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Conference Paper

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Proceedings of the German Development Economics Conference, Berlin 2011, No. 79

Provided in Cooperation with:

Research Committee on Development Economics (AEL), German Economic Association

Suggested Citation: Völker, Marc; Tongruksawattana, Songporne; Hardeweg, Bernd; Waibel, Hermann (2011) : Climate risk perception and ex-ante mitigation strategies of rural households in Thailand and Vietnam, Proceedings of the German Development Economics Conference, Berlin 2011, No. 79, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

This Version is available at:

<https://hdl.handle.net/10419/48291>

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Climate risk perception and ex-ante mitigation strategies of rural households in Thailand and Vietnam

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1 Introduction

In emerging market economies vulnerability to poverty is a common phenomenon. People who have escaped poverty may fall back because of natural disasters, economic and political crisis. Especially rural households are often subject to high future risks due to their inadequate ex-ante risk management and ex-post shock coping ability (Chaudhuri et al. 2002, Kocher 1995, Kozel et al. 2008). Thailand and Vietnam are two typical examples where vulnerability to poverty remains an issue in spite of successful advances in chronic poverty reduction. (ADB 2008, UNDP 2008, World Bank 2003, World Bank 2008). Major risk factors for the rural areas in these two countries are climate change, which among other effects brings about an increased frequency and severity of extreme weather events (ADB 2009, IPCC 2007) and continued environmental degradation (Millennium Ecosystem Assessment 2005), which damages natural resources that are crucial for the livelihoods of poor and vulnerable households, especially those living in remote rural areas (World Bank 2005). As a consequence, these countries are faced with high costs of adapting to the adverse effects believed to be associated with climate change (ADB 2009).

The negative impact of shocks on welfare depends on the ability of households to apply effective ex-ante mitigation strategies such as income diversification, adoption of new agricultural technologies, investment in physical, human and financial capital,

as well as building up buffer stocks and savings (Dercon 2002, Morduch 1995, Townsend 1995). Adoption of such strategies is a function of socio-economic household and location characteristics including, among others, knowledge, market and government incentives, and the decision makers' perception of risk (Dercon 2002, Sivakumar & Motha 2007).

Existing studies related to risk and agriculture usually use historical data on rainfall, temperature and other environmental variables for surveillance and forecasting models (Boisvert 1990, Musser et al. 1984). For example, climate models focusing on climate change and variability in Vietnam have been based on historical data on the frequency and strengths of weather events such as rainfall, storms and typhoons (Ngyuen Tuong 2010). One disadvantage of models based on objective information is that they generally do not take into account individual perceptions and preferences of the decision makers and hence are less suitable for deriving policy recommendations (Anderson et al. 1977). Also with such models it is difficult to influence the behavior of decision makers, especially if these are small scale farmers, because it is the subjective perception of risk that influences their decision-making. It is therefore important to complement normative models with those which are based on subjective perceptions of the decision makers.

Although risk perception is a well-established concept, climate-related risk¹ with regards to rural farm households in developing countries has rarely been addressed. Existing studies mainly have focused on the developed world including both technological risks, e.g. posed by hazardous facilities such as nuclear power plants (Sjöberg 2000), and physical hazards such as flooding (Kates 1962), earthquake (Mileti and Darlington 1997), wildfire (Gardner et al. 1987), volcanic eruption (Gregg et al. 2004), drought (Taylor et al. 1988), snow (Earney and Knowles 1974), tornado and cyclone (Hanson et al. 1979), and hurricane (Cross 1980). Few studies have focused on climate risk in developing countries. Paul (1984) found that perception of flood risk among Bangladeshi farm households was positively affected by their experience with past floods, and that farm households applied traditional techniques in order to cope with the adverse effects of both normal and abnormal floods. Findings of a study conducted by Ologunorisa and Adeyemo (2005) indicate that

¹ Climate-related risk refers to extreme weather events, such as floods, storms and drought, and is denoted as "climate risk" throughout this paper.

floodplain residents in the Niger Delta, though being familiar with the main causes of floods, lack important knowledge about flood frequencies and alleviation schemes, and are often unable to migrate to less flood-prone areas because of their occupations in agriculture and fishery, and the high costs of migration. Wong and Zhao (2001) found that Chinese flood victims favor functional adjustments to mitigate the adverse effects of floods over engineering structures constructed to control floods physically.

In relation to climate change and agriculture it is important to understand how rural households experience environmental change, i.e. what is their subjective perception of both the severity and the likelihood of climate related events. To advance the research in this area, this study aims to analyze both the determinants of climate risk perception and its influence on households' behavior regarding the choice of ex-ante mitigation strategies of rural households in Central Vietnam and Northeastern Thailand by investigating the following research questions:

1. What is the current status of climate shock experience, risk perception and ex-ante risk management of rural households in the study areas?
2. What determinants shape climate risk perception?
3. How does climate risk perception affect the households' decision to apply any ex-ante risk management actions?
4. What effect does climate risk perception have on the use of specific ex-ante risk management strategies?

The paper is organized as follows: the next section presents results of a descriptive analysis of households' climate shock experience and risk perception, as well as major socio-demographic characteristics. In Section 3 the methodology used for empirically testing the relationship between climate shock experience and risk perception, as well as between climate risk perception and the adoption of ex-ante risk management strategies is explained. Section 4 presents the empirical model results, and the last section concludes.

