Risk assessment and risk management decisions: a case study of Thai rice farmers

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Abstract
This study aims at analyzing the agricultural risks that rice farmers in different areas have faced and the risk management decisions. The latent regression of binary choice using the logit model is employed to empirically test factors influencing risk management decisions of Thai rice farmers. The interview data of 426 rice farmers in four major rice production provinces: Supanburi, Pisanulok, Khonkhan and Nakornratchasrima are used in this analysis. The empirical results have shown that factors that statistically significant influence the risk management decision that prevents the incidence of floods in the future or mitigates the severity of future flood incidences are rice planted areas, the location of farm whether or not in lowland area, the subjective expectation that flood will occur in the next ten years and the farmers'judgments regarding the ability to protect from flood risk.

1. Introduction

Rice is a major crop for agricultural production in Thailand. Total rice planted area is 70 Million Rais (11.2 Million Hectares), accounted for 47 percent of total agricultural land use. Rice is also an important crop as 3.7 farming households in Thailand, or 63 percent of total farming households rely their livelihood on rice. However, Thai rice farmers are highly exposed to flood, delayed rainfall and drought (Thailand Fiscal Policy Office, 2010). Pests are also one of the key risks for rice production (Chantarat, et al., 2013). As a result, Thai rice farming households are more vulnerable to weather shocks and pest infestations resulting fromthe negative impacts on production and income.

Natural disasters, particularly the severe flood in 2011, caused huge damages on assetsand income, with the estimated of total loss in agriculture of 909 Million USD (World Bank, 2012). The flood in 2011 generated severe impact on livelihood, productivity, income and consumption. The Thai government has always assisted the affected-disaster farmers. On average, the government spends 3,350 Million Baht annually for rice farmers affected by flood, drought and pests (Chantarat, et al., 2013). However, risk management actions to prevent future flood incidence or mitigages the damage and loss of future flood events can reduce negative consequences of flood to household welfare, reducing the government budget for disaster assistance. Examples of risk prevention or mitigation actions include having savings, diversifying on farm and off-farm activities, building on-farm flood protection, having community flood protection, buying crop insurance, buying more assets, reducing rice planted areas, adjusting farming practices such as choosing short-duration variety or even changing rice cropping calendar. However, the decision to take risk prevention actions depends on households' characteristics, risk attitudes and subjective expectation of the flood risks. Therefore, it is interesting to study factors affecting rice farming households to undertake flood risk prevention or mitigation actions after the incidence of severe flood in 2011

2. Theoretical Framework

A farmer has two choices to select which is either taking or not taking risk prevention or mitigation actions (RPA). RPA will take only two values, say, 1 if farmers take RPA and 0 if not. According to the rational choice theory, the risk prevention actions can be assessed by comparing the a neoclassical random utility model for individual choice (Green, 2003) thereby the random utility functions of those two choices are described as follows.

Utility of taking RPA $U_{RPA} = X'\beta_1 + \varepsilon_{RPA}$

Utility of not taking RPA $U_{NRPA} = X'\alpha_1 + \varepsilon_{NRPA}$

Thereby the measurable vector of characteristics of the farmer is shown by X'. This might include gender, age, income and other demographics, risk attitudes and subjective expectation of the flood risks and ε_i for i=RPA and NRPA is the error term.

The rational farmers will take an actions if his or her utility function is greater than the utility of not taking $(U_{RPA} > U_{NRPA})$ or the utility from benefits of prevent income or asset losses due to flooding are higher than the cost of doing RPA. On the other hands, those who will not take any actions, his or her utility function of taking any actions is less than the utility of not taking.$(U_{RPA} < U_{NRPA})$. However, the observed choice only reveal which one provides the higher utility but the magnitudes of the utilities are unobserved. Therefore the probability that a farmer will takes RPA or the probability that Y=1 and the probability that a farmer will not take RPA or the probability that Y=0 can be given as

Probability of taking RPA $\text{Prob}(Y = 1|X) = \text{Prob}(U_{RPA} > U_{NRPA})$

Probability of not taking RPA $\text{Prob}(Y = 0|X) = \text{Prob}(U_{RPA} \leq U_{NRPA})$

To estimate the probability of RPA, the binary choice model or a latent regression model will be applied since the theory states that the farmer make marginal benefit/marginal cost based on the utilities achieved by taking RPA and by not taking thus the difference between benefit and cost, which is net utility can be described as an latent unobserved variable Y* such that

$$Y^* = X'\beta + \varepsilon$$

Assuming that ε has zero mean and has either standard normal distribution or standardized logistic, therefore

$Y = 1$ if $Y^* > 0$ or $Y^* = X'\beta + \varepsilon > 0$ and $Y = 0$ if $Y^* \leq 0$ or $Y^* = X'\beta + \varepsilon \leq 0$

3. Methodology

The research methodology including of sample and the approach employed are discussed in the following.

