Perception of Climate Change and Farmers' Adaptation: A Case Study of Poor and Non-Poor Farmers in Northern Central Coast of Vietnam

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Abstract: Successful implementation of national climate change agriculture adaptation policy in Vietnam requires rural communities to be able to respond to government programs. Critical players in ensuring this include provincial government officials and local farmers. Program success depends on strong uptake by farmers, which in turn depends on strong understanding of climate change and its agricultural and environmental impacts. Small-scale farming is dominant in Vietnam, and therefore the perceptions of such farmers regarding climate change and variability, necessary farming practice adjustment, and barriers to adaptation are important. However, there has been very little research devoted to understanding the factors that may influence farmers' responses to climate change in Vietnam. The objectives of this paper are, therefore, to: (i) identify the of understanding and awareness of climate change among small-scale farmers in Vietnam, as it may affect their continuing practice as farmers; (ii) evaluate farmers' understanding of adaptation to climate change; and (iii) record small-scale farmers' responses to climate change adaptation, and therefore the capacity for rural communities to respond meaningfully to government climate change adaptation programs. Drawing on interviews of 172 small-scale farmers and six agricultural officers, we find that the majority of the farmers are, indeed, aware of local climate change. Both poor and non-poor farmers hold similar perceptions of changes in local climatic conditions. Importantly, however, these two groups differ significantly in terms of their perceptions and understandings of adaptation measures, barriers to adaptation, and factors influencing decisions. These differences reflect differences in income, financial capacity and education. Adaptation measures taken by poor farmers typically comprise relatively simple and minimal collective actions, and are typically low cost options. These are likely to have relatively low impacts in terms of their efficacy in responding to climate change. Non-poor farmers, on the other hand, tend to adopt more sophisticated responses, which require greater knowledge, skills and investment costs. These farmers are more likely to be able to respond to climate change with greater efficacy.

Keywords: Adaptation, Climate change, Perception, Poor and non-poor households.

INTRODUCTION

Vietnam is very vulnerable to climate change and climate variability, due to a combination of climatic and geographic factors and socioeconomic structure. The country has around 3,260 km of coastline and more than 3,000 islands. Over 70% of the population lives in low lying coastal plains potentially affected by sea level rise and floods, such as the Mekong River Delta, the Red River Delta, and the central and mountainous areas. All these areas are highly exposed to climate extreme events such as storms, flash floods and droughts [1-4]. Climate research in Vietnam suggests that average temperature in 2070 is projected to be 2.5°C higher than for the period 1980-1990, and that sea level is projected to rise by up to 33cm by 2050 [5].

Some attempts have been made to understand how Vietnamese farmers adapt to the change of climate elements [6-11]. Le [9] and Hoa [7] discuss how perceptions of long-term change in temperature, precipitation and drought have influenced adaptation strategies of farmers in the central coast and Mekong River Delta, while Miguel [6] considers institutional barriers and successful adaptations in the Red River Delta. Quan *et al*. [8] identifies the role of agro forestry system in reducing adverse impacts of climate change and variability on cropping systems in the northern central coast of Vietnam.

Although informative, these studies do not address the extent to which household economics affect perceptions, adaptation and barriers to adaptation of farmers to climate change in Vietnam. Poor farmers, for example, who have the lowest economic capacity to adapt to climate change are expected to experience greater negative impacts from climate change. Adopting adaptive measures are, therefore, essential to

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support these farmers to better face to the change of climatic conditions [12].

With 12% of the population still classified as living in poverty, 2.5 million households are currently living under the official poverty line, with 1.5 million households just above it. They are mostly small-scale farmers, whose livelihoods rely largely on agricultural activities, and who have limited or no financial reserves. To our knowledge, no published research has so far explored the differences between poor and non-poor farmers in terms of adaptive behaviours to changes in climate conditions. To enhance the government's capacity in tackling the challenges that climate change poses to poverty reduction programs, it is essential to understand poor farmers' perceptions of climate change, adaptation measures and the factors affecting their adaptation to changing climate factors.

The research reported in this paper aims to fill a critical gap in understanding of how poor farmers in Vietnam can adapt to climate change. The focus of this research is poor rice farmers in the northern central coast area, being a contribution to enhancing national and local policy-making by providing policy makers insight into how poor farmers perceive climate change in relation to their farming adaptation practices. Based on the case of farmers in northern central region of Vietnam, we hypothesize that there are no differences between the poor farmers and non-poor farmers in term of their perception of climate change and variability, the adjustments they make in their farming practices in response to these changes, and any barriers to their adaptation. While this study is focused specifically on the situation in Vietnam, and especially to the pragmatics of climate change adaptation program implementation in Vietnam, it contributes to a wider global discussion regarding small-scale and low-income farmer responses to climate change [13-15].

ADAPTATION TO CLIMATE CHANGE IN AGRICULTURE

Farmers' Perception and Adaptation Process

The importance of climate change perception in the adaptation process has long been recognised [16-20]. This aligns well with the theory of planned behaviour, a practical theory that helps understand the beliefs, attitudes and values that influence behaviour relating to environment; it focuses on behavioural, normative and control beliefs [21-27]. A central factor of the theory of planned behaviour is an individual's intention to perform a given behaviour. In this study, we consider the effect of perception of an environmental condition (climate change) on likelihood of behaviour (response to a government program) as the indicator of beliefs translated into behaviour. According to Weber [28], understanding farmer's perceptions of climate change is required before any attempt is made to encourage adaptive behaviour. An individual's perceptions are influenced by both that person's direct experiences and the knowledge and beliefs they have developed or learnt from others they trust. It may be very difficult to notice slow changes in climate. However, farmers tend to place more value on perceptions they gain from their own direct farming experiences, rather than what others have told them, particularly if there is a lack of trust [28]. It is important, therefore, to recognise that individuals may be more likely to accept changes are happening if they have learnt about it from an authority they trust, such as through their education [28].

Maddison [29] argues that, to adapt to climate change, farmers are required first to notice that climate has altered, and then identify potential useful adaptation measures and implement them; this being the first step in a two-step process of farmers' adaptation [18]. There are three ways in which farmers can learn about the best adaptation options are learning: by doing, learning by coping, and learning from instruction.

Factors Shaping Climate Change Perceptions of Farmers

Exploration of factors that shape farmers' perceptions in the adaptation process has interested scholars of different countries [16, 17, 19, 30]. The climate change literature records important factors to include household characteristics, years of farming experience, farm size, access to markets, access to agricultural extension service, land tenure, soil fertility and access to credit. These factors a reconsidered to account for farmers' adaptive responses and form the foundation of decision-making [29, 31]. A positive relationship between education level of farmers, the adoption of improved technologies and adaptation to climate change is widely recognised as being crucial [32, 33]. Daberkow and McBride [34] demonstrate that farmers with higher level of education are more likely to adapt successfully to climate change than those with lower level of education, as high level of education has a link with access to information on improved technologies and production challenges.

The association between the gender of the household head and adaptation decisions to changes and to wealth has also been examined. Many studies in Sub-Sahara Africa and developing countries indicate that male-headed households are more likely to be wealthier and to have more adaptation capacity than female-led households [35-38]. Nhemachena and Hassan [39], on the other hand, argue that women carry out most of the agricultural work in Southern Africa and that they have good information and significant experience on various management practices. They are, therefore, more likely to take up climate change adaptation measures.

Farming experience was found to account for increasing the likelihood of taking up adaptation strategies. This is because experienced farmers have more knowledge about changes in climatic elements, and on best agricultural practices to adopt. Taylor *et al*. [16] have indicated that farming experience plays a significant role in farmers' drought perception. However, the positive contribution of farming experience in responding to climate change depends much on other factors such as land and access to credit. Without sufficient financial resources to purchase improved seeds, experienced farmers will not be able to adapt to climate change efficiently [39]. Farming experience, on the other hand, might constrain expectations of farmers for future environmental change.

Other factors such as farm size, access to markets, access to agricultural extension service, land tenure, irrigation rate, non-agriculture incomes, soil fertility and access to credit or loans also have a positive correlation with adaptation to climate change of farmers. Daberkow and McBride [34] demonstrate that bigger farm holders are more likely to adopt new technology, whereas the fixed production costs associated with new agricultural adaptation technologies prevent small farm holders from adopting similar measures. According to Adesina and Forson [40], agricultural extension services are vital to farmers in the adaptation process, as it provides education in both best farming practices and climate knowledge, hence increasing the likelihood of uptake of adaptation strategies.