2 Shock experiences, risk perception and ex-ante mitigation strategies

The data which forms the empirical basis of the analysis were collected in a long term DFG research project of four German universities (DFGFOR 756) entitled “Impact of Shocks on the Vulnerability to Poverty: Consequences for Development of Emerging Southeast Asian Economies”. By using a 3-stage cluster sampling design a representative sample of the target population of rural and peri-urban households was obtained (Hardeweg et al., 2007). Focusing on rural households in Northeastern Thailand and Central Vietnam, a comprehensive survey among some 4,400 rural households in six peripheral provinces was conducted in 2007 and the same households were followed-up in 2008. The survey instrument contained a comprehensive shock and risk section to collect retrospective information about shock experience and current risk perception towards a wide range of shock scenarios. Respondents were asked about shock incidents that the household experienced during the past 7 years from 2002 to 2008, reporting a subjective assessment of their severity, e.g. high, medium, low or no impact, their consequences in terms of income and asset loss, the duration of impact and coping actions adopted. In addition, respondents were asked to express their subjective assessment of the probability, the frequency and the severity of future risks to occur in the next 5 years. Furthermore, information on their ex-ante coping strategies including the cost and scope of such preventive measures were indicated for each type of risk.

Rural households in the study area were affected by different types of unexpected adversities (Tongruksawattana et al. forthcoming), including climatic, biological, socio-demographic as well as economic shocks (Table 1). Adverse climatic shocks were the most prevalent type of calamity experienced by households, with events like flooding, unusually heavy rainfall, storm, drought and unusually cold weather having affected about three quarters of the rural population in Vietnam and more than half in Thailand. On average, each household in both countries was affected by about two climate shocks during the 7-years reference period between 2002 and 2008 but Vietnamese households assessed the severity of shock incidents to having been higher than Thai households. However, standard deviations of reported shock frequency and severity show that some households suffered a higher number or severity of shocks while others were not affected at all or only by events of low severity. A similar variation in shock frequency and severity can be observed for other shock types. Socio-demographic shocks were reported with the second-highest frequency in both

countries with illnesses of household members ranked high while other events, such as deaths of household members, were only experienced by a small share of households. Biological shocks, such as crop pests and livestock diseases, affected about 40% of rural households in Vietnam but only 15% in Thailand. Last but not least, economic adversities, especially unexpected fluctuations in input and output prices, made up for a substantial proportion in Thailand (27.5%) but generally played a minor role in Vietnam with only slightly more than 9% of households affected.

Some striking differences exist between the households' experience of shocks between 2002 and 2008 and their perception of future risk (Table 1). Based on their experience of adversities in the 7-years reference period, households appear to be quite pessimistic about the incidence of shocks in a future reference period of 5 years from 2008 to 2013. Results indicate that not only those shock types which have been experienced by large shares of the population are expected to happen in the future by still more households, but that even adversities which hardly affected any household are feared by considerable shares of the rural households with an average expected frequency for all risk types of at least once per year and low to medium severity on income and asset. The majority of households expect to be affected by climate risks especially drought, flooding and storm (73% in Thailand; 90% in Vietnam) followed by socio-demographic risks, i.e. mainly illnesses of household members (78.6% in Thailand; 98.5% in Vietnam). Almost 70% of Thai households fear that economic risks such as rising in production input prices and falling in output prices will affect them comparing to a smaller but still considerable share of 41% of Vietnamese households. On the other hand, three-quarter of Vietnamese households anticipate biological risks especially crop pest and livestock diseases comparing to 44% in Thailand.

Table 1: Shock events experienced between 2002 and 2008 and risk types perceived in 2008 (n¹=2146 for Vietnam & 2127 for Thailand)

