ISSN 2250-3153

Assessing the Impact of Climate Change on Small Scale Farmers: A Case Study of Champhone District, Savannakhet Province, Lao P.D.R.

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DOI: 10.29322/IJSRP.11.02.2021.p11063
http://dx.doi.org/10.29322/IJSRP.11.02.2021.p11063

***Abstract*-**Climate change is a severe threat to rural communities' livelihoods, particularly in the agricultural sector, because they are vulnerable to such changes. This study aims to assess trends in rainfall and temperature in the district of Champhone for at least 30 years and check its Correlation and effects on rice production. And to propose steps for adaptation and essential guidelines for farmers. The objective sampling and questionnaire survey using closed and open-ended approaches were employed in four villages simple linear regression using available meteorology data. Correlation analysis was used for the Study of rice productivity. Multiple regression analysis was used to assess the impact of temperature and rainfall to determine factors affecting rice productivity in the wet season, drivers of farmers' preference for adaptation practices, and factors influencing the choice of adaptation. The result of the current Study showed that in three decades, the temperature rose by 0.042 °c/year, and rainfall patterns decreased by -31.28 mm, especially in the later decades. Owing to R= 0.3 and R= 0.4, temperature and precipitation were linked to rice productivity. The result also infuses that increase in temperature, resulting in increased rice production by 0.34T/ha, which is 0.02 %. An increase in rainfall increased rice production by 0.003 T/ha, showing a rise of 0.09 %. Farmer's adaptation strategies involved efficient fertilizers application, irrigation, crop rotation, and short-season crop cultivation. The result of the present Study recommended that government and stockholders supply farmers with early warning services, successful farming approached.

Index Terms- Adaptation practices, Champhone District, Climate change; rice production

INTRODUCTION: Climate change is a global threat to the environment that seriously affects agricultural productivity and affects humanity in other ways, including its direct effect on food production[1]. The role of climate is becoming increasingly important due to anthropogenic climate change, which could drastically change local environments, damage yield [2]. Climate extremes are a key driver affecting food production and food-export policy, as exemplified by the 2012 drought in the United States[3] and the rising incidence of climate extremes[4,5]. Food price spikes may become more prevalent in coming decades[6]. Climate changes the Lively-hood of millions of poor and marginalized people currently threatened by climate change, altering the natural and Physical resources they depend on in general and in particular on agricultural production[7]. Because consumers, including the poor in many countries, are increasingly dependent on food imports[8]. Some studies analyzed the possible effect of catastrophic weather on the crop insurance industry and found that 93% of crop losses were directly linked to adverse weather [9]. Much of central Asia is located in arid and semi-arid regions in particular. Regional agriculture faces the challenges of climate change[10]. Crop yields display a good association with changes in temperature and length of heat or cold waves and vary depending on the stage of plant maturity during severe weather events[11]. Climate variability is most strongly affected by crop production year after year, including high-yield and high-tech agricultural areas[12]. Due to local mean temperature increases of up to 1-3 ° C, crop productivity increases marginally at mid to high latitudes and then decreases beyond that in certain regions. Crop productivity decreases at lower latitudes, particularly in seasonally dry and tropical areas, with even small local temperature increases (1-2°C), raising the risk of hunger[13] Crop yields could decrease by 15-35 percent and 25-35 percent in Africa, Western Asia, and the Middle East, respectively, due to a rise in average global temperatures of only two to four degrees Celsius above pre-industrial levels[14]. Disasters include increased flooding in low-lying areas, higher semi-arid drought frequency and intensity, and severe heat conditions, all of which can restrict crop growth and yields. The effects on agriculture will be significant as temperatures continue to rise[15]. In the face of evolving consumer habits, the impacts of climate change, and rising water and land scarcity[16]. the world will need to increase crop production by 2050 to feed a projected 9 billion people. South Asia, where more than 75% of the rural poor in the area rely for their livelihoods on rain-fed agriculture, livestock, and forestry, has similar problems[17]. The people of Lao PDR are particularly vulnerable to climate change because 80% of livelihoods are associated with some form of agricultural activity. Furthermore poor farmers have a limited asset base and lack access to support

