IMPACTS OF CLIMATE CHANGE ADAPTATION MEASURES ON RICE PRODUCTION IN YEN THANH, NGHE AN

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Abstract

In recent years, increasing climate change has caused natural disasters such as droughts, storms, floods and salination, leading to heavy losses in agricultural production, especially in the field of crop production. In Yen Thanh, the adaptation to climate change has faced many difficulties due to complex topography, along with pressure from rapid economic development and population growth. Based on 146 survey samples, this study addresses the impact of climate change adaptation measures that farmers have been implementing on rice revenue in Yen Thanh, Nghe An.

Keywords: *Climate change adaptation, rice, Yen Thanh, Nghe An*

1. Introduction

According to the World Bank (2018) and Eckstein, Hutfils and Winges - Germanwatch - (2019), Vietnam regularly suffers from extreme weather phenomena, causing serious damage to people and properties. According to statistics from the Ministry of Natural Resources and Environment, natural disasters tend to increase abnormally, with increasing frequency and increasing intensity, especially strong storms, floods, cold weather, drought, and salination. Climate change is warned to negatively affect human life. According to the IPCC scenario by 2050, climate change will reduce about 50% of the food production of Asian countries, including Vietnam.

As a semi-mountainous plain, Yen Thanh has a complex climate. Due to the great radiation from the Sun, Yen Thanh often suffers from drought. On the other hand, the average annual rainfall here is relatively high, from 1,500 to 1,700mm, Yen Thanh thus has been directly affected by many storms, accompanied by heavy rain, sometimes over 300mm per day. In recent years, climate change has caused the average rice-yield in Yen Thanh to decrease by 30% to 40%. In 2010 and 2018, storms and floods damaged thousands of hectares of summer-autumn rice, nearly 4000 hectares of rice crop, and about 700 hectares of vegetables. Although most of the negative weather phenomena are forecasted, in Yen Thanh, adaptation is still difficult.

Most studies in Vietnam focus on selecting climate change scenarios and assessing those scenarios' impacts on the economy and society without paying attention to quantifying the effectiveness of implemented climate change adaptation solutions. Therefore, this study

aims to analyze climate change adaptation measures in relation to rice revenue, thereby, making recommendations to improve the effectiveness of these measures in the context of climate change in Yen Thanh, Nghe An.

2. Method

The data used in this study includes primary and secondary data. Secondary data is collected mainly from published documents such as domestic and foreign specialized reports, meteorological agency reports and local statistics. Primary data was collected by interviewing 146 rice growing households at the intensive research sites (Hoa Thanh, Phu Thanh and Dong Thanh communes) Yen Thanh district, Nghe An.

This study selected OLS regression to analyze the impact of climate change adaptation measures on rice cultivation of Yen Thanh households. The model is applied to cross-sectional data. The specific model is as follows:

$$Ln\_revenue_i = \beta_0 + \sum \beta_1 measure_{ij} + \sum \beta_2 household_{ij} + U_i$$

In which,

- The dependent variable $ln\_revenue_i$ is the base e logarithm of revenue from rice of household i. Since the revenue is relatively large compared to the values of other variables in the model, the study uses the base e logarithm of this indicator.

- The independent variable $measure_{ij}$ includes the group of j climate change adaptation measures that households apply. The variable is assigned to 1 when the household i applies measure j ; assigned to 0 when the household i does not apply measure j.

- Control variables are characteristics of the household ($household_{ij}$), including gender of the head of household i ($gender_i$), age of the head of household i (age_i), education level of the head of household ($academic\_level_i$).

- β_i are the coefficient of the variables and U_i are the random errors.

3. Results

3.1. Overview of adaptation to climate change

According to IPCC (2014), Adaptation to climate change is an adjustment to life in changing climate conditions. The purpose of this process is to minimize damage caused by harmful effects of climate change and further to help people prepare well in terms of living habits, and production techniques. Thereby, people can take the advantage of all potential opportunity to gain maximum benefits (for example, flexible crops or changes in crop and livestock structure to ensure productivity and farmers' incomes).

There are many adaptation measures that can be taken in response to climate change. The IPCC report mentioned 228 different adaptation measures, which will be divided into 6

groups, including (1) Loss acceptance (doing nothing); (2) Loss sharing through insurance packages or community supports; (3) Flood controls by reinforcing dams, ditches, dykes; (4) Prevention of negative impacts by strengthening irrigation systems, increasing fertilization, and controlling pests; (5) Change in production methods (switching to drought or moisture-tolerant crops, or changing in land use purposes); (6) Relocation of production activities such as shifting main crops to more favorable areas.