Vietnam (N = 2146 ¹)								
Type of events	Households (%)		Frequency per household ²		Subjective severity ³			
	Shock	Risk	Shock	Risk	Shock	Risk (income)	Risk (asset)	
Climatic	75.2	90.0	1.7 (0.8)	8.4 (6.4)	2.7 (0.5)	2.3 (0.8)	0.9 (1.0)	
Flooding	34.3	52.7	1.2 (0.5)	3.9 (1.6)	2.7 (0.5)	2.5 (0.8)	0.8 (1.1)	
Drought	27.3	53.7	1.2 (0.5)	3.1 (1.7)	2.7 (0.5)	2.3 (0.8)	0.2 (0.5)	
Heavy rainfall	14.9	35.4	1.0 (0.2)	3.3 (1.8)	2.6 (0.6)	2.2 (0.9)	1.1 (1.1)	
Erosion	1.0	5.0	1.0 (0.2)	2.9 (1.8)	2.9 (0.4)	2.2 (0.9)	1.1 (1.1)	
storm	15.9	54.9	1.0 (0.2)	4.2 (1.7)	2.6 (0.6)	2.1 (0.9)	1.8 (1.1)	
Snow/ice rain	16.5	7.5	1.0 (0.0)	3.4 (1.5)	2.6 (0.5)	2.0 (1.0)	0.9 (0.9)	
Biological	40.2	75.2	1.3 (0.6)	5.7 (3.2)	2.6 (0.5)	2.3 (0.8)	0.3 (0.7)	
Socio-demographic	60.1	85.5	1.6 (0.8)	5.5 (3.4)	2.6 (0.5)	1.8 (0.9)	0.7 (0.9)	
Economic	9.2	41.3	1.1 (0.4)	5.0 (3.1)	2.7 (0.5)	2.2 (0.8)	0.4 (0.9)	
Thailand (N = 2127 ¹)								
Type of events	Households (%)		Frequency per household ²		Subjective severity ³			
	Shock	Risk	Shock	Risk	Shock	Risk (income)	Risk (asset)	
Climatic	53.9	73.2	1.9 (1.4)	4.2 (4.2)	0.9 (0.5)	2.1 (0.9)	1.2 (1.2)	
Flooding	34.8	22.6	1.6 (1.3)	3.2 (1.7)	0.7 (0.5)	2.3 (0.9)	1.4 (1.3)	
Drought	41.9	57.3	1.6 (1.1)	3.2 (1.6)	0.8 (0.5)	2.3 (0.8)	1.3 (1.3)	
Heavy rainfall	2.5	18.7	1.4 (1.3)	2.8 (1.6)	0.5 (0.4)	1.7 (1.2)	1.2 (1.3)	
Erosion	0.3	1.7	1.0 (0.0)	2.6 (1.8)	0.2 (0.1)	1.9 (1.0)	2.0 (1.1)	
storm	2.1	26.7	1.0 (0.2)	2.9 (1.8)	0.4 (0.3)	1.8 (1.2)	1.6 (1.3)	
Snow/ice rain	0.5	11.5	1.1 (0.3)	2.7 (1.7)	0.5 (0.4)	1.1 (1.2)	1.0 (1.2)	
Biological	15.3	44.1	1.3 (0.6)	2.5 (3.8)	0.6 (0.4)	1.8 (0.9)	1.2 (1.1)	
Socio-demographic	51.2	89.0	1.8 (1.3)	4.7 (3.9)	0.9 (0.7)	1.8 (0.9)	1.0 (1.1)	
Economic	27.5	69.5	1.4 (0.9)	4.5 (4.5)	0.6 (0.5)	2.5 (0.7)	1.2 (1.2)	

Source: DFGFOR756.

Note: ¹ Complete sample of households with at least 1 nucleus member which were interviewed in both survey waves. ² Number of shocks and shock severity were computed exclusively for households affected by the respective shock type. Standard deviations are presented in brackets. Expected number of risk and risk severity were computed exclusively for households perceiving the respective risk type. ³ Shock and risk severity measured as ordinal scale from 0 (=no impact) to 3 (=high severity).

This discrepancy between shock experience and risk perception can be explained by various theories which address the dynamic process of risk perception formation, including (social) learning theory and prospect theory (Rogers 1997). In general, there is range of different factors that in addition to direct experience impact on individuals' perception of risk. Learning theory addresses the process through which direct

experience of events is translated into personal perception. Factors in that process include “exposure, attention, acceptance, retrieval of information, beliefs and attitudes to execution of behavior” (Bandura 1986). Prospect theory focuses on the relationship between stimulus and response in the formation of risk perception. It suggests that perceived risk is relatively stable and only changes in the event of intense shock experience (Rogers 1997).

In both countries the expected frequency of risks is highest for climatic events, especially flooding and drought in Thailand as well as flooding and storm in Vietnam. In terms of expected severity households in both countries expected the adverse effects of risks to be higher on income than on assets, particularly severity on income from climatic and economic risk.

Although the majority of households anticipate climate risk to occur in the next 5 years, a comparatively small share of households applied various ex-ante risk management strategies in order to prevent the adverse effects of future climate shocks (Table 2). Overall, about one third of Vietnamese households and 20% of Thai households applied any ex-ante coping strategy. In both countries, two major strategies stand out, both focusing on the physical prevention of damage. On the one hand about 13% of households in Vietnam and 8% in Thailand engaged in collective action in order to build infrastructure that can ameliorate the threat of climatic hazards. Such infrastructure includes, for instance, river dikes which help to prevent flood water from inundating agricultural land, and irrigation canals that maintain water provision to cropping systems during times of drought. Some households jointly manage common property resources, such as forests and lakes to ensure a sustainable extraction of natural resources. Collective action as a means to adapt to climate change has become increasingly important in Vietnam where local-level hazard planning and defense systems which had been previously provided by the state were decentralized in the mid-1990s (Adger 2003). It is argued that, particularly for marginalized groups, collective action will be a crucial means to maintain security in an increasingly risky natural environment.

On the other hand about 12% of the climate risk perceiving households in Vietnam and 4% in Thailand invested in the security of their own homestead as well as in

physical and human capital. Investments in homestead security, similar to collective action, focus on the physical prevention of adverse weather calamity effects including, for example, building elevated wooden platforms as a place of retreat when flood waters enter the house. Investment in physical and human capital extends the ability of households to equip their members with skills to deal with adverse effects of climate risk. In contrast to Vietnamese households, a similar share of Thai households adjusted their income portfolio from on-farm agricultural production and off-farm employment and build up savings through buffer stocks (e.g. storage of food and seeds) and savings accounts in financial institutions in addition to collective action and investment activities. Other ex-ante risk management strategies such as migration were only applied by very few households.