Barriers to Climate Change Adaptation of Farmers

Barriers, as defined by Moser and Ekstrom [41], Huang *et al*. [42] and Biesbroek *et al*. [43], are factors, conditions or obstacles that decrease the effectiveness of adaptation strategies. Barriers, however, can be overcome with creative management, changed thinking or concerted effort [41]. Several studies have tried to distinguish between barriers and limits to climate change adaptation. Limits are defined in the fourth assessment report of the Intergovernmental Panel on Climate Change as "conditions or factors that render adaptation in effective as a response to climate change and largely insurmountable" [12]. Hulme *et al*. [44] and Dow *et al*. [45] have indicated that limits are endogenous and absolute; they are, therefore, unsurpassable.

Socio-economic factors, resource constraints and psychological factors have been widely identified as the major barriers to adaptation of farmers [33, 38]. They include poverty levels, societal hierarchies, lack of communication in case of threat, lack of information on adaptive measures, lack of access to credit, maladaptation, force of habit, and the perception of the importance of climate change and adaptation [7, 31, 43].

In this study, we define climate change as perceived changes in average rainfall and temperature. Since rainfall and temperature are the two most important climatic elements to agricultural production, farmers were asked about their perception of long-term changes or variability of those two factors over the last two decades.

STUDY SITE AND METHODS

Study area

The study took place in the Tho Dien commune, in the lowlands of Thanh Hoa province, northern central Vietnam (19°18' to 20°40' N; 104°22' to 106°05' E; Figure **1**). Thanh Hoa was chosen as a research site for its location in northern central coast, which is characterized by strong climate variability, frequent weather hazards, and high vulnerability to adverse effects of climate change.

The province has the highest number of poor households in the country. A report of the Vietnam Ministry of Labour-Invalids and Social Affairs [46] indicates that, in 2011, Thanh Hoa province had 182,439 poor and nearly poor households, accounting for 20.3% of total poor households in Vietnam. Tho Dien community is characterized by 98% of the population being farmers and 100% of poor and nearly poor households are farmers [47, 48].

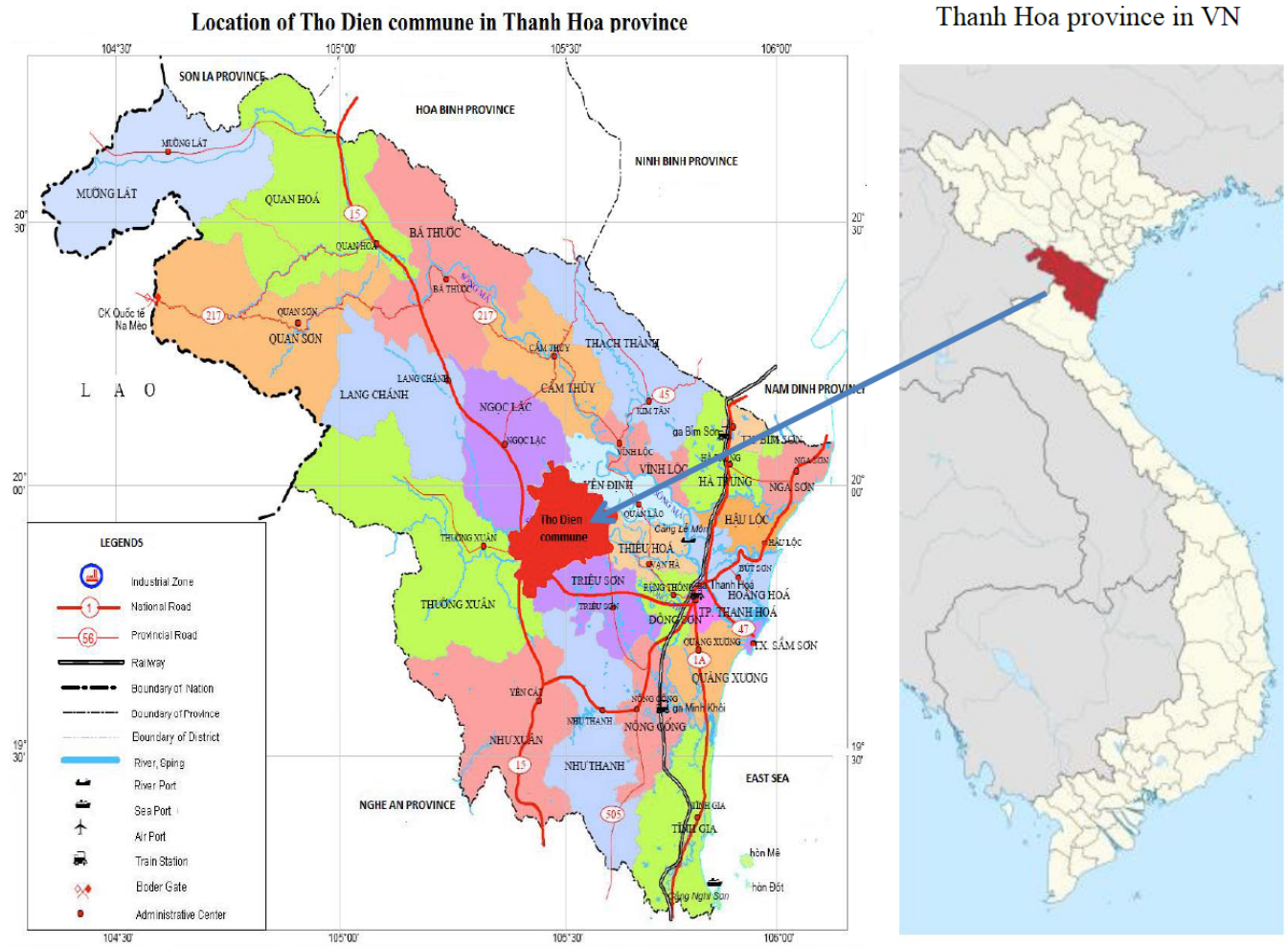

Figure 1: Study site, Tho Dien commune in Thanh Hoa province.

The survey was carried out in 6 of the 13 villages of Tho Dien commune. These differ in terms of poverty rate, access to market, and off-farm income (Table **1**).

Methods

Data Collection

Primary data was collected from household interviews, personal discussions with farmers, and group discussion with local agricultural officers. For the household interviews, a structured questionnaire was deployed to gain insight into how farmers perceive climate change in relation to their farming adaptation practices, and their views on the main barriers to their adaptation [49]. The interviews progressed in five stages: design questionnaire; reliability and pilot questionnaire; interviewee recruitment; conducting survey; and data coding and cleaning.

Table 1: Background Information on the Six Chosen Villages in Tho Diem Commune

	Village 1	Village 2	Village 4	Village 8	Village 10	Village 12
Number of households	115	124	98	107	132	112
Rice fields (ha)	10.9	11.2	10.3	11.8	13.5	10.1
Rain-fed crop fields (ha)	4.0	5.0	4.7	5.4	5.1	5.0
Poverty rate (%)	11.3	9.7	14.3	15.0	13.6	13.4
Main incomes	Agriculture and non-agriculture	Agriculture and non-agriculture	Agriculture	Agriculture	Agriculture	Agriculture
Distant to local market (m)	500	200	800	1500	2000	3000

Source: Communal reports, 2011.

Six agricultural officers from the Department of Agriculture and Rural Department of Thanh Hoa province and Tho Xuan district, Agricultural Extension Centre of Tho Xuan district, and the Tho Dien commune, participated in the group discussion. The discussion focused on understanding administrative procedures relating to agriculture production at commune level and barriers to farmers' adaptations.

Secondary data was collated from provincial, district and commune annual and non-government organisations reports, on climate extreme event damage, agriculture production plans, and socio-economic conditions for the period 2009-2012. Rainfall and temperature data, used to contextualise the survey responses and examine potential impacts of temperature change on rice seasons, were collected from the Bai Thuong meteorology station; that station is located in Tho Xuan district and is 9 km from study site.

Data Analysis

Meteorological data analysis for the 20-year period 1993-2012 determined temporal changes in annual temperature and rainfall in Tho Xuan district. Temporal variations in annual rainfall were assessed by five year moving average and cusum technique. Cusum is a statistical technique used by Murtagh [50], Erskine and Bell [51] to assess changes in annual rainfall in Australia.

The survey data were analysed using the Statistical Package for the Social Sciences (SPSS 20) and STATA statistic package (STATA 12), running descriptive frequencies, logistic model and Chi-square.

The logistic model, which has been used in several studies of farmers' adaptation to climate change [29, 30, 52], was used to determine factors influencing the farmers' decision to adapt to climate change.