Climate change adaptation is a long-term process, requiring the attention of actors. Over the years, the system of legal documents on strengthening the capacity to respond to climate change has built a legal framework to improve management efficiency and implementation efficiency. Along with that, due to frequent natural disasters, people have been applying many measures to cope with climate change. According to experts, the community's awareness and understanding of climate change will result in an effective measure (Bryant et al. 2000; Wang et al. 2009). As a typical example, farmers in the Central region that are frequently affected by drought understand that planting drought-tolerant crops such as peanuts as an alternative to rice will achieve high production efficiency and reduce risks from natural disasters.

3.2. Climate change situation in Yen Thanh

Yen Thanh is located in the monsoon tropics with cold winters and divided into two seasons: hot, humid summers with a lot of rain and cold winters with little rain. The average annual temperature is from 24 to 25^{0}C. The temperature difference between months of the year is quite large. The average temperature of the hottest months (June to July) is 30-31^{0}C, the absolute high temperature is 42,7^{0}C, while the average temperature of the coldest months (December to February next year) is 19^{0}C. and the absolute low temperature is -0,5^{0}C. The average number of sunshine hours per year in Yen Thanh is around 1.500 to 1.700 hours.

Yen Thanh is the area with average rainfall compared to other areas in Nghe An. The average annual rainfall ranges from 1,200 to 1,900 mm per year with around 123 to 152 rainy days and divided into two seasons. The dry season from November to April next year, the rainfall accounts for 15-20% of the annual rainfall; The driest months are January and February (rainfall reaches 7-60 mm/month). The rainy season from May to October, the rainfall makes up 80-85% of the year's rainfall; The most rainy months are August and September with a rainfall of 220-540mm per month and 15 – 19 rainy days per month. During these two months, rain is often accompanied by stormy winds.

Table 1: Climate change in Yen Thanh

	Rainfall (mm per day)			Max temperature (^{0}C per day)			Min temperature (^{0}C per day)		
Year	Hoa Thanh	Phu Thanh	Dong Thanh	Hoa Thanh	Phu Thanh	Dong Thanh	Hoa Thanh	Phu Thanh	Dong Thanh
2010	3.99	3.96	3.92	29.61	29.64	29.69	22.33	22.33	22.26
2011	6.80	6.68	6.61	27.27	27.24	27.29	20.90	20.90	20.85
2012	5.11	4.91	4.90	28.06	28.04	28.09	21.63	21.64	21.59
2013	5.22	5.04	5.04	29.24	29.19	29.26	22.47	22.45	22.41
2014	4.66	4.85	4.77	30.94	30.96	30.99	21.70	21.70	21.65
2015	3.75	3.66	3.62	29.50	29.51	29.57	22.10	22.04	22.00
2016	4.33	4.23	4.19	29.10	29.08	29.14	22.29	22.23	22.20
2017	5.99	5.32	5.36	29.17	29.10	29.17	22.81	22.74	22.71
2018	5.67	6.18	6.06	28.42	28.34	28.40	22.12	22.07	22.03
2019	5.72	5.48	5.34	29.46	29.32	29.41	22.13	22.03	21.89

Source: North Central Hydro-meteorological Center

The number of cold days in Yen Thanh has tended to decrease, however, the temperature has shown negative signs, the extremely low temperature has gradually decreased in recent years, especially reaching 4-7 degrees with frost in 2018 . Similarly, the number of heavy rainy days per year has slightly decreased, but the rainfall per has increased. In the period 1991-1999 the maximum rainfall was 320 mm/day, then in the period 2010 - 2018 the maximum rainfall was reported at 345.3 mm/day. Regarding the number of storms, although the number of storms affecting Yen Thanh has decreased, the storm intensity have been alarming. Due to climate change, the number of hot days tends to increase significantly, especially, in 2016 there were 12 times of 5-7 hot days, the temperature reached approximately 43^{0}C.

Table 2: Extreme weather phenomena in Yen Thanh

Periods	Number of days with heavy rain per year (over 100mm/24h)	Number of storms per year	Number of extreme cold days per year (less than 13^0C)	Number of hot days over 37 degrees per year
1991-1999	46	12	13	16
2000-2009	42	8	11	29
2010-2018	39	5	9	41

Source: North Central Hydro-meteorological Center

3.3. Impact of climate change on rice production

In Yen Thanh, agricultural production is heavily affected by climate change. Interviews with 146 farmer households showed that many extreme weather phenomena, namely salinity, severe cold, harmful cold, heat, drought, and storms have seriously affected their crops.