Table 2: Ex-ante copings for climate risk perceived in 2008

Type of coping strategy	Households (%)	
	VN	TH
Any coping strategy	33.0	18.4
Collective action	13.7	8.2
Collective action for infrastructure	12.5	8.1
Common property resource management	2.9	0.1
Investment activites	11.9	3.9
Investment in security of homestead	11.7	0.3
Investment in physical and human capital	0.2	3.5
Investment in travel safety	0.1	-
Income diversification	3.8	2.7
Crop, plot, livestock diversifiacation	1.7	0.8
Income source diversification	1.6	1.8
Switch to more secure income sources	0.6	0.1
Savings	3.6	1.6
Buffer stocks	3.2	1.3
Savings accounts in financial institutions	0.2	0.3
Membership in rotating savings and credit associations	0.1	-
Contract insurances	0.1	0.1
Old age annuities	0.1	-
Others	6.2	1.6
Migration	2.6	0.1
Sharecropper tenancy	0.6	-
Medical treatment	0.3	-
Membership in occupational organisations	0.1	-
Preventive health practices	0.1	0.1
Marriage and extended family	0.1	-
Not specified	2.7	1.5
N ¹	1932	1555

Source: DFGFOR756.

Note:¹ Households with at least 1 nucleus member which perceived climate risk.

3 Empirical model

A three-step regression approach is applied in order to identify possible linkages between past shock experience and future climate risk perception, and to clarify the role of climate risk perception in influencing households' decisions to apply ex-ante risk management strategies. In the first step households' risk perception is estimated while controlling for the short-term effect of climate-related shocks on households' risk perception as well as for other socio-demographic factors that construct and maintain risk expectations. The ordinary least squares (OLS) regression which is employed for that purpose takes the following form:

$$R_i = \lambda S_i^c + \phi X_i^r + \gamma P_p \quad (1)$$

where i indexes household and R_i is an ordinal risk score which indicates the magnitude of climate risk which a household expects to happen in the future. In the household questionnaire respondents were asked to quantify both the expected frequency of each climate shock type which they expected to happen in a 5-year future reference period and the expected severity of each of these events. The expected severity was stated separately in terms of income and asset loss, and by using an ordinal scale from 0 (=no impact) to 3 (=high severity). The risk score is computed by summing the expected severity of each risk event and then multiplying it with the expected frequency of the event. The sum of the risk scores of all expected climate shocks of a household is then R_i . Furthermore, S_i^c is a vector of climate shock incidents that a household experienced during 2002 and 2008 and X_i^r is a vector of socio-demographic characteristics of the interview respondent. P_p is a vector of dummy variables in order to capture the effect of provinces. λ , ϕ and γ are the parameters to be estimated.

The second step is to assess the probability to adopt any ex-ante risk mitigation action by applying a standard probit model,

$$\begin{aligned} Y_i^* &= \psi R_i + \phi X_i^h + \gamma P_p + u_i \\ Y_i &= 1 \quad \text{if} \quad Y_i^* > 0 \\ Y_i &= 0 \quad \text{otherwise} \end{aligned} \quad (2)$$

where i indexes household, Y_i^* is a latent decision variable, R_i is the ordinal risk score which was used as dependent variable in the first-step regression, X_i^h is a vector of socio-demographic household characteristics and P_p is a vector of dummy variables in order to capture the effect of provinces. Instead of observing Y_i^* a binary variable Y_i is observed which takes the value 1 if a household applies any ex-ante risk management strategy in order to cope with perceived climatic risk. ψ , ϕ and γ are the parameters to be estimated (Wooldridge 2002).

In the third step the likelihoods of households taking up the most frequently applied ex-ante risk management strategies are estimated. It is assumed that the decisions of households to engage in the different strategies are intercorrelated. Therefore a standard probit model is not suitable for making predictions about the joint probabilities of the relevant risk management strategy choices. Instead a bivariate probit model is used for Vietnam which includes two strategies: collective action and investment activities. In Thailand a multivariate probit model is used to extend the choice of strategies to also include income diversification and savings. Consider the following stochastic functions, one for each risk management strategy choice from 1 to J .

$$\begin{aligned} Y_{1i}^* &= \psi_1 R_{1i} + \phi_1 X_{1i}^h + \gamma_1 P_{1p} + u_{1i} \\ Y_{1i} &= 1 \quad \text{if} \quad Y_{1i}^* > 0 \\ Y_{1i} &= 0 \quad \text{otherwise} \end{aligned} \tag{3}$$

$$\begin{aligned} Y_{2i}^* &= \psi_2 R_{2i} + \phi_2 X_{2i}^h + \gamma_2 P_{2p} + u_{2i} \\ Y_{2i} &= 1 \quad \text{if} \quad Y_{2i}^* > 0 \\ Y_{2i} &= 0 \quad \text{otherwise} \end{aligned} \tag{4}$$

$$\begin{aligned} Y_{Ji}^* &= \psi_J R_{Ji} + \phi_J X_{Ji}^h + \gamma_J P_{Jp} + u_{Ji} \\ Y_{Ji} &= 1 \quad \text{if} \quad Y_{Ji}^* > 0 \\ Y_{Ji} &= 0 \quad \text{otherwise} \end{aligned} \tag{5}$$

where the variable coefficients and parameters are specified as in the second-stage standard probit model. The bivariate and multivariate probit model hypothesizes that

at least parts of these errors are correlated (Greene 2003) and is estimated by means of maximum likelihood methods.