ISSN 2250-3153

provided by the state[18]. Climate change is a subject that impacts the way we live and work. It is having a significant impact on many economic sectors including agriculture[19]. The poorest people, who often live in the most fragile environment and are especially reliant on climate-sensitive agriculture sector, are highly vulnerable to climate change[20]. The direct effects of climate change on livestock include the increase of existing vector-borne diseases and the emergence and spread of new diseases[21]. Flooding triggered by heavy rainfall during the rainy season, drought caused by prolonged dry seasons, sudden flash floods in the mountainous areas of the country, landslides and large-scale land erosion on slopes, frequent windstorms, and, recently, typhoons in the South are the primary climatic disasters Lao P.D.R. regularly faces.[22] Therefore, the main objective of the current paper was to assess trends in rainfall and temperature in the district of Champhone for the last three decades and check its Correlation and effects on rice production. However, the specific objectives included (1) To evaluate trends in rainfall and temperature between at least 30 years in Champhone district. (2) To study impact of climate change on rice productivity. (3) Suggest adaptation measures and key recommendations for farmers. According to a review study by the Champhone District Agriculture Office on natural disasters, it figures that catastrophe occurred twice in at last ten years. While there are major differences in the way in which these threats are felt in the world, these events can also be very damaging, not only by altering the environment, fauna, flora, and vegetation but also by destroying public infrastructure, property, productive land, agricultural assets and potential harvests.

II. MATERIALS AND METHODS

2.1. Description of the study area

The Champhone district is located in Savannakhet province, which it is in the central part of Lao P.D.R., the mention district is about 54 kilometers south-east far from the town. The total population of the study area is estimated to be 108,899 of which 63.312 are females, and 45.587 males respectively. The household size is around 21.332 people [23] Considering the size of the study area, the average population density would stand at about 188 people per km^2 having a latitude of 10 ° 45'- 15 ° 5' and a longitude of 104 ° 45'-105 ° 45' and shares boundaries with seven districts of the province of Savannakhet. They include Outhomphone to the north, Kaisone Phomvihane, Xayphouthong to the east, Songkhone, and Xonbouri to the South, Atsaphanthong, and Phalanxai to the west. (Figure 1), Showing the specification of the district's geographical position. Champhone is in the tropical area and partly in the monsoon zone with two different seasons, the dry season stretches from November to May, and July to October is the rainy season. But in the last decade, this pattern has fluctuated a lot. The annual average temperature is 26.3, while the average yearly precipitation for the long-term is 1441.5 mm. Commodity Crops: Commodity Crops focus on family and group implementation, popular crops such as. In 2019, the total rice production was 32,222 hectares yield 78,449.06 tons, cassava 107 hectares yield 1,310 tons, sweet potato 78 hectares yield 701 tons, maize 65 hectares yield 158 tons, beans 100 hectares yield 1 hectare 60 tons in the harvested area.

Figure 1: The geographical location of the district and showing the study area

2.2. Sampling Techniques

Sampling procedures refer to selecting a given number of respondents from a chosen population-representative[24]. Sampling for the socio-economic survey of the study area was done in two phases. The first phase involved the assortment of the sample sites/communities, whereas the second step involved choosing the individual households from the designated community. Several stages in the survey's conduct were carried out as used by other research studies[25]. The target population for the Study consists of 108,889 Champhone inhabitants. These households were chosen based on climate change effects on various family farming activities and rice productivity. The first process was a closed and open-ended questioner with individual farmers, and the second was a focus group conversation with the village leader in Champhone This Study applied a simplified formula following the work done by Yamane [26] in the second stage to determine the appropriate sample size at a confidence level of 95% with a degree of variability = 0.5 and a precision level (e) = 6 %. Using equation (1): population size, 108,899 in this case; e= accuracy level (6%) since Laos is a developing country; 1= constant value. The total sample size required based on this formula is 280 smallholder farmers' households in Champhone. Such as four villages, including the current research area. The Study using a random stratified sample of 70 households for each village. Relevant guiding questions were intended for the third stage interview to explore selected primary informant interviews with village leaders. Office of Agriculture and Forestry. Office of Climate and Natural Resources. District of Champhone. For this group of respondents, the methodology was ideal as it provided exhaustive and adequate knowledge on their points of view[27]. Besides, the interview schedule allowed the researcher to check the Study and direct it.