Table 3: Impact of climate change on rice production

	Cultivated area decreased	Productivity is reduced	Rice plants grow slowly	Lack of water for irrigation	More diseases	Plants are dead	Crops are lost	Not affected
Salinity	103	90	79	0	0	59	0	26
Cold	6	57	120	2	13	103	29	4
Drought	11	42	35	92	4	73	16	0
Heat	1	29	57	86	41	60	10	0
Storm	12	120	7	0	18	39	85	0

Source: Author's calculation from survey data

The above table shows that the cold weather in Yen Thanh in recent years caused slow growth and death of crops (82.19% and 70.55% of surveyed households, respectively). Salinity has also made many areas uncultivable. In fact, according to the survey, 70.55% of the households believed that salinity caused a decrease in the cultivated area, 61.64% of the households confirmed that the rice yield decreased. In Yen Thanh, heat and drought are the main environmental constraints. These two phenomena caused water shortage (63.01%), dead rice plant (50%), and a decrease in crop yield (26.1%). Prolonged periods of heat with high temperatures in the summer affected labor efficiency, spring rice harvest progress, and summer rice cultivation. The most severe impact on crop productivity is the storm. Storms

have reduced productivity (82.19%), especially storms caused damage to crop areas accounting for a high proportion (58.22%). Since storms are often accompanied by heavy rains and floods, the disease on crops is very serious.

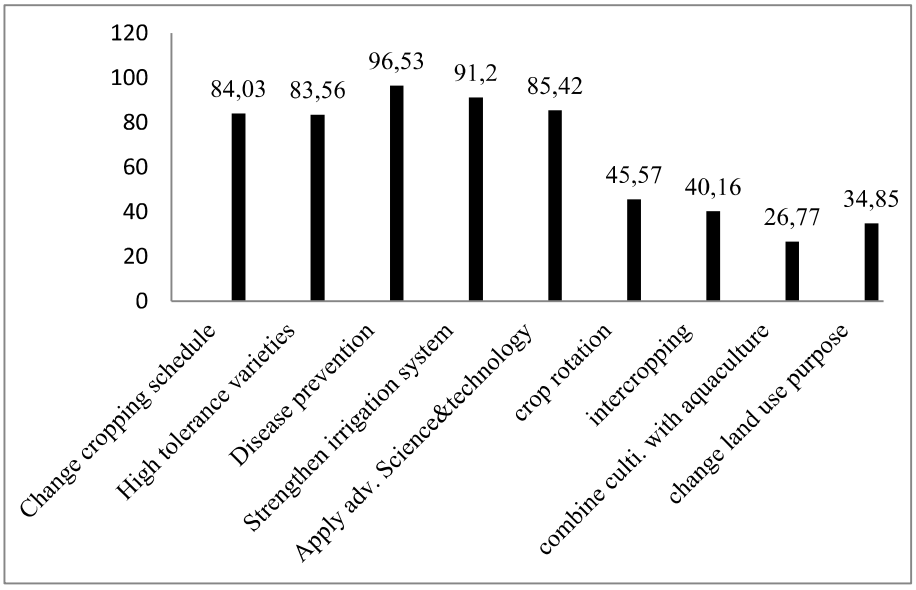
3.4. Climate change adaptation of rice farmers

3.4.1. Overview of climate change adaptation measures of households

According to the survey results, farmers in Yen Thanh have applied five main measures to adapt to climate change, including: (1) Changing the cropping schedule; (2) Select rice varieties with high tolerance; (3) Strengthen disease prevention; (4) Strengthen the irrigation system; (5) Application of advanced science and technology. In addition, some other measures used by households are crop rotation, intercropping, combination of rice cultivation with aquaculture, and change of land use purpose.

The chart shows that in adaptation activities, measures to strengthen disease prevention for rice made up the highest percentage (96.53%), followed by strengthening irrigation system (91.2%), applying advanced science and technology (85.42%), changing the cropping schedule (84.03%), and using rice varieties with high tolerance (83.56%).

In addition, according to the survey, to adapt to climate change, farmers use many different methods at the same time. Most of the households have applied two or more adaptation measures (accounting for 70%). That proves, climate change strongly affects production activities, farmers have to find many different ways to adapt. To have a more specific analysis on the impact of climate change adaptation measures on rice production results, the study will perform a regression.



Source: Author's calculation from survey data

Figure 1: Climate change adaptation measures applied by households

3.4.2. Impact of climate change adaptation measures on rice production results

To analyze the impact of climate change adaptation measures on rice production results, the study implements OLS regression as follows:

$$Ln\_revenue_i = \beta_0 + \sum \beta_1 measure_{ij} + \sum \beta_2 household_{ij} + U_i$$

Within the scope of the analysis, the study deals with the measures applied by farmers with the highest percentage, The variables used in the model are described in the table below:

Table 4: Descriptive statistics of variables in the regression model

Variables	Unit	Coding variables	Mean	Min	Max
Age		Age	46	23	78
Gender		Gender	0.601	0	1
Education level		Academic_level	3.6875	1	5
Revenue from rice	Mil. VND	Revenue	5.923	4.830	14.212
Changing the cropping schedule		Change_schedule	0.8403	0	1
Select rice varieties with high tolerance		Tolerant_varieties	0.8356	0	1
Strengthen disease prevention		Disease_prevention	0.9653	0	1
Strengthen the irrigation system		Irrigation	0.912	0	1
Application of advanced science and technology		Science_tech	0.8542	0	1

Source: Author's calculation from survey data

Since the rice revenue has a high value that exceeds the values of the variables, the topic uses the base e logarithm of the revenue from rice *(ln_revenue)* to make the data uniform. In addition, gender and the application of adaptation measures are coded 0 and 1, in which male takes the value 1; female takes the value 0; households have applied the measure of receiving value 1; otherwise it is 0.