The logistic model for 'n' independent variables (X_i, X_2, X_3, ...X_n) is given by

$$\underset{i=1}{\overset{n}{\text{Logit}}}\ P(x) = \alpha + \sum \beta_i * X_i \quad (1)$$

β_i is the odds ratio for a farmer having characteristics i versus not having i (farmers taking any adaptation measure or not), while β_i is a set of coefficient to be estimated. X_i is explanatory variables hypothesised, based on theory and related empirical work, to influence farmers' decision of adaptation. The description of explanatory variables and their expected signs are presented in Table **2**.

RESULTS

Farmers' Awareness of Climate Change and Sources of Information

Among survey respondents, 78% were aware of climate change and 91% observed the change of at least one of the climatic elements (rainfall, temperature or climatic extreme events) through personal experience (Table **2**).

Mass media such as radio and television was the main source of information on climate change (58%), following by the commune's loudspeaker (12%) (Table **2**). The use of mass media in providing information of

Table 2: Climate Change Awareness and Sources of Information

		Disaggregate samples (%)		Entire samples (%)	X^2 (α =0.05)
		Poor household	Non-poor household		
Aware of climate change phenomenon	Yes	81.4	75.6	78.5	0.353
	No	18.6	24.4	21.5	
Noticed long term change in climate elements	Yes	88.4	91.9	90.1	0.443
	No	11.6	8.1	9.9	
Sources of climate change/variation information	Television	60.5	55.8	58.1	0.450
	Radio	1.2	5.8	3.5	
	Neighbours	10.5	12.8	11.6	
	Extension officers	1.2	4.7	2.9	
	Communes' loudspeakers	25.6	14.0	19.8	
	Printed media	1.2	7.0	4.1	

climate change to farmers has been documented by Salau *et al*. (2012) in Nigeria, with 68% of respondents relying on radio as their main source information of climate change. Since only a few farmers in this study get information from agriculture extension officers (3%) and printed media such as newspapers (4%), information dissemination on climate change through these means is poor.

Farmer's Perceptions of Climate Change and Variability

To assess local community perceptions of climate change and variability, we first look at how climate change is perceived by local farmers, and then analyse the scientific data on climate trends and variability in Tho Xuan district to test these perceptions. This type of analysis has been done in several other studies [9, 7, 17, 29, 53]. In this study, farmers' perceptions were classified into four categories: temperature/rainfall increased, decreased, no change and do not know.

Temperature Perceptions

Data on perceptions of temperature change by both poor and non-poor farmers (Table **3**) show that most respondents perceived that annual temperature has increased (86%). Respondents claimed that temperature was increasing in autumn-summercrop season (88%), and winter crop season (81%), with no change in spring crop season (83%). The data also indicate that the increasing trends were perceived not only for the annual and seasonal temperature, but also for the number of extremely hot days. The Kruskal-Wallis test, however, indicates that there is no

Table 3: Perceptions of Temperature Change by Poor and Non-Poor Respondents

		Disaggregate samples (%)		Entire samples (%)	X^2 (α =0.05)
		Poor household	Non-poor household		
Annual temperature	Increased	81.4	90.7	86.0	0.830
	Decreased	1.2	1.2	1.2	
	No change	10.5	8.1	9.3	
	Do not know	7.0	0.0	3.5	
Spring crop temperature	Increased	5.8	10.5	8.1	0.690
	Decreased	2.3	0.0	1.2	
	No change	80.2	86.0	83.1	
	Do not know	11.6	3.5	7.6	
Summer-autumn crop temperature	Increased	89.5	87.2	88.4	0.769
	Decreased	0.0	0.0	0.0	
	No change	7.0	7.0	7.0	
	Do not know	3.5	5.8	4.7	
Winter crop temperature	Increased	8.1	2.3	5.2	0.374
	Decreased	77.9	84.9	81.4	
	No change	8.1	8.1	8.1	
	Do not know	5.8	4.7	5.2	
Annual extremely hot days	Increased	86.0	89.5	87.8	0.205
	Decreased	0.0	0.0	0.0	
	No change	8.1	2.3	5.2	
	Do not know	5.8	8.1	7.0	
Annual damaged cold days	Increased	25.6	33.7	29.7	0.249
	Decreased	36.0	41.9	39.0	
	No change	25.6	15.1	20.3	
	Do not know	12.8	9.3	11.0	

significant difference between the views of the two farmer groups (Table **3**).

The respondents' claim of temperature changes was tested by analysing historical temperature data in Tho Xuan district in 20-year period, 1993-2012. The recorded temperature data shows an increasing trend. During the last 20 years, the mean annual temperature in Tho Xuan district has increased significantly, with a positive slope of 0.052°C year^{-1} (Appendix: Figure **A1**). In addition, recorded temperature data during the period of summer autumn crop, winter crop, and spring crop also indicated an increase trend, with slopes of 0.034, 0.049 and 0.056°C year^{-1} (Appendix: Figures **A2, A3, A4**). Increasing temperature was not only indicated by mean annual and seasonal temperature, but also by frequency of extremely hot days. The annual number of extremely hot days has increased significantly during the last 20 years, with a positive slope of 1.1°C year^{-1} (Appendix: Figure **A6**). This increasing trend is in line with the findings of MONRE [54], confirmed by the local officers in the discussion group, that temperature has increased for the north central coast region of Vietnam.

The farmers' perceptions of temperature change appear to be consistent with observed scientific data from this district, with the exception of winter crop temperature: 82% of interviewed farmers claimed temperature decreased during the winter crop season, although the historical temperature data analysis indicates an increase trend during the past 20 years (Appendix: Figure **A4**). The difference between farmers' perception and the recorded data regarding winter crop temperature change could be explained by the frequency of crop-damaging cold days (crop-damaging cold day is the day with air temperature dropping to 13°C or below). There has been a significant increase in the number of crop-damaging cold days during winter crop in the period 1993-2012, with an increase of 0.12 day/year^{-1} (Figure **A6**). It is, therefore, likely that the increase in number of cold days has shaped temperature perceptions of farmers

Table 4: Perceptions of Change in Rainfall by Poor and Non-Poor Farmers

		Disaggregate samples (%)		Entire samples (%)	X^2 (α =0.05)
		Poor household	Non-poor household		
Annual rainfall	Increased	3.5	5.8	4.7	0.019
	Decreased	1.2	4.7	2.9	
	No change	70.9	81.4	76.2	
	Do not know	24.4	8.1	16.3	
Spring crop rainfall	Increased	3.5	5.8	4.7	0.680
	Decreased	1.2	4.7	2.9	
	No change	59.3	69.8	64.5	
	Do not know	36.0	19.8	27.9	
Summer-autumn crop rainfall	Increased	7.0	9.3	8.1	0.650
	Decreased	8.1	10.5	9.3	
	No change	52.3	65.1	58.7	
	Do not know	32.6	15.1	23.8	
Winter crop rainfall	Increased	12.8	15.1	14.0	
	Decreased	5.8	8.1	7.0	
	No change	43.0	52.3	47.7	
	Do not know	38.4	24.4	31.4	
Annual rainy days	Increased	4.7	4.7	4.7	0.540
	Decreased	29.1	23.3	26.2	
	No change	31.4	51.2	41.3	
	Do not know	34.9	20.9	27.9	

Note: Spring crop (February to May), Summer-autumn crop (June to September), Winter crop (October to January), (District annual agriculture production plan, 2012).

for the winter season, and farmers may place more weight on number of cold day changes than the average temperature change during winter crop season.

Rainfall Perceptions

Farmers have not noticed any considerable change in annual rainfall, seasonal rainfall, and number of rainy days (Table **4**); 75% of respondents perceived no change in annual rainfall. The same pattern is observed across the three crop seasons (66% for spring crop, 59% for autumn-summer crop, and 51% for winter crop). Similar to temperature perception, there are no significant differences between the perceptions of different farmer groups.

The observed scientific data, however, do not support the farmers' perception. A downward trend of recorded annual rainfall and seasonal rainfall in the period from 1993 to 2012 was noticeable in Tho Xuan district (Appendix: Figures **A8, A9, A10**); a slight decrease in annual rainfall, summer crop rainfall and spring crop rainfall, as well as a slight increase winter crop rainfall and annual rainy days is recorded (Appendix: Figure **A8, A9, A10, A11, A.12**). A further analysis of annual rainfall variance using cusum technique also shows that annual rainfall varied dramatically over the 20-year period, with annual rainfall increasing from 1993 to 1996, decreasing from 1997 to 2000, being stable for 2001-2005, decreasing again in 2006 and 2007, and finally stable during the last 5 years 2008-2012 (Appendix: Figure **A7**).