2. 3. Methods of data collection and analysis

This research used quantitative and qualitative approaches to gather primary data. Household surveys, primary informant interviews, and direct observation were the techniques used. Most of these preliminary data were collected with open-ended questions via a household survey using a structured and semi-structured guide. They were analyzed using qualitative methods that included codes' development, and categorizing data to assess household survey responses' veracity, essential knowledge interviews[27]. The sampling unit was the smallholder farmers' households.
To complement the data collected through household surveys, primary informant interviews with purposefully selected resource persons in the study area provided general information. The independent qualitative method, a semi-structured interview schedule, which included clear guiding questions, was discussed in selected primary informant interviews.
To assess the integrity of responses obtained from household surveys, direct field observations via transect walks were also frequently conducted in the study area. A stratified random sampling of 70 households per village with a sampling rate of 25 % is the primary data from the four villages collected.
Secondary data mainly on past 30-year precipitation and temperature data collected from the meteorological station located some 30 km away in the study area. The Environment and Natural Resources Agency Province of Savannakhet and rice productivity data was obtained from the Ministry of Forestry and Agriculture.
The data collected from the household survey were statistically analyzed using analytical methods to study farmers' adaptation to climate change. A household survey was used for data processing via a questionnaire, STATA kit, and Microsoft Excel 2016. Statistics such as percentage indices, frequency tables, bar charts, graphs, and inferential statistics such as Simple Linear Regression Model Equation 1, Correlation Analysis Equation 2 clarify the understanding of climate change effects on small-scale growers, rice production, and adaptation strategies. And the equation of multiple regression model 3.

2.4. Model Simple Linear Regression

The simple linear regression model analyzes the average temperature and means rainfall to identify climatic changes in yearly weather patterns, including annual precipitation and annual temperature and time series results. To account for this transition, the simple regression equation takes the form:

$$Y_n = \beta_0 + \beta_1 X_n + \epsilon_n, \quad n = 1, 2, T \qquad (1)$$

Y_i = is temperature has a linear relationship between X_i is years and
Y_j = is rainfall has a linear relationship between X_i is years

2.5. Study of Correlation

The Correlation with rice productivity depends primarily on the average rainfall and the average temperature in the wet season. The equation below was used to calculate the Correlation.

$$R = \frac{n\sum xy - \sum x \sum y}{\sqrt{\{n\sum x^2 - (\sum x)^2\}\{n\sum y^2 - \sum y^2 \; - (\sum y)^2\}}} \qquad (2)$$

Y refers to the Productivity values, in tons per acre, *X* is rainfall, and *Xj* is temperature, in centimeters for thirty successive years. The absolute value of the correlation coefficient of ~0.31 is statistically significant at the 90% confidence level using a two-tailed t-test (df = 28)[7]

2.6. Multiple regression analysis

To analyze the effect of average temperature and average rainfall in wet season on productivity rice). To account for this effect is using the equation.

$$Y_i = \beta_0 + \beta_1 \, Rain_i + \beta_2 \, Tem_i + \beta_3 \, \ldots \ldots_i + \epsilon_i, \; i = 1, 2, T \qquad (3)$$

Where Y_i is rice productivities of season, *X*'s are term explanatory variables. The $\beta's$ are the unknown regression coefficients. The ϵ_i is the error (residual) of observation *i.*
Using STATA version 15, simple regression, correlation analysis, and multiple regression analysis tests were implemented. The Hausman Specification tested the Independence of Irrelevant Alternatives (I.I.A.) assumption before running the actual model estimate. The null hypothesis of the independence of the adaptation options under consideration accepted this test.

III. Results and Discussion

3.1. Trend of annual average temperature during 1990-2019 in Champhone district

Since 1990-2019 the area's average temperature has been increased from 24.79°c -27.63°c (Figure 1). The formula in figure 2, (y=0.042x-59.161) indicated that the average temperature had changed periodically and R^2=0.23, which means that 23% 0f total temperature changed (y) in relating to a straight line between X=year and temperature Y= (as explain by reversing formula). Therefore, there is an essential change over 30 years. Under an increase in the temperature, Champhone district is one of the areas that had this effect. At the beginning of the decade, there was no remarkable change, like at the end of the decade. The average temperature increase started from mid-year to the end of the year, which happened through the decade with 0,042% year within three decades. The climate changeindicated in figure 2, which was the effect of the factors on society and ecologies. The result showed that there is a tendency to increase the warming day in the last decade. Hence, based on the analysis could be projected that the summer will be longer in the whole area of Champhone district.