4 Results

In the following the outcome of the econometric analysis is presented. Note that the number of observations included in the regression models is smaller than the initial sample size since some households have been excluded from the analysis in order to ensure the normal distribution of all variables. All models have been tested for multicollinearity between explanatory variables and no problematic collinear relationships could be detected. The regression estimates of the presented models are adjusted for heteroskedasticity. Testing for specification error by means of a link test indicated that no important independent variables have been omitted.

Results of the OLS regression of climate risk perception are presented in Table 3. The reported F-test and R^2 indicate that the independent variables are jointly significant and that the model has a reasonable goodness of fit. Identical regression was applied for both countries except that ethnicity and a multiplicative term have been added to the Vietnamese model in order to capture the ethnic diversity and to interact highly severe climate shocks with the Dak Lak province dummy variable. The estimated effects of the constitutive terms must be interpreted with care as the effect of one constitutive term on the dependent variable is conditional upon the value of the other independent constitutive term (Wooldridge 2000).

Results from both countries indicate that households which experienced more frequent adverse climate incidents during the last 7 years are more sensitive and pessimistic to future climate risk estimation than households which undergone fewer or no climate shocks, a finding similar to the outcome of Paul's (1984) study. Climate risk perception of Thai households is especially responsive to past climate shock experiences with both high and medium subjective severity assessment. Moreover, households in the provinces of Buriam and Nakhon Panom generally perceive climate risk to be higher than households in the province of Ubon Ratchathani. This indicates differences in micro-climatic conditions and socio-cultural factors between provinces.

Table 3: OLS regression of climate risk perception against socio-demographic characteristics

OLS climate risk perception	Vietnam		Thailand	
	Coef.	t-value	Coef.	t-value
Respondent characteristics				
Agricultural occupation (1=Yes)	6.23	3.84 ***	2.47	2.62 ***
Member in socio-political organization (1=Yes)	4.38	3.65 ***	0.67	0.54
Age (Years)	0.39	2.27 **	-0.04	-0.12
Age squared (Years)	0.00	-2.42 **	0.00	-0.03
Ethnicity (1=Kinh)	0.75	0.66	- ^a	- ^a
Education (Years)	0.10	0.77	-0.10	-0.75
Gender (1=Male)	-1.51	-1.59	-0.26	-0.32
Province dummies				
Buriram (TH) / Ha Tinh (VN) (1=Yes)	-1.68	-0.76	4.87	4.88 ***
Nakhon Panom (TH) / Dak Lak (VN) (1=Yes)	-18.90	-8.72 ***	2.44	2.00 **
Climate shock incidents 2002-2008				
Climate shocks of high severity (Number)	8.87	7.51 ***	5.19	7.29 ***
Climate shocks of medium severity (Number)	1.42	1.21	2.69	4.27 ***
Interaction terms				
Dak Lak * Climate shocks of high severity	-6.24	-4.88 ***	- ^a	- ^a
Constant	6.66	1.18	12.20	1.70 *
P > F (joint significance)	0.00		0.00	
R ²	0.28		0.10	
N	1651		1555	

Data source = DFGFOR756.

Note: ^a Variables omitted. *P<0.1, **P<0.05, ***P<0.01.

In Vietnam, climate shocks of high subjectively perceived severity are found to be significantly and positively correlated with the level of climate risk which households from provinces other than Dak Lak perceive. For households from Dak Lak province a similar positive effect is indicated after calculating the relevant marginal effect, however the size of the effect is comparatively small. This means that the climate risk perception of households from Dak Lak province increases to a smaller extent as a response to experiencing highly severe climate shocks. This may be due to the geographical location of Dak Lak in Vietnam's Central Highlands region that is less prone to cyclones and tropical storms than coastal provinces. Thus, households might see extreme climate conditions as rare events that are unlikely to occur again in the near future. Results furthermore indicate that household respondents from Dak Lak province reveal a considerable and significant lower perception of climate risk than household from Thua Thien Hue province in the absence of highly severe climate shocks. No significant relationship can be identified with regards to climate shocks of lower subjectively perceived severity, which emphasizes the importance of differentiating between shock events of different severity levels.

Further results show that agricultural occupation of the respondent in both countries increases the level of perceived climate risk, suggesting that household members who

are actively engaged in agriculture are more aware of the hazards that climatic fluctuations can bring about regardless of any actual climate shock experience. Furthermore, two other socio-demographic characteristics of respondents are found to have significant influence on climate risk perception in Vietnam. Membership in a socio-political organization, such as the Communist Party or the Veteran's Union, is indicated to be positively related with perceived climate risk. As social learning theory suggests, beliefs of individuals are not only shaped by self-experience but also by observing and retrieving information from others (Bandura 1971, Rotter 1954). Those Vietnamese farmers who have a larger personal network through which they can access information from both other farmers and governmental sources may perceive the risk of being affected by climatic adversities to be higher than farmers who can only rely on their own experience. Moreover, older respondents are likely to evaluate a higher perception of climate risk which may be explained by an increasing preoccupation for their family and a more profound long-term experience of the effects of climate shocks. However, for respondents who are very old a declining climate risk perception is indicated.