The difference between the farmers' perceptions and recorded scientific rainfall data may be due to a stronger influence of recent rainfall patterns (no change) rather than long term patterns (decreasing). While rainfall has varied considerably during the last 20 years in Tho Xuan district, annual precipitation during the last five years has been consistent. Other studies have also found that some farmers place more weight on recent variability rather than long-term changes in climate [29, 31, 55]. Another factor impacting on farmers' perceptions of rainfall variability may be the extensive use of irrigation in the province. Since all rice is grown in irrigated fields, farmers are less reliant on rainfall for cropping and accurate information on rainfall patterns is less crucial to their operations.

From Climate Change Perceptions to Personal Adaptive Responses

In spite of 90% of farmers noticing changes in climate pattern in last 20 years, only 56% of poor farmers and 65% of non-poor farmers took adaptive responses to cope with negative impacts from this change (Figure **2**). While the number of respondents who did not adopt any new measures may seem high (35-44%), this figure is in line with similar studies in Ethiopia, Ghana and South Africa, where 37%, 56% and 62% of farmers respectively did not take any measure in response to climate change [38, 56]. This low response rate suggests other factors are at play, such as household financial capacity, the availability and cost of inputs such as fertilizer, improved seeds, and water availability for irrigation.

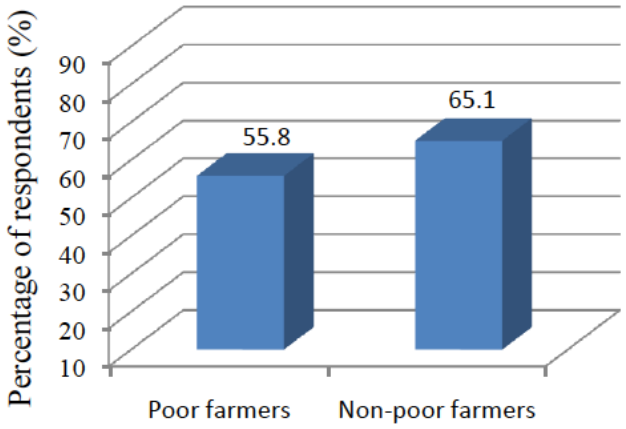

Figure 2: Percentage of poor and non-poor farmers who have changed their agriculture practices to adapt to climate change.

Most of the adaptive responses are characterised by relatively simple, minimum collective action and low cost. Examples include adjusting planting date or switching to drought or heat-tolerant varieties. Those private adaptive measures are aimed at maximizing yields and insuring against crop failure. Poor and non-poor farmers implemented significantly different types of adaptive measures. While adjusting planting time was the most common strategy of poor farmers in response to increasing temperatures temperature (35% of respondents), adjusting planting time, diversifying crops and varieties, and seeking alternative income source were the main strategies of non-poor farmers; 19%, 12% and 15% of respondents adopting these measures respectively (Table **5**). Adopting crop diversification implies that farmers believe that different crops are influenced differently by climate factors; growing a variety of crops at the same time and in the same plot may be seen to be a strategy to reduce the risk of crop failure.

Poor and non-poor farmers also differed significantly in finding alternative off-farm income

Table 5: Adaptive Methods to Temperature and Rainfall Changes

		Disaggregate samples (%)		Entire samples (%)	X^2 (α =0.05)
		Poor household	Non-poor household		
Adapting measures to temperature change	Adjust planting time	34.9	18.6	26.8	0.020
	Adjust planting techniques	2.3	4.7	3.5	
	Diversify crops or varieties	8.1	11.6	9.9	
	Diversify income sources	3.5	15.1	9.3	
	Migrate to the big cities or buying insurance	0.0	8.1	4.1	
	No adaptation	51.2	41.9	46.6	
Adapting measures to rainfall change	Adjust planting time	3.5	1.2	2.3	0.670
	Adjust planting techniques	2.3	3.5	2.9	
	Diversify crops or varieties	3.5	1.2	2.3	
	Change water use	4.7	5.8	5.2	
	No adaptation	86.0	88.4	87.2	

sources to reduce dependence on farming (Table **5**). Around 8% of non-poor farmers mentioned crop insurance and urban migration as other adaptive responses, whereas none of the poor farmers adopted these approaches. Crop insurance is used in several countries as a useful strategy to help farmers to reduce the risk of negative climate change impacts [57]. This measure has been officially launched since 2011 in several provinces of Vietnam. Long *et al*. [58] records that farmers in Vietnam have little interest in crop insurance, reflecting the high cost of insurance. However, the small number of non-poor farmers electing to take crop insurance is a positive sign for the crop insurance program in Vietnam.

In Vietnam, the crop planting calendar is designated by the provincial and district Department of Agricultural and Rural Development, although each commune has to modify it for suitability with their local conditions. Adjusting planting time was the most popular adaptive measure identified by both poor and non-poor farmers (and by the agricultural officers), as it is low cost, simple to apply and considered to be effective in reducing climate change impacts.

In terms of adaptation to rainfall variability, the survey yielded evidence that farmers have little interest in taking any adaptive measure to respond to the change of rainfall pattern. Only 13% of respondents had changed their agriculture practices in order to cope with changes of rainfall. If these, 2% adjusted planting time, 6% changed cultivation techniques or switching to drought-tolerant crops or varieties, and 5% changed water management. Up to 87% of respondents did not do anything to adapt to the rainfall change. The low interest of farmers in responding to rainfall change may be for two reasons: (i) few farmers detected any long-term decrease in rainfall, and (ii) farming in the community relies onawell-developed irrigation system.

Farmers' Perceptions of Barriers to Adaptation

To understand constraints to farmers implementing adaptation strategies, the farmers were asked to identify difficulties in adapting to climate change. The most cited barriers in Tho Dien commune (Table **6**) were:lack of advanced weather and climate change information; lack of money; insufficient knowledge relating to appropriate adaptations; insufficient labour; insufficient water for irrigation; and lack of a market for agricultural products. Some of those barriers were perceived differently by poor and non-poor farmers. The most commonly identified constraint was the lack of advance weather and climate change information, with about 30% of both types of farmers citing this as a serious barrier (Table **6**). Lack of weather and climate forecast information for climate change adaptation was also noted by farmers in Red River and Mekong River Deltas [6, 7]. In Vietnam, weather forecast information and climate change information is sent and received *via* a top-down system, from the Weather Centre of the Ministry of Natural Resources and Environment to the local communes, through the province and district level. While there are no problems identified in the communication system, the quality of the information has been noted. Poor and insufficient weather forecast

Table 6: Barriers to Climate Change Adaptation

	Disaggregate samples (%)		Entire samples (%)	X^2 (α=0.05)
	Poor household	Non-poor household		
Lack of advanced weather and climate change information	30.2	31.4	30.8	0.019
Lack of money	24.4	7.0	15.7	
Lack of knowledge concerning appropriate adaptations	23.3	24.4	23.8	
Shortage of labour	4.7	3.5	4.1	
Lack of water for irrigation	2.3	11.6	7.0	
Lack of processing and storing facilities for agricultural products	4.7	8.1	6.4	
Lack of market	10.5	14.0	12.2	

information delivered to the district and commune level is recorded in the production plan reports of Tho Xuan district for period 2009-2013 [48], being considered to have had a significant negative impact in Tho Dien community in relation to failure crops of year 2009, 2010 and 2012. Jones [59] and Kandlinkar and Risbey [60] argue that insufficient weather and climate change forecast information increase the risk of failure when farmers adopt new technologies as adaptation measures.

Lack of money to purchase farm inputs, such as hybrid seeds, fertilizers and farm implements, was perceived as an important barrier in the poor farmers' view (27% of respondents), whereas only 7% of non-poor farmers perceived it as a constraint for adaptation.

About 23% of both poor and non-poor groups identified a lack of knowledge concerning appropriate adaptations as a barrier. This indicates that agricultural extension services, the link between local agricultural officers and farmers, and climate change education programs in the study area are not efficient. Improving these services may enhance the adaptation capacity of farmers. The lack of expertise, as well as a lack of documents related to climate change and adaptation measures at commune and district level, was reported as a concern in discussions with local agricultural officers.

More non-poor farmers (12%) than poor farmers (2%) described insufficient water for irrigation as a constraint for their adaptation. The difference between the two farmers groups, in term of water demand for irrigation, was explained by local agricultural officers in the following way. Non-poor farmers tend to use the high value crops, such as hybrid varieties, which require more water than the local native varieties. The poor farmers, on the other hand, were more interested in using the local drought resistant varieties.