3.1 Data Collection

This study focuses on factors affecting rice farming households to undertake flood RPA after the incidence of severe flood in 2011. As a results, two rice-growing regions of Thailand: central and northeastern region are chosen as the study area. Four rice-growing provinces that experienced the severe flood in 2011: Pitsanulok and Suphanburi in the central region, and Khonkaen and Nakorn-Ratchasima in the northeastern region are chosen as samples. In addition, the survey data covers farmers from different agricultural risk zones (flood-prone areas and non-flood prone areas). A flood prone area is defined as an area that has had a frequency of flood occurring every year or occurring 3 to 4 years within the past 5 years. The chosen provinces in the central region represent flood prone area and the chosen provinces in the northeastern region represent non-flood prone area. The field-survey included a total of 426 respondent rice farmers in two regions (226 samples in Central area and 200 samples in the Northeastern area), described in Table 1. It is noted that the field-survey data used in this study was taken in 2013 from a collaboration between Samphantharak and Chantarat (2014) for the ERIA project "The Effects of Natural Disasters on Household's Preferences and Behaviors: Evidence from Thai Farmers During and After the 2011 Mega Flood"and the Agricultural

Research Strategy Unit, Faculty of Economics, Kasetsart University for the study under the title of "Demand Assessment for Area Yield Index Insurance"of Thai rice-farming households.

Region/Provinces	Number of samples
Central region (flood-prone area)	
Suphanburi	104
Phitsanulok	122
Northeastern region (non flood-prone area)	
Khon Kaen	104
Nakhon-Ratchasima	96
Total	**426**
Source: from survey in 2013	

Table 1: Sample classified by areas and provinces

The questionnaires were developed for collecting (1) socio-economic characteristics of rice farming, (2) agricultural information:rice planted area, production and income, (3)risk perceptions: source of risks, frequency and impact of risks, experice of shocks and a chance that the occurrence of severe flood events future, (4) risk management actions to prevent future flood incidence or mitigages the damage and loss of future flood events and (5) farmer's Judgment on ability to protect from flood risk.

3.2 Research approach

Both qualitative and quantitative approaches are employed in this research. Firstly, the descriptive analysis are utilized to identified or to addressed agricultural risks assessment of rice farmers in the studied area and then analyze the risk prevention or mitigation actions of rice farmers. In order to analyze the relationship among the factors effecting risk prevention activities of rice farmers, t the logistic distribution function was constructed as the following.

$$P_i = E(Y = 1|X_i) = \frac{1}{1 + e^{-(\beta_1 + \beta_1 X_i + \varepsilon_i)}} = \frac{1}{1 + e^{-Z_i}} = \frac{e^{Z_i}}{1 + e^{Z_i}}$$

And

$$\log\left(\frac{P_i}{1 - P_i}\right) = \beta_1 + \beta_1 X_i + \varepsilon_i$$

Where $Z_i = \beta_1 + \beta_1 X_i + \varepsilon_i$., $-\infty \leq Z_i \leq \infty$ and P_i is the probability that the farmers take a risk prevention action and it ranges between 0 and 1($0 \leq P_i \leq 1$). The general model of logit model in this study can be written as

$$Prob(Y = 1|X_i) = P_i$$
$$= f(Gender(MALE), HH\ members(HHSRICE), Rice\ income\ share(SHRICEINCOME),$$
$$Rice\ production\ area(RICEAREA), Areas\ characteristics(DLOWLAND), Flooding\ frequency$$
$$(F\_FLOOD), \text{Expected numbers of severe flood in the future } (N\_FLOOD), \text{Cost of taking RPA}(EXPENSE),$$
$$Ability\ to\ cope\ with\ flooding(ABILITY))$$

where Y=1 if farmers taking at least one flood-RPA such as having saving account, diversifying on farm and off-farm activities, building on-farm flood protection, having community flood protection, buying crop insurance, buying more assets, reducing rice planted areas, or adjusting farming practices such as choosing short-duration variety or even changing rice cropping calendar and Y=0 if not. The independent variables included in the model can be described as following table.