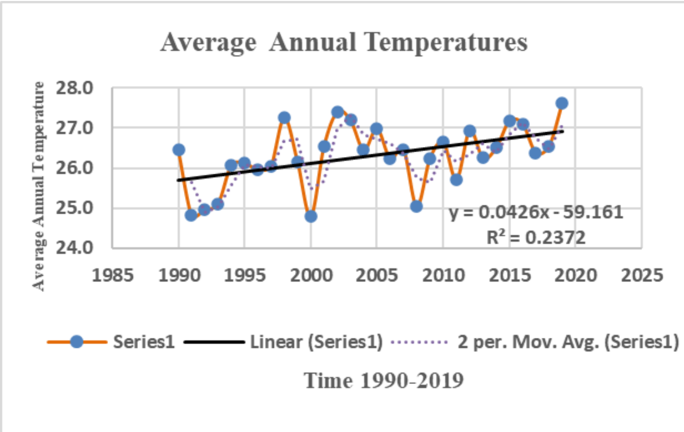


Figure 2: The trend of average annual temperature over the past 30 years

Source: Department of Environment and Natural Resources, Savannakhet Province

3.2. Trends of average annual rainfall during 1990-2019 in Champhone district

The result of the present Study indicated that annual rainfall fluctuates from a minimum of 757.56 mm to a maximum of 1738 mm from 1990-2019. It is also shown that the average rainfall rate changes periodically, and R^2= 0.62 indicated to be 62%. Therefore, the investigation reveals changes in rainfall distribution over the area that has decreased within 30 years. Champhone district is one of the regions that had this effect. Especially in the end decade, there was a decrease by -31,28 mm/year within three decades. Figure (3) showing that rainfall in the Champhone district has changed in the past year.

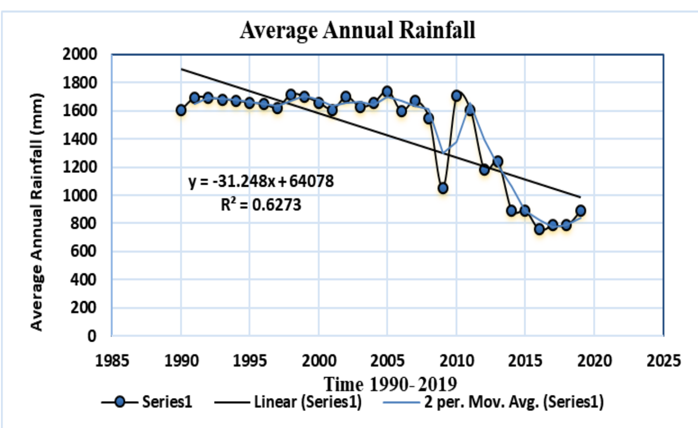
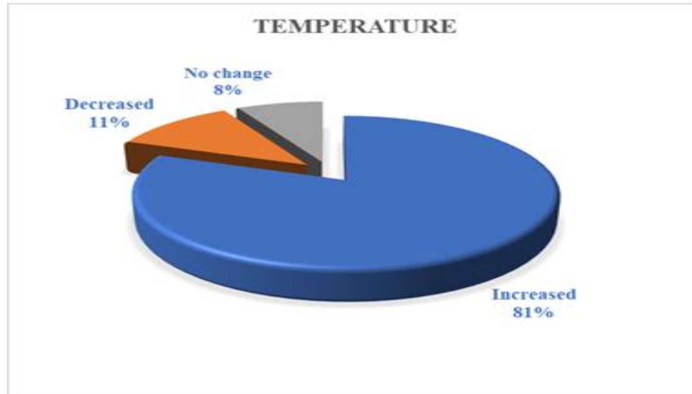


Figure 3: The trend of average annual rainfall over the past 30 years

Source: Department of Environment and Natural Resources, Savannakhet Province

3.3. The perspective experience of climate change

From the Study the Champhone district farmers' representative found that they were aware of temperature increased by 80.71 %, known the decreasing of weather down to 11.43 % and 7.86% of the sample know the temperature was not changes respectively. For the rainfall rate known that there was increased by 15.36%, the reducing rate was 76.43% and about 8.21 % known that there was no change in rainfall rate based on the Study Figure 4



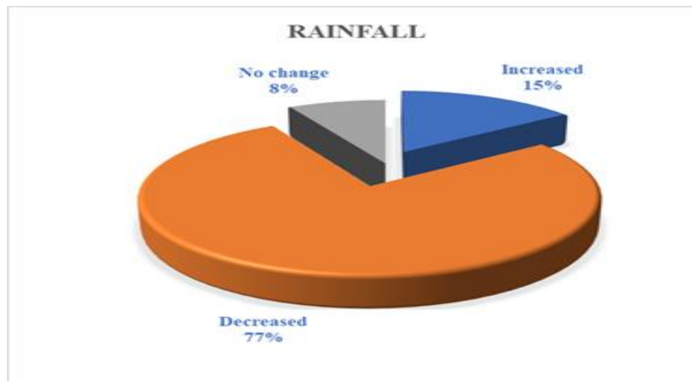


Figure 4: Showing Percentage of farmers' perception experience on temperature and rainfall

3.4. Comparison of farmers' awareness of the past temperature

Comparing the Champhone's farmers' Awareness of the climate change on increasing the average temperature of 80.71 %, the decrease in rainfall rate was about 76.34 %. Therefore, most of the farmers have access to information on meteorology and hydrology.