Both poor and non-poor farmers claimed the lack of market for selling their agricultural products was a further barrier. Both groups largely sell rice and vegetables at the local market at a low price. Local residents have been consuming these products for a very long time, and it may be difficult to persuade them to change their consumption habits to include new crops, such as those suited to changing climate conditions.

Determinants to Farmers' Adaptation Decision

In this analysis, identifying factors that influence adaptation decisions to climate change was done using the binary logit model on the entire sample of respondents, as well as on the sample disaggregated into the two economic categories (poor and non-poor farmers) (Table **7**). The logit regression model over the entire sample indicates that four factors significantly and positively influence farmers' decisions to adapt to the change of climate:(i) access to advance climate information, including weather forecast and estimated climatic factors change; (ii) access to credit; (iii) percentage of irrigated land area; and (iv) ability to access subsidies. The positive sign means those four factors increased the likelihood of adaptation to climate change of farmer community in Tho Dien commune. The availability of better climate information, better access to credit, and higher irrigation rate, have all been shown elsewhere to enable farmers to make better comparative decisions among alternative crop management practices [59, 61]. Other factors – including household economic status, gender of

Table 7: Adaptation Determinants to Climate Change of Entire Household Samples in Tho Dien Commune

	Old ratio	Coefficients	Std err	z	P > z	95% confidence intervals	
Household Economic	0.499	-0.598	0.907	-0.659	0.510	-2.376	1.180
Age	1.002	0.002	0.039	0.048	0.962	-0.074	0.078
Residential time	0.024	0.017	0.023	0.741	0.458	-0.028	0.063
Gender	1.096	0.134	0.959	0.139	0.889	-1.746	2.014
Education level	0.142	0.173	0.119	1.454	0.146	-0.060	0.407
Non-agriculture income share	0.027	0.025	0.026	0.958	0.338	-0.026	0.076
Family size	0.265	0.066	0.248	0.264	0.792	-0.421	0.553
Farm experience	0.041	0.049	0.039	1.260	0.208	-0.027	0.125
Access to extension	0.462	-0.311	0.631	-0.493	0.622	-1.547	0.925
Access to advance climate information	2.741	1.500*	0.611	2.453	0.014	0.302	2.699
Access to credit	4.804	2.070**	0.606	3.413	0.001	0.881	3.258
Irrigation rate	0.021	0.053**	0.020	2.673	0.008	0.014	0.092
Access to subside	41.780	4.043**	0.733	5.513	0.000	2.605	5.480
Constant		-10.428	3.022	-3.450	0.001	-16.351	-4.504

** and * are significant at 1% and 5% level respectively.
Number of obs = 172.
Prob> chi^2 = 0.000.
Pseudo R^2 = 0.579.
LR chi^2 (13) = 133.78.
Log likelihood = -48.53.

household head, education level of household head, non-agriculture income share, family size and access to extension – showed no association with respondents' climate change adaptation decisions.

When the samples are categorised into the two different economic farmer groups (poor and non-poor; Tables **8** and **9**), their adaptation decisions were influenced by different sets of factors. Five of the factors are identified as positively influencing the adaptation decision of poor farmers: (i) education level; (ii) farm experience; (iii) access to credit; (iv) irrigation rate; and (v) access to subsidies. Age of household head also became significant in the household economic status disaggregated model, and it negatively influenced climate change adaptation decision-making of poor farmers. For non-poor farmers, significant factors that positively influenced the decision to adapt to climate change were: (i) non-farm income; (ii) access to extension service; (iii) access to advance climate information; and (iv) access to credit. Access to credit, which increases financial resources of farmers and enables farmers to purchase inputs, associated with other adaptation options (e.g. drought tolerant varieties, improved hybrid seeds, fertilizers, new irrigation technologies) have been shown elsewhere to positively influence the chances of farmers adapting to changing climatic conditions for both poor and non-poor farmers [33, 55, 56, 62, 63].

Education level is also demonstrated here to significantly influence poor farmers' decisions to adapt to climate change of poor farmers, while not being significant for non-poor farmers. This implies that the probability of adaptation to climate change will increase among poor farmers as they acquire more education, a conclusion echoing findings elsewhere [33, 64].

DISCUSSION

Farmers in Vietnam can be classified into two main groups based on the different levels of income, namely poor and non-poor farmers; the way they farm and their social position differs notably. It may be expected that their response to changing conditions, such as climatic conditions, will also differ. To investigate the adaptive behaviour of farmers in relation to responding to climate change, it is therefore important to explore how poor and non-poor farmers differ with respect to both their perceptions of climate change and access to enabling factors that allow them to adopt climate change adaptation behaviour. To our knowledge, no

Table 8: Adaptation Determinants to Climate Change Among Poor Farmers in Tho Dien Commune

	Old ratio	Coefficients	Std err	z	P > z	95% confidence intervals	
Age	0.422	-.860*	0.365	-2.36	0.018	-1.576	-0.145
Residential time	0.996	-.003	0.044	-0.09	0.930	-0.091	0.0830
Gender	3.492	1.250	1.118	1.12	0.264	-0.942	3.443
Education level	2.124	0.753**	0.279	2.69	0.007	0.205	1.301
Non-agriculture income share	0.967	-0.033	0.040	-0.82	0.410	-0.113	0.046
Family size	0.817	-0.201	0.440	-0.46	0.647	-1.065	0.662
Farm experience	2.649	0.974*	0.403	2.41	0.016	0.183	1.765
Access to extension	0.443	-0.813	0.982	-0.83	0.407	-2.738	1.111
Access to advance climate information	1.562	0.446	0.897	0.50	0.619	-1.312	2.205
Access to credit	9.336	2.233*	0.995	2.24	0.025	0.282	4.185
Irrigation rate	1.121	0.114**	0.037	3.06	0.002	0.041	0.188
Access to subside	7.770	2.050*	1.041	1.97	0.049	0.009	4.091
Constant		5.132	7.341	0.70	0.484	-9.256	19.521

** and * are significant levels at 1% and 5% probabilities, respectively.
Prob> chi^2 = 0.000.
Pseudo R^2 = 0.55.
LR chi^2 (12) = 65.27.
Log likelihood = -26.39.

Table 9: Adaptation Determinants to Climate Change Among Non-Poor Farmers in Tho Dien Commune

	Old ratio	Coefficients	Std err	z	P > z	95% confidence intervals	
Age	1.046	0.045	0.057	0.786	0.432	-0.066	0.156
Residential time	1.006	0.006	0.038	0.162	0.871	-0.068	0.080
Gender	0.352	-1.045	1.290	-0.810	0.418	-3.574	1.483
Education level	1.005	0.005	0.142	0.038	0.970	-0.272	0.283
Non-agriculture income share	1.073	0.071*	0.032	2.186	0.029	0.007	0.134
Family size	0.578	-0.548	0.336	-1.630	0.103	-1.206	0.111
Farm experience	1.056	0.055	0.047	1.163	0.245	-0.037	0.147
Access to extension	6.164	1.819*	0.811	2.243	0.025	0.229	3.408
Access to advance climate information	7.622	2.031*	0.892	2.277	0.023	0.283	3.780
Access to credit	14.681	2.687**	0.981	2.739	0.006	0.764	4.609
Irrigation rate	0.618	-0.482	0.768	-0.627	0.530	-1.987	1.024
Access to subside	0.986	-0.014	0.033	-0.424	0.672	-0.078	0.050
Constant	0.009	-4.749	3.765	-1.261	0.207	-12.127	2.630

** and * are significant levels at 1% and 5% probabilities, respectively.
Prob> chi^2 = 0.000.
Pseudo R^2 = 0.51.
LR chi^2 (12) = 57.21.
Log likelihood = -27.01.

such studies have been published to date in the context of Vietnam. Research elsewhere in Vietnam has focused on farmers in general, not differentiating poor from non-poor. There are parallels with this study.

Mekong Delta farmers, for example, have been shown to perceive risk to production, health and income more than to social parameters [1]; as with farmers elsewhere [5], their perception relates to their experience of events that can be attributed to climate change, mediated by farmers' sources of information [2]. Farmers who believe that climate change is happening perceive higher risks, while those who consider climate change to be government's concern perceive lower risks. Perception of public adaptive measures reduce perceived risk, although positive perceptions of disaster warning system increase perceive risks; sources and quality of information are particularly important [1, 2]. In such studies, improving accessibility and utility of local services, such as irrigation, agricultural extension, credit and health care, is seen to be necessary for successful adaptation [2]. These studies, however, focus on an agriculturally-rich part of Vietnam. The research reported here, on the other hand, focuses on adaptive behaviour of farmers in northern central coast of Vietnam in a region containing the poorest farmers in Vietnam, and therefore a region likely to be most sensitive to climate change.