Table 4 shows the results of the probit regression of households' application of any ex-ante climate risk management strategies in 2008. Note that the explanatory variables vary slightly to reflect the country-specific situations. In addition to the income indicator for Thailand, wealth is an asset-based indicator reflecting aggregate value of productive and consumption assets, house, owned land, livestock and savings. In Vietnam, on the other hand, tangible assets and land size are separated since land is more difficult to sell or buy due to the political frame conditions. The value of land is therefore difficult to estimate and land size is used as a reasonable proxy for land value. Furthermore, although the majority of households rely on agriculture as main income source, simultaneous off-farm and/or non-farm employment are common among Thai households. Hence, "off-farm employment as main option" village variable is replaced with ratio of "engagement in agriculture" household characteristic. In both countries it is indicated that the degree of climate risk perception is significantly increasing the probability of households to use any such strategies, although the magnitude of this effect is relatively small. More importantly, location characteristics in Vietnam are significantly decreasing the likelihood of applying ex-ante climate risk management strategies, with households

living in Dak Lak province revealing a probability that is about 43% lower than in the province of Thua Thien Hue. The reason for this large difference is to be explored in the bivariate probit regressions.

Table 4: Probit regression of household use of ex-ante climate risk management strategies in 2008 against socio-demographic characteristics

Probit: Ex-ante climate risk mitigation (1=Yes)	Vietnam		Thailand	
	Coef.	dF/dx	Coef.	dF/dx
Household characteristics 2007/2008				
Maximum education (Years)	0.0023	0.0005	0.0167	0.0031
Wealth per capita (PPP\$)	- ^a	- ^a	0.0000	0.0000
Tangible assets (PPP\$)	0.0001	0.0000	- ^a	- ^a
Number of household members	0.0389	0.0085	-0.0130	0.0065
Average monthly per capita income (PPP\$)	-0.0005	-0.0001	-0.0003 *	0.0000
Engagement in off-farm employment (Months)	-0.0087 *	-0.0019	0.0012	0.0009
Age of household head (Years)	0.0092	0.0020	-0.0250	0.0056
Age of household head squared (Years)	-0.0001	0.0000	0.0002	0.0000
Engagement in agriculture (%)	- ^a	- ^a	0.1474	0.0360
Land size (ha)	0.7966	0.1750	- ^a	- ^a
Ethnicity of household head (1=Kinh)	0.4618 *	0.0839	- ^a	- ^a
Climate risk score	0.0039 *	0.0009	0.0044 **	0.0006
Village/province characteristics				
Time to district town (Minutes)	0.0013	0.0003	-0.0001	0.0008
Time to market (Minutes)	-0.0042	-0.0009	-0.0056 *	0.0009
Off-farm employment as main option (1=Yes)	-0.1419	-0.0308	- ^a	- ^a
Buriram (TH) / Ha Tinh (VN) (1 = Yes)	0.0782	0.0173	-0.1019	0.0257
Nakhon panom (TH) / Dak Lak (VN) (1 = Yes)	-2.3375 **	-0.4282	0.3046 **	0.0331
Constant	-0.9082		-0.2373	
P > F (Wald test)	0.0000		0.0001	
N	1476		1555	

Data source: DFGFOR756.

Note: ^a Country-specific omitted variable. *P<0.1, **P<0.05, ***P<0.01. dF/dx indicates the marginal effect of a one-unit change in the explanatory variable on the probability to use any ex-ante climate risk management strategies.

In Thailand, the decision to adopt ex-ante mitigation strategies are significantly and negatively influenced by household income level and travel time to market suggesting that higher-income households and living closer to market are less likely to apply precautionary measures against climate risks, however the marginal effect is rather small. Moreover, households in the provinces of Ubon Ratchathani and Buriram are more likely to take up ex-ante risk mitigation actions than households in Nakhon Panom province. In Vietnam, additional covariates which have a significant effect on households' decision to use ex-ante climate risk management strategies are the ethnicity of the household head and the engagement of the household in off-farm wage- or non-farm self-employment. Belonging to Vietnam's ethnic Kinh majority

increases the probability of applying these strategies by about 8% which might suggest that ethnic minorities have a relatively poor access to the knowledge and resources required to apply risk mitigation techniques. Contrary, income source diversification, i.e. being engaged more months in off-farm wage- or non-farm self-employment, lowers the likelihood of ex-ante climate risk management strategy use, indicating that such households only depend on their agricultural production to a smaller extent and can still count on their non-agricultural income sources when weather calamities damage their crops or livestock (Phung Duc & Waibel 2010).

The outcome of the bivariate probit regressions of Vietnamese households' use of collective action and investment activities as ex-ante climate risk management strategies are shown in Table 5. Results indicate that higher climate risk score is significantly increasing the probability that households engage in collective action for infrastructure, such as dikes and irrigation canals, in order to reduce their vulnerability to climate risk, while no significant relationship is suggested with respect to investment in homestead security, including for example structural reinforcements of buildings to make them more resistant to storm damage. The reasons for this difference might be that collective action can be organized more spontaneously when the risk perception level of a group of households is high, requiring mainly labor input from the household side, whereas investment in homestead security depends more on long-term strategic decisions of households which often have a limited ability to invest due to financial constraints.

Again, location factors play a key role in determining the adoption of these main ex-ante climate risk management strategies. In Dak Lak, households are significantly less likely to apply either of the two strategies as compared to households in Thua Thien Hue. In Ha Tinh, however, investment activities are significantly more likely than in Thua Thien Hue. A possible explanation for these findings is a difference in the promotion of risk management behavior between Vietnamese provinces that may cause such distinct adoption of ex-ante strategies.

