For SRESB2 the minimum temperature shows a potential increase of 0.46 ^{o}C by 2030 and 1.19 ^{o}C by 2050.

The impact of climate change includes floods, droughts, pest and disease outbreak, have already been occurring in the target area of the research site and it is clear that the communities are already being impacted by climate change. The timing, duration and intensity of climate hazards are changing and have already impacted the cultivation of rice for the last 20 years. Additionally, farmers in the research area are aware of climate change and they also understood the drivers of it as well with their lengthy experience of growing rice but their background level of education is very low which has a negative effect on the ability to assess the new information, and learn new coping strategies and techniques to deal with the challenges of climate change.

Research finding showed that rice is affected by high temperature increase and changing patterns of rainfall as a result of climate change. Farmers who are dependent mainly on rainfall and with a very small land holding are highly vulnerable to the impact of climate change; rice farming constitutes the back-bone of the household as well their livelihood. In addition to the negative impacts on livelihood, the effects of climate change will lead to a decline in production of one of the dominant crops in the Cambodian economy.

In order to improve rice yields, farmers have autonomously changed their rice cultivation practices and techniques. These make them better adapted to cope with climate hazards. Usage of short-term rice varieties, changing the crop calendar, and usage of chemical fertilizers and pesticides are already strategies the selected respondents have chosen to cope with the effects of climate change. Every respondent had changed their planting methods from rice transplanting to rice broadcasting. Additionally, when they had the financial resources they invested in digging ponds and drilling wells to cope with flood and drought. However, this left farmers without the financial resources to invest in these coping strategies vulnerable to shock.

From the perspective of the farmers, and based on their experience, an increase in temperatures in the next five to 30 years with a decrease in rainfall is expected to affect the cultivation of rice. Some of the farmers in Cheung Phnum could access irrigation systems, but they will still face the increasing the demand for water supply and an associated increased cost.

During the course of the interviews for this research, the rice fields of the farmers had already been damaged by a severe drought this season, and the farmers had already begun to broadcast rice again.

Climate change is a national issue, and the farmers alone cannot not adapt to this situation without external support. From the findings of this research, the following recommendations provided to national, sub-national, and local level as well as relevant NGOs:

- Strengthen the national early warning system and advertise information widely, including through social media, television and radio.
- Develop a quick and effective system at the local level for the delivery of key messages to farmers, especially to warn of an impending flood.
- Improve administrative management through the collection of all data on the impact of climate change on rice cultivation, and climate data to track and monitor climate change trends.
- Work closely with the various line ministries to address the climate change impacts
- Provide financial support to the sub-national government bodies to run activities such as the provision of training for farmers to use different rice seed varieties, to monitor farmers, and do the activities on-site to show the farmers.
- Provide capacity building to the sub-national government bodies.
- More fully explore the constraints that are facing farmers in adapting to climate change and take remedial actions.
- At the local/community level, farmers should call attention to the challenges they are facing and request help from experts, and including the request of access to new technology and capacity enhancement.
- NGOs have an important role to play through the provision of technical and financial support for vulnerable groups, and building the capacity of farmers in particular.

Non-climatic drivers also need to be taken into consideration. Respondents from the target areas faced with two main constraints - climate change and market demand. Relevant institutions should assist farmers to find solutions to these challenges by exploring fair market prices and offering assistance with the effects of climate change. These two main issues are inter-linked and remedial actions must be considered together.

Seeds Tolerant to Climate Change and Market Demand

It is important to consider the non-climatic drivers of change as well. In order for farmers to successfully cope with climate change, there must also be a market demand for the seed varieties that are tolerant to the effects of climate change.

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Appendix

Irrigation System Was Dry during Rice Cultivation

Paddy Field Was Dry

Adaptation to Drought by Digging Pond

Agricultural Practice Change to Rice Broadcasting

Rice Broadcasting

Additional Jobs to the Main Work of Rice Cultivation

About MINZAS

MINZAS program is a partnership program of Mekong Institute and New Zealand Embassy in Bangkok. The objective of this program is to enhance research capacity of young GMS researchers by providing a structured learning and filed research application program for 36 master's degree students from provincial universities in Cambodia, Lao PDR, Myanmar and Thailand.

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Mekong Institute (MI) is an intergovernmental organization with a residential learning facility located on the campus of Khon Kaen University in the northeastern Thailand. It serves the countries of the Greater Mekong Subregion (GMS), namely, Cambodia, Lao P.D.R., Myanmar, Thailand, Vietnam, Yunnan Province and Guangxi Zhuang Autonomous Region of PR. China.

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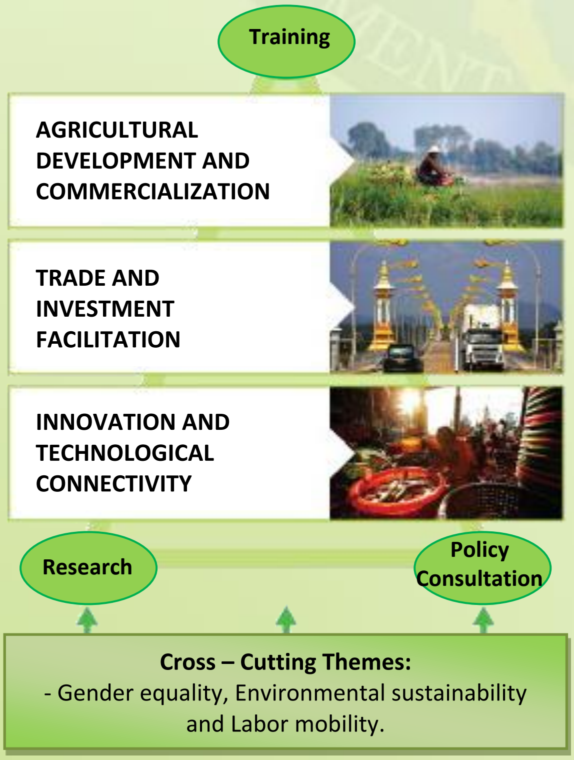

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