The analysis indicates that the majority of farmers (91%) are aware of local climate change, but that only 50% have resorted to adaptive responses to reduce its negative impacts. Farmers' knowledge of climate change has been largely derived through personal experience and social organizations. Temperature, including annual temperature and seasonal temperature, was perceived to have significantly changed in the last two decades, a perception that is consistent with recorded weather data in the region. Perceptions of change in rainfall are weaker, and appear to contradict the recorded weather data. This latter pattern reflects a reliance in the study area on irrigation, and thus the farmers' lower sense of risk associated with declining rainfall.

The primary adaptation measures reported by the farmers in this study are: (i) change in planting time; (ii) adoption of different crops and different varieties, at the same time on the same plot; (iii) seeking alternative income from off-farm activities; (iv) adjusting cultivation techniques; (v) urban migration; and (vi) purchase of crop insurance. Factors identified, on the other hand, as substantial barriers to adaptation are: (i) inadequate information about weather and climate change; (ii) lack knowledge of appropriate adaptation measures; (iii) inadequate finance; (iv) lack of water for irrigation; and (v) lack of a market for selling agricultural products. These barriers are directly linked to the development of institutions and infrastructure, and are similar to perceived barriers to farmers' adaptation recorded elsewhere in Vietnam [6-9]. Institutional factors related to constraints to adaptation, notably access to climate information, credit, water for irrigation and subsidies, were also identified as significant variables influencing farmers' decisions of adaptation.

Further analysis importantly reveals that poor and non-poor farmers differ significantly in terms of the adaptation measures they adopt, the barriers they perceive to adaptation, and the factors influencing their decisions. Adaptation measures taken by poor farmers are characterised by relatively simple, minimum collective action, and low cost options. These include adjustments to planting time and diversification of crops. Non-poor farmers, on the other hand, tend to adopt adaptive responses requiring greater knowledge, skills and investment costs. Typical examples are changing cultivation techniques, purchasing crop insurance, and seeking alternative incomes from off-farm activities. Factors influencing adaptive response decisions likewise differ between poor and non-poor farmers. For poor farmers, age, education level, irrigation rate, access to credit, farm experience, and access to subsidies are important in influencing decisions to adapt to climate change. For non-poor farmers, the important influences are non-farm income share, access to extension services, access to climate information, and access to credit.

The practical implications of these findings are currently being examined in a broader context of research into (i) Vietnamese government policy implementation, (ii) government officials' perceptions of climate change and adaptation, and (iii) modelling of social vulnerability to climate change and capacity to address it. What is already clear is that understanding farmers' responses to government policies, based on understanding their perception of climate change, is an important factor in identifying appropriate regional responses to adaptation requirements [65]. An important implication of these patterns is that government policies need to take into account differences among poor and non-poor farmers in order to successfully design, disseminate and support adaptation strategies. This is especially important since, although both poor and non-poor farmers have different personal characteristics, their perceptions of climate change are similar. This does not, however, mean that both groups will and can respond in the same way; they adopt different approaches, and,

importantly, perceive different barriers and enabling characteristics. This study highlights, therefore, the need for farmers' income classification to be used to differentiate interventions to promote climate change adaptive responses. The study also supports an argument that low-cost adaptation options have good potential to encourage climate change adaptation among poor farmers. A further important finding is that agriculture extension services appear to be ineffective in influencing farmers. This implies two needs: (i) an intensive capacity building programs for existing extension personnel on climate change and adaptation strategies; and (ii) and examination of ways in which the extension service can become more accessible and relevant to farmers.

Finally, an important aspect of improving farmer engagement with climate change needs to focus on those farmers who claim to be aware of climate change, but who do not appear to respond to their perceptions by adapting their farming practices. More work is required to understand the factors associated with this phenomenon.

CONCLUSION

By examining farmer's perceptions of climate change in a region of Vietnam with the poorest farmers, a region likely to be most sensitive to climate change in terms of social capacity to adapt, this study has identified patterns similar to those recorded elsewhere in Vietnam and beyond. However, unlike other studies, this study has identified a critical difference between the poorest of farmers and non-poor farmers, in terms of how they adapt to climate change, what they consider the barriers to be, and what influences positive adaptation. This finding as important consequences for how government climate change adaptation policy can be effectively implemented. This study highlights, therefore, the need for farmers' income classification to be used to differentiate interventions to promote climate change adaptive responses. Furthermore, current extension services appear to be ineffective in promoting climate change adaptation. This finding implies that there is a need for intensive capacity building programs for existing extension personnel, and ways in which the extension service can become more accessible and relevant to farmers in both income groups.

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This research has been carried out at School of Environment, Science & Engineering, Southern Cross University, Lismore, New South Wales 2480, Australia.

APPENDIX: CLIMATE MODELLING RESULTS

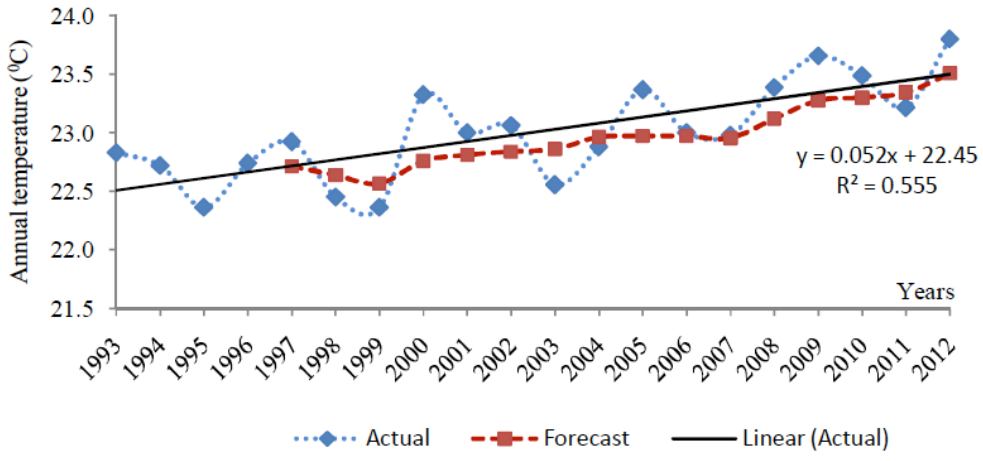

Figure A1: Five years moving annual temperature trend over 20 year period of Tho Xuan district, Thanh Hoa province.

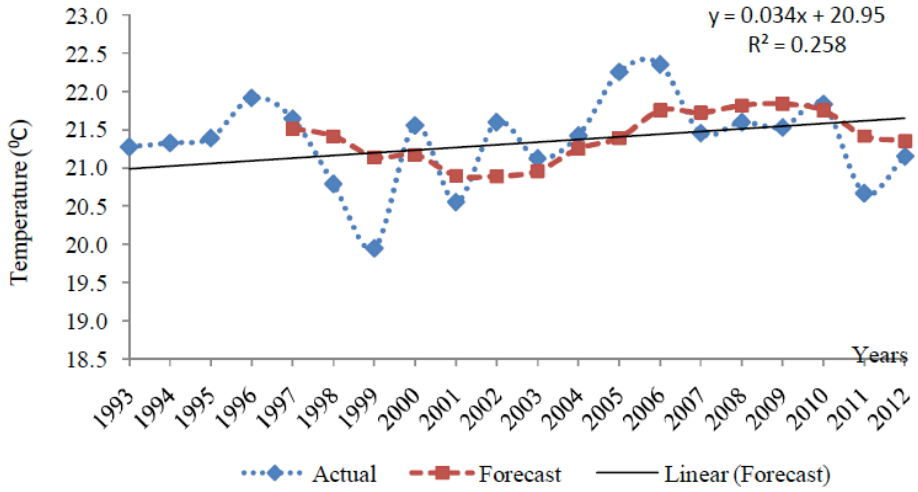

Figure A2: Five years moving average temperature trend in spring crop over 20 year period at Tho Xuan district, Thanh Hoa province.