The estimates of the effect of the value of all tangible assets which a household possesses on the application of the most frequently applied ex-ante climate risk management strategies yield contrary signs. Tangible asset value is significantly

positively related to the engagement in collective action, an expected outcome since a household with more valuable tangible assets should have a higher incentive to protect its assets by applying ex-ante climate risk management strategies. However, a significant negative relationship is indicated between tangible asset value and investment in homestead security. Given the above reasoning, this result is unexpected and requires further scrutiny. Investment in homestead is furthermore significantly positively correlated with farm size, another possible indicator for the value of household assets.

Table 5: Bivariate probit regressions of Vietnamese household use of collective action for infrastructure and investment in homestead security as ex-ante climate risk management strategies against socio-demographic characteristics

Vietnam: Bivariate probit (N = 1476)	Collective action		Investment activities	
	Coef.	dF/dx	Coef.	dF/dx
Household characteristics 2007/2008				
Maximum education (Years)	0.0014	0.0001	0.0186	0.0000
Tangible assets value (PPP\$)	0.0004 ***	0.0000	-0.0002 *	0.0000
Number of household members	0.0543	0.0034	-0.0376	0.0000
Average monthly per capita income (PPP\$)	-0.0008	-0.0001	-0.0014	0.0000
Ethnicity of household head (1=Kinh)	0.2987	0.0154	0.4713	0.0003
Off-farm employment (Months)	-0.0095	-0.0006	0.0025	0.0000
Land size (ha)	-2.7192	-0.1712	2.1668 **	0.0024
Age of household head (Years)	-0.0060	-0.0004	0.0115	0.0000
Age of household head squared (Years)	0.0000	0.0000	-0.0002	0.0000
Climate risk score	0.0102 ***	0.0006	-0.0012	0.0000
Village/province characteristics				
Off-farm employment = main option (1=Yes)	-0.3974	-0.0240	0.2191	0.0003
Time to district town (minutes)	-0.0012	-0.0001	0.0036	0.0000
Time to market (minutes)	0.0055	0.0003	-0.0010	0.0000
Ha Tinh dummy (1=Yes)	0.1903	0.0125	0.4731 ***	0.0007
Dak Lak dummy (1=Yes)	-1.5047 ***	-0.0903	-6.1764 ***	-0.1632
Constant	-1.7788		-1.8934	
P > F (Wald test) = 0.0000				
Rho (ρ) = -0.2637061***				

Data source = DFGFOR756. Note: *P<0.1, **P<0.05, ***P<0.01. dF/dx indicates the marginal effect of a one-unit change in the explanatory variable on the probability to use collective action for infrastructure and investment in homestead security, respectively, as ex-ante climate risk management strategy.

For Thai households, Table 6 summarizes the results of multivariate probit model which further reveals specific relationships between the same set of variables from the previous probit model and the adoption probability of four major ex-ante mitigation

activities, i.e. collective action, investment activities, income diversification and savings. Climate risk score are found to have positive influence on all strategies. On the one hand, the effect of climate risk perception is significant on collective action for infrastructure and common property resource management as well as individual household income diversification. Households which perceive climate risk to be threatening are more likely to get together and form a joint cooperation within the village to protect and preserve common infrastructure and natural resources. Moreover, they are more likely to diversify agricultural portfolio and income sources to cushion negative effects of risks on income and asset. On the other hand, high risk perception does not immediately prompt for investment and savings accumulation as households may be short of financial capital. Furthermore, reliance on agriculture as main occupation increases the likelihood that a household would invest in physical and human capital as well as security of homestead. Off-farm employment, on the contrary, increases the probability that a household would build up savings from additional income sources.

Village and province characteristics also play a role in making a choice of ex-ante mitigation strategy. Closer distance to district town significantly encourages diversification of income sources due to greater possibility to find off-farm and non-farm employment. Furthermore, households living in Ubon Ratchathani are more likely to join collective action and to invest than in other provinces while households living in Buriram and Nakhon Panom are more likely to diversify income sources and build up savings.

Table 6: Multivariate probit regressions of Thai household use of major ex-ante climate risk management strategies against socio-demographic characteristics