Independent variables	Unit classification	Expected effect
Gender (*MALE*)	1=male, 0= female	+/-
HH members (HHSRICE)	Household members (persons)	+
Rice income share (SHRICEINCOME)	Income from rice production (%)	+
Rice production area (RICEAREA)	Size of rice area (Rais)	+
Areas characteristics (DLOWLAND)	Lowland=1, highland=0	+
Flooding frequency (*F_FLOOD*)	Frequency of flooding in past 5 years, 1= at least once 0=otherwise	+
Expected severe flood in future(N_FLOOD)	Expected number of servere flood in the next ten years	+
Cost of taking RPA (EXPENSE)	Cost of adopting prevention activities (thousand bahts)	-
Ability to cope with flooding (ABILITY)	Be able to cope with flooding=1 Unable to cope with flooding=0	-

Table 2: Unit and expected sign of independent variables

4. Research results and discussions

4.1. Agricultural risk assessment

Farmers were also asked to rank the impact of those risks on rice income (0=no impact, 1= low impact and 2 = high impact).The results in Table 3 indicated that river flooding is the natural hazard that most rice farmers in the central region (flood-prone area) identified as the risk caused high impact on rice income, followed by high temperature and rainfall flooding, respectively. On the other hand, most rice farmers in the Northeast region (non flood-prone area) identified that drought was the majority natural risk problem with high impact on rice income followed by river flooding and rainfall delay, respectively. For the price risks, the farmers in both areas also indicated that price risk in the form of low rice price and high input costs had a major impact on their rice incomes. For other production risks, pests and weedy rice were also considered as the factors having high impact on rice income of farmers in the central area (Table 3).

Unit: %

Agricultural Risks	Central (Flood-prone area))			Northeast (Non flood-prone area)		
	0	1	2	0	1	2
Production Risk						
Natural risks						
Drought	37.61	25.66	36.73	12.50	26.00	**61.50**
Rainfall delay	54.42	23.01	22.57	15.00	37.00	48.00
River flooding	15.93	19.91	**64.16**	40.00	11.50	**48.50**
Rainfall flooding	28.76	34.07	37.17	60.50	12.00	27.50
High temperature	15.93	44.69	39.38	37.00	35.50	27.50
Disease	9.29	55.75	34.96	16.50	46.50	37.00
Pest (rat, golden apple snail)	3.98	38.94	**57.08**	16.50	40.00	**43.50**
Weedy rice	7.52	30.09	**62.39**	57.00	32.50	10.50
Price Risk						
Low rice price	15.93	12.83	**71.24**	22.00	27.50	**50.50**
High input cost	8.85	15.49	**75.66**	17.00	23.50	**59.50**
Source: survey 2013						

Table 3:Rating Impact of Agricultural Risks (0= No Impact, 1= Low Impact, 2= High Impact) classified by regions

The results in Table 4 showed that most of rice farmers in northeastern area revealed that in the past 5 years the production risk such as high temperature and flooding were happened one or two times while pests infestination occured every year. On the other hands, high cost of production was the most frequency of the price risk. While most of central rice farmers revealed that in the past 5 years the production risk such as drought, hign temperature and flood due to rainfall were happened one or two times while the river flooding happened every year. Furthermore, pest and weedy rice happened every year and cost of production also was the most frequency of the price risk. Overall, most rice farmers in thecentral region (flood-prone area) gave higher weight to flood incidences as risks likely to occur more frequently than those in the northeastern region (non flood-prone area).

Unit: %

Agricultural risk	**Frequency of risk in the previous 5 years**			
	0	1	2	3
Northeast				
Natural risks				
Drought	14.00	37.50	26.00	22.50
Rainfall delay	13.50	**40.00**	24.50	22.00
River flooding	13.50	**40.00**	24.50	22.00
Rainfall flooding	53.50	18.00	12.50	16.00
High temperature	24.00	**44.50**	17.00	14.50
Disease	11.50	33.00	18.50	37.00
Pest (rat, golden apple snail)	11.00	26.00	15.50	**47.50**
Weedy rice	53.00	18.00	9.50	19.50
Low rice price	26.00	37.50	21.00	15.50
High input cost	14.50	20.00	13.50	**52.00**

Agricultural risk	**Frequency of risk in the previous 5 years**			
	0	1	2	3
Central				
Natural risks				
Drought	38.94	**49.56**	9.29	2.21
Rainfall delay	50.88	34.96	11.06	3.10
River flooding	11.50	29.65	20.35	**38.50**
Rainfall flooding	28.76	**37.17**	11.50	22.57
High temperature	16.