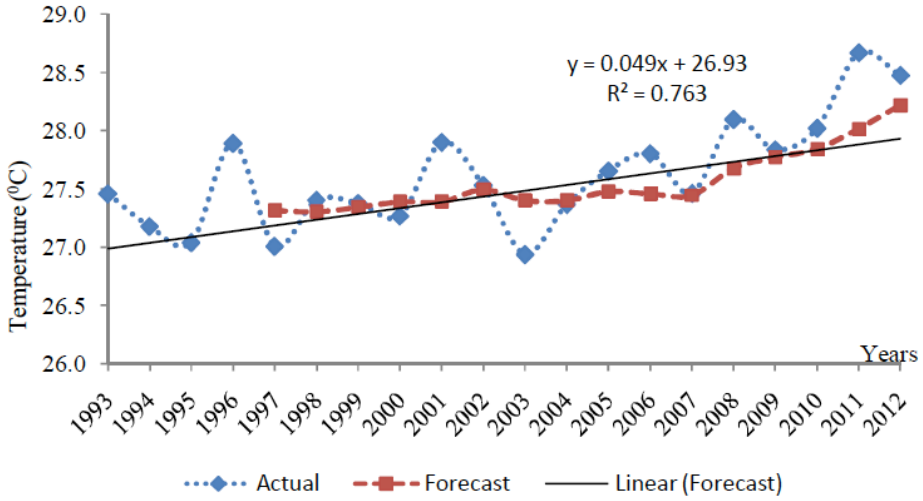

Figure A3: Five year moving average temperature trend in summer-autumn cropping period over the past 20 years at Tho Xuan district, Thanh Hoa province.

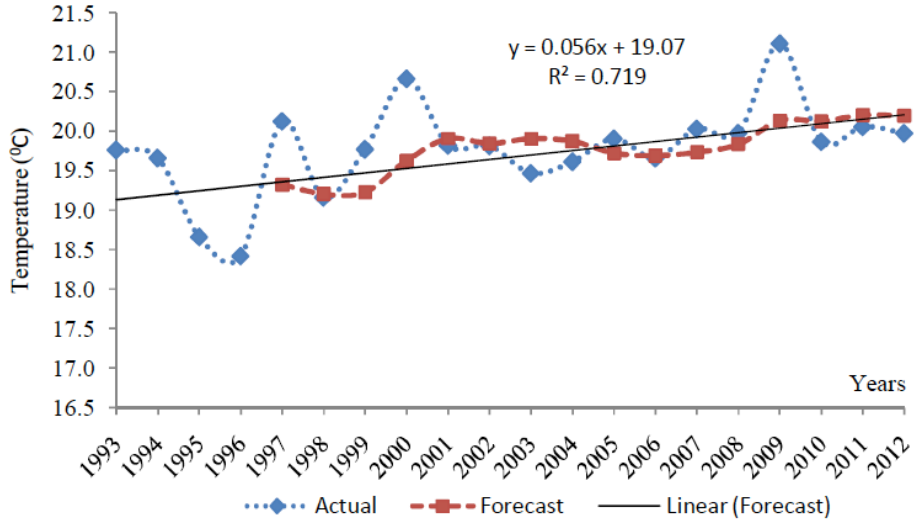

Figure A4: Five years moving of average temperature trend in winter crop over 20 year period at Tho Xuan district, Thanh Hoa province.

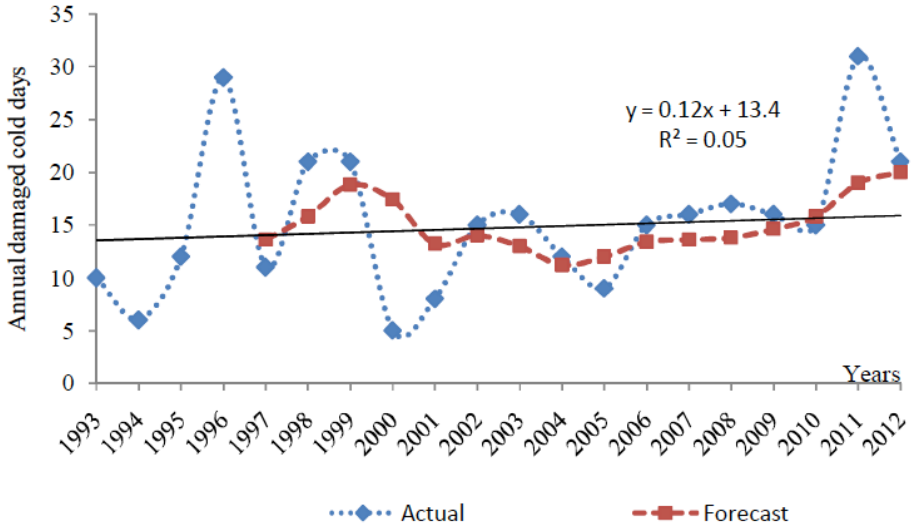

Figure A5: Five years moving of annual damaging cold day frequency trend over 20 year period at Tho Xuan district, Thanh Hoa province. Note: The terms "extremely cold" and "damaging cold" are used in Vietnam media weather forecast when air temperature drops to 13°C or below. At this level, the temperature is believed to cause some damage to crops and livestock.

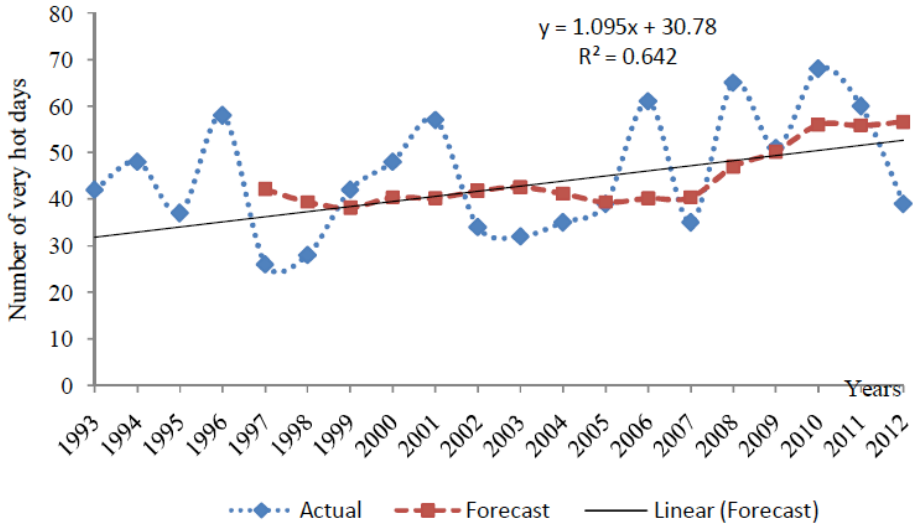

Figure A6: Five years moving of annual extremely hot day frequency trend over 20 year period at Tho Xuan district, Thanh Hoa province. Note: extremely hot day is the day when temperature exceeds over 35°C.

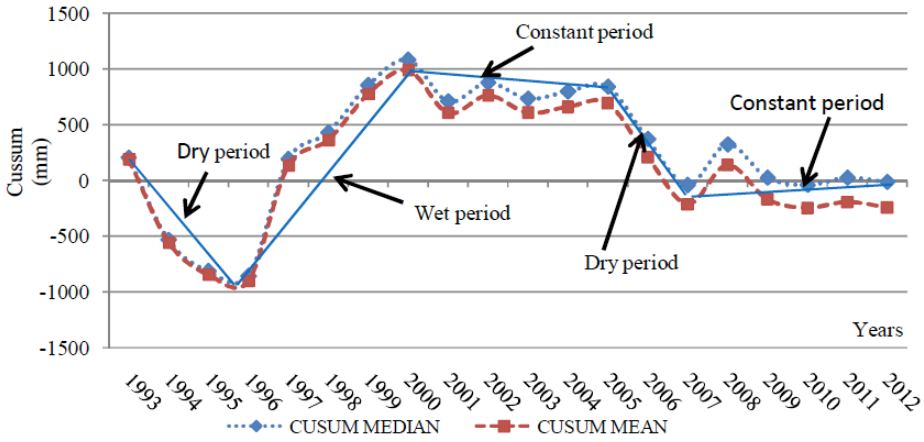

Figure A7: Annual rainfall variability over 20 year period at Tho Xuan district, Thanh Hoa province.