Wald chi2(52) = 168.87
Prob > chi2 = 0.0000

Log pseudolikelihood = -507075.72
SML, # draws = 40

Thailand: Multivariate probit (N = 1530)	Collective action		Investment		Diversification		Savings	
	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Household characteristics 2007/2008								
Maximum education (years)	0.0155	0.0022	0.0246	0.0019	-0.0126	-0.0007	0.0100	0.0004
Wealth per capita (PPP\$)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Number of household members	0.0274	0.0039	-0.0097	-0.0008	-0.0150	-0.0008	-0.0211	-0.0008
Average monthly per capita income (PPP\$)	-0.0001	0.0000	-0.0004	0.0000	-0.0003	0.0000	-0.0003	0.0000
Engagement in agriculture (%)	0.2694	0.0385	0.5577 **	0.0441	0.0235	0.0013	-0.5781 *	-0.0214
Off-farm employment (Months)	0.0004	0.0001	-0.0022	-0.0002	0.0027	0.0001	-0.0241 **	-0.0009
Age of household head (Years)	-0.0236	-0.0034	-0.0243	-0.0019	-0.0444	-0.0025	0.0296	0.0011
Age of household head squared (Years)	0.0002	0.0000	0.0002	0.0000	0.0004	0.0000	-0.0004	0.0000
Climate risk score	0.0064 **	0.0009	0.0013	0.0001	0.0124 ***	0.0007	0.0023	0.0001
Village/Province characteristics								
Time to district town (Minutes)	0.0015	0.0002	0.0049	0.0004	-0.0160 **	-0.0009	-0.0041	-0.0002
Time to market (Minutes)	-0.0042	-0.0006	-0.0057	-0.0004	0.0020	0.0001	-0.0109	-0.0004
Buriram dummy (1 = Yes)	-0.3653 ***	-0.0523	-0.5045 ***	-0.0399	0.7971 ***	0.0448	0.3628	0.0134
Nakhon panom dummy (1 = Yes)	0.0160	0.0023	-0.0512	-0.0040	0.7681 ***	0.0432	0.7226 ***	0.0268
Constant	-1.0236		-1.2941		-1.1412		-2.2781 *	
/atrho21	-0.1015	rho21	-0.1011					
/atrho31	0.0593	rho31	0.0592					
/atrho41	-0.0184	rho41	-0.0184					
/atrho32	-0.1293	rho32	-0.1286					
/atrho42	-0.3362	rho42	-0.3241					
/atrho43	-0.0011	rho43	-0.0011					

Likelihood ratio test of rho21 = rho31 = rho32 = rho42 = rho43 = 0: chi2(6) = 1.0e+06 Prob > chi2 = 0.0000

5 Summary and conclusions

The empirical findings from six provinces in Northeastern Thailand and Central Vietnam provide some important insights into the relationship between shock experience, risk perception and the use of ex-ante risk management strategies with regards to climate risk among rural households. Concerning the status of climate shock experience during 2002 and 2008, risk perception anticipated for the next 5 years and ex-ante risk management currently applied (research question 1), it is indicated that households in both countries are affected by different types of shocks among which climate calamities rank highest followed by socio-demographic shocks, mainly illnesses of household members. Furthermore, a large share of households in Thailand suffer from economic shocks especially price fluctuations of production inputs and outputs, whereas Vietnamese households are more prone to biological shocks, such as crop pests and livestock diseases. On average households in both countries experienced two climate shocks between 2002 and 2008 with Vietnamese households reporting a higher average subjective severity.

Compared to the observed shock experience households appear to be relatively pessimistic with regards to their perception of respective future risk as both the share of households expecting future shocks and the variety of shock types expected is larger. This points to the existence of factors other than shock experience which are additional determinants of climate risk perception. In both countries the expected frequency and severity of risks is highest for climatic events. In terms of expected severity households in both countries expected the adverse effects of risks to be higher on income than on assets. The main ex-ante climate risk management strategies which rural households in the study areas apply are 1) engagement in collective action to build infrastructure and manage common property resource, 2) investment in homestead security as well as physical and human capital, 3) income source diversification and 4) savings accumulation. In general only about one third of Vietnamese and 18% of Thai households applied respective precautionary measures.

Referring to the link between climate shock experience and risk perception (research question 2), the experience of climate shocks of high and medium subjective severity increased climate risk perception of households while other factors, in particular

agricultural occupation of the respondent and location, are also identified as significant determinants. Regarding the effect of climate risk perception on the use of any (research question 3) and specific main (research question 4) ex-ante climate risk management strategies, it can be shown that although a positive relationship is indicated in the former case, the latter case shows an ambiguous outcome. The likelihood of the decision that a household would engage in collective action and income source diversification increases with rising risk perception while no such link is indicated with regards to the decision to investment and savings. Again, further determinants of adoption can be identified among which the degree of agricultural engagement and off-farm occupation of household members are the significant factors in Thailand while location factors stand out as the most important ones in Vietnam.

Rural households in the study areas are able to translate their experience of climate shocks into climate risk perception, suggesting that they are to a considerable extent aware of those climatic hazards that are common in their regions. Risk communication processes between disaster management institutions and rural households thus can build on such knowledge. The behavioral response of households is limited to four major ex-ante risk management strategies. The use of these main strategies depends on the level of climate risk perception as well as other determinants, most importantly location factors in the case of Vietnam which may reflect inter-provincial differences in the promotion of climate risk management and the respective knowledge of households, and engagement in agriculture and off-farm employment in the case of Thailand. The low share of farm households using alternative ex-ante risk mitigation option, particularly functional adjustments such as agricultural and non-agricultural income diversification, points to a possible existence of entry barriers to such strategies. Again further studies are required in this context, in order to pinpoint respective problems and find ways to improve the situation.

This study provides a comprehensive starting point for climate risk perception and ex-ante climate risk mitigation analysis focusing on small-scale rural households. As a further step in the analysis, the effect of ex-ante climate risk mitigation on the vulnerability to poverty of households will be estimated. Linking climate risk to poverty will allow drawing conclusions on the welfare implication of climate risk perception and facilitate the design of social risk management policies. Since several

vulnerability concepts exist, a comparison is necessary. The standard vulnerability as expected poverty measure (Chaudhuri et al. 2002) and the more refined concept of vulnerability as expected deprivation (Calvo and Dercon 2007) will be compared in forthcoming papers.

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