OLS regression result with dependent variable the base e logarithm of the revenue from rice under the influence of household characteristics and dummy variables of climate change adaptation measures, after checking for defects including multicollinearity, heteroscedasticity and autocorrelation is as follows:

Table 5: Regression results

VARIABLES	model ln_revenue
Age	-0,00165
	(0,00347)
Academic_level	0,0673*
	(0,0524)
Gender	0,0256
	(0,0798)
Change_schedule	1,632***
	(0,141)
Tolerant_varieties	0,184**
	(0,0901)
Disease_prevention	0,154*
	(0,105)
Irrigation	0,0171**
	(0,127)
Science_tech	0,034***
	(0,083)
Constant	7,744***
	(0,234)
Observations	146
R-squared	0,782

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculation from survey data

The above results show that all five main measures have a positive impact on rice revenue, in which, measure of changing in cropping schedule has the greatest effect.

Regarding the change in cropping schedule, because the weather and natural disasters forecast of Nghe An province are relatively good, the instructions from the authorities on natural disaster prevention are timely, resulting in reduced damage. Additionally, to cope with natural disasters such as storms, droughts, heat, cold or salinity, local authorities have instructed farmers to plant or harvest early. Regression results show that changing in cropping schedule can increase rice revenue by 1,632% compared to cropping in the usual schedule.

For the measure of selecting rice varieties with high tolerance, the agricultural extension agencies have useful advice on rice varieties for farmers. For pure rice, farmers have changed from Bac Thom to BC15 and RVT „…; for hybrid rice, farmers have changed from Tap Giao 838, 903, CT16 to TH3-3. According to the results of the regression, farmers that choose varieties with high tolerance in production can increase rice revenue by 0,184% compared to households that do not apply this measure.

Disease preventing for rice needs to be carried out regularly, especially before and after natural disasters. Accordingly, farmers who well apply these techniques can increase their rice revenue by 0,154%. This measure need to be learned from local communities and agencies.

In terms of strengthening the irrigation system, the improvement of economical irrigation methods, strengthening the irrigation system to ensure enough water for the winter-spring and summer-autumn crops, preventing salinization can increase tolerance of rice, thereby increasing revenue. The regression results also prove this, compared with farmers that do not regularly strengthen their irrigation systems, farmers with good irrigation systems could earn 0,0171% higher rice revenue.

For the measure of applying advanced science and technology, the regression results show that farmers applying this method could gain 0,034% higher rice revenue than traditional rice farmers. Currently, many Yen Thanh farmers have applied advanced farming methods such as Good Agricultural Practices (VietGAP), Integrated Crop Management (ICM), 3 decrease 3 increase rice cultivation techniques (3G3T), 1 must 5 reduce cultivation techniques (1P5G), System of Rice Intensification (SRI), Integrated food-energy system (IFES),... These successful models will create new directions in farming, contributing to soil protection, stabilizing productivity, increasing income and economic efficiency for farmers.

4. Discussion and Conclusion

The study has contributed to understanding the effects of climate change on rice production of farmers in Yen Thanh, Nghe An. Regarding the impact of climate change on rice cultivation, natural disasters such as cold, heat, salinity, drought, and storm have caused many adverse impacts on production activities to varying degrees. from low, medium to high. These effects generally cause difficulties for rice cultivation, affecting rice yield, growth and production output. Storms cause the most impact and damage, followed by drought and salinity.

Regarding measures to adapt to climate change of farmers, the study proposed nine main adaptation measures, however, there are five measures chosen by the majority of people, which are strengthen disease prevention for rice, strengthening irrigation system, applying advanced science and technology, changing the cropping schedule, and using rice varieties with high tolerance. The analysis results show that these measures, when applied, have a positive effect on rice revenue.

On the basis of the research results, the study makes some recommendations on solutions to increase the effectiveness of the response for households to changes in climate change as follows: (i) Local authorities play an important role in enhancing the response capacity of local communities. Therefore, it is necessary to effectively promote the role and responsibility of local authorities in climate change adaptation programs in the locality; (ii) With agricultural production as the main activity, farmers are the first to suffer the consequences of these adverse effects. Therefore, farmers must be the first and proactive in raising awareness and capacity to respond to climate change.

5. References

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