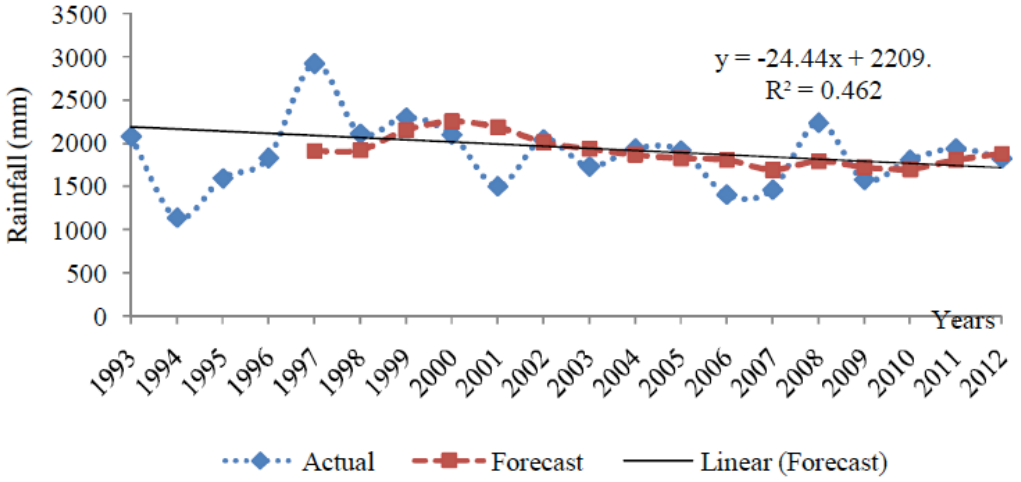

Figure A8: Five years moving annual rainfall trend over 20 year period at Tho Xuan district, Thanh Hoa province.

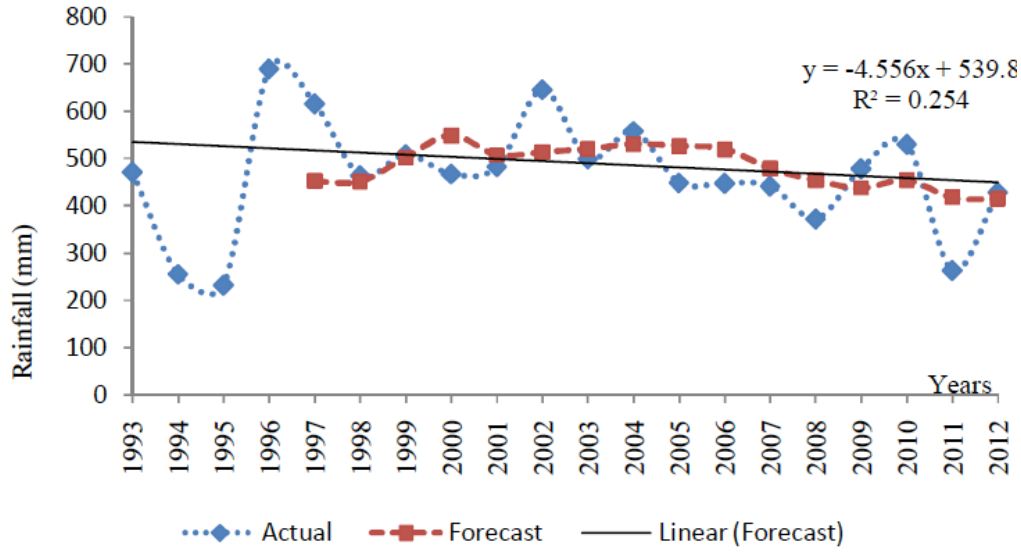

Figure A9: Five years moving of spring crop rainfall trend over 20 years period at Tho Xuan district, Thanh Hoa province.

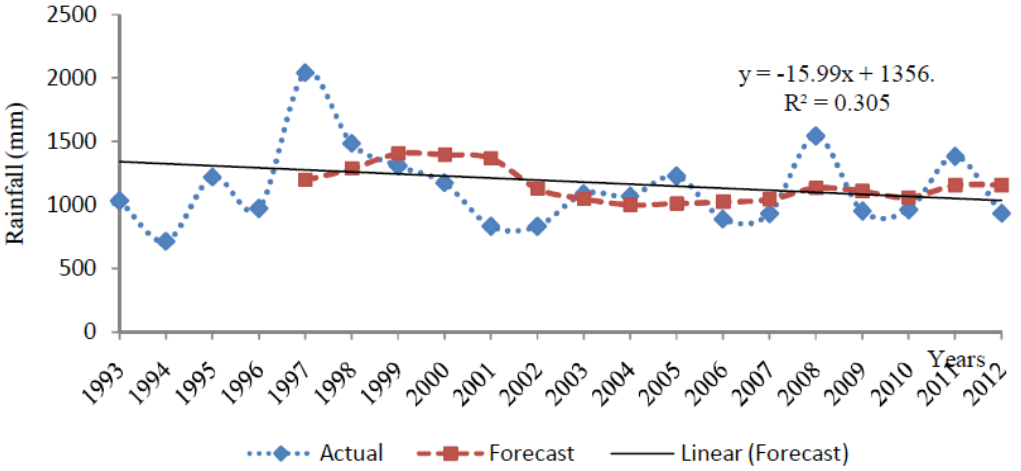

Figure A10: Five years moving of summer-autumn crop rainfall trend at Tho Xuan district, Thanh Hoa province.

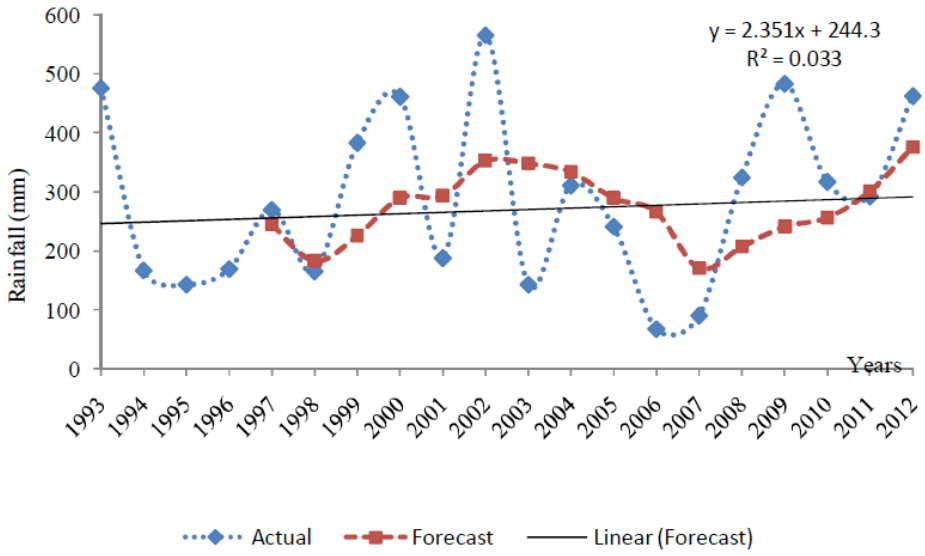

Figure A11: Five years moving of winter crop rainfall trend at Tho Xuan district, Thanh Hoa province.

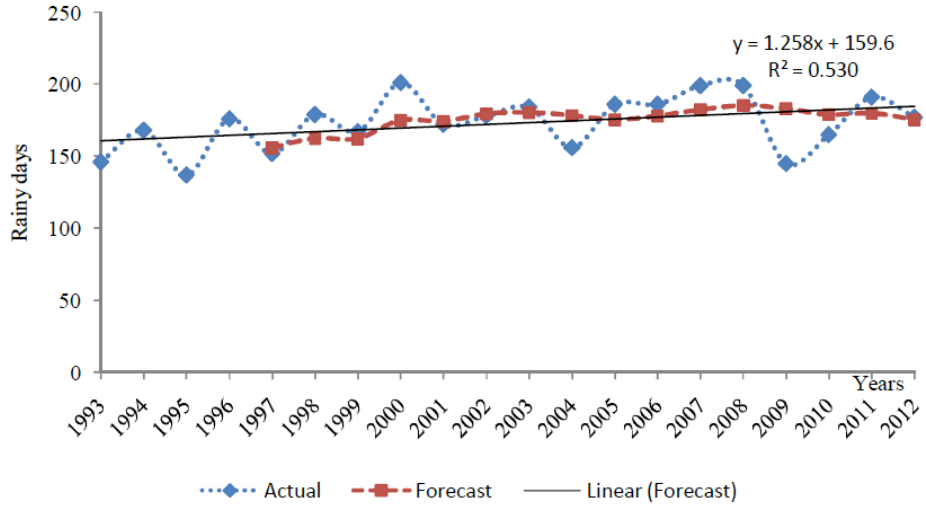

Figure A12: Five years moving of annual rainy day trend at Tho Xuan district, Thanh Hoa province.

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