3.5. Study of the Correlation

The analysis results on the Correlation between rice productivity and annual rainfall and the temperature rate over the 30 years from May to October showed an effect on the rice productivity of qualitatively close to global research results[28]. Although the correlation coefficients between anomalies rainfall and rice anomaly productivity are roughly the same for temperature (R= 0.3, important at 95% confidence level with df=29) and temperature (R= 0.4, marked at 95% confidence level with df=29), the productivity of rice is higher for temperature when looking at productivity anomalies The research shows that, as predicted, precipitation can counter much of the physiological response of the plant to temperature change (as measured by rice productivity). Still, planting area decisions (as included in productivity) remain susceptible to the availability of temperature. The hypothesis that rice productivity increases or decreases are influencing by other factors for 70-60 percent, such as fertilizer, rice type, technological, pest removal, moisture, and other factors. Flowchart presenting the techniques of current Study was illustrated in figure 5

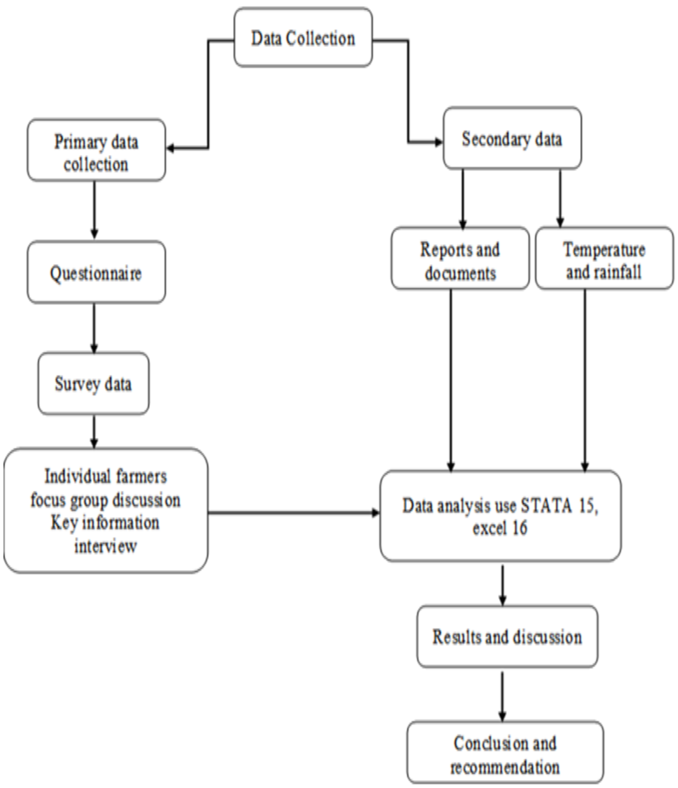


Figure 5: Flowchart presenting the techniques employed in Study

3.6. Multiple Regression and Prediction Model Analysis

3.6.1. Study of Regression

The multiple linear regression analysis of rice production in the study area with the temperature and rainfall environment parameters in Table (1) shows that the Adj R-Squared modified model is 0.192 with R^2= 0.248 shows that due to rainfall and temperature, the multiple linear regression explains 24.8 percent of rice productivity difference. As the F-calculated value (4.46) is more critical than the F-tabulated value (3.35) [29], the F-ratio, which measures the regression's overall importance, is statistically significant at a 5 % likelihood level. To this end, it is also believed that climate change has significantly impacted rice productivity.

3.6.2. Model for Prediction

The multiple regression analysis projections that increase in temperature increase rice production by 0.34T/ha by assuming that no improvement in other variables is statistically 0.02 percent. A significant goal for plant breeders is the potential to increase yields at rising temperatures [30]. Assuming that other variables do not shift, the precipitation increased their productivity rice would cause an increased 0.003T/ha. 0.09 percent is statistically relevant. The multiple regression analysis models predict that an increase in precipitation would lead to an increase in rice yield [31].

Table 1: Parameter estimates of the multiple regression analysis of drivers to analyze the affected rice productivity (Lowland Rain fed Paddy in Wet Season).

Variable	Coefficients	Std. Err	T	P>❘t❘	95% Conf	Interval
Rainfall	.003	.002	1.73	0.09**	-.0006	.0079
Temperature	.348	.146	2.37	0.02*	.0474	.6503
Constants	-7.037	4.084	-1.72	0.09	-15.41	1.3427

*Significant at the 0.05 test level (2-tailed)
**Significant at the 0.1 test level (2-tailed)
Number of observations = 30
F (2, 27) = 4.46
Prob > F = 0.0212
R-squared = 0.2485
Adj. R-squared = 0.1928

3.7. Adaptation Strategies and socio-economics factors

Progressive agricultural systems such as inorganic fertilizers, irrigation, change of cropping pattern, and application of genetically modified varieties, crop rotation, and wetland farming have increased farmers' adaptation to climate change. Accessibility of information and knowledge from government agencies, private individuals, N.G.O.s, and social media played a role in accepting climate change by farmers

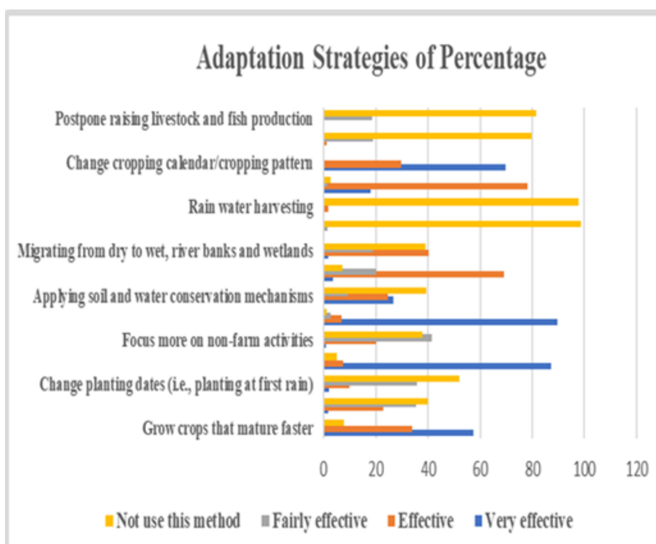


Figure 6: Graphs Percentage of farmers who adopted the main adaptation strategies

IV. Conclusion and recommendations

The Champhone district farmers have experience in climate change situations. The result showed that the temperature increasing by 0,042°c/year within three decades, and trends of the rainfall decreased by -31.28 mm, especially in the end decades. Temperature and precipitation correlated to rice productivity due to R= 0.3 and R= 0.4. The productivity of rice variation can be due to the impact of temperature and rainfall. The multiple linear regression analysis explains 24 percentage and statistically significant at a 0.02 ratio (Table1). The model of numerous regression analysis predictions in contrast, the temperature increased by 1°c; their productivity rice will cause increased by 0.34T/ha by statistically is 0.02 percentage. The rainfall increased by 1 mm; the productivity of rice will cause an increase of 0.003T/ha by statistically significant is 0.09%. The other factor affecting rice production capacity up or down also depends on fertilizer, type of rice, technical, and elimination of pests, moisture, and other factors. Rice production tends to increase if there is no disaster of flooding, drought, and problems. The farmers can use adaptation measures strategy and effectively increase inorganic fertilizers, irrigation agriculture, change cropping calendar/cropping pattern and grow crops that mature faster. However, the service unit related had to take action and helping the farmer by providing: Increasing advocacy access to climate information to encourage people to adaptation climate change, developing and implementing effective cultivation, livestock fisheries, and watershed management plan, promoting livelihood activities that are less and indirectly dependent on climate change, improve reservoir and expanding irrigation system. Continuing and increasing research and development work to support climate change. Increasing social protection schemes in term coverage and benefits offered.

Acknowledgments

We stretch out our appreciation to Tongji University particularly the Instituted of Environmental Sciences and Sustainable Development (IESD). My supervisor, Prof Li Jainhua, and Lao Statistic Bureau. Ministry of Agriculture and Forestry, Department of Environment and Natural Resources, Savannakhet Province, Staff, Village Leader, Framers, and Champhone district for their unexhausted support during the article writing. We might want to recognize Savannakhet Province for giving precipitation, temperature, and other useful information during our study period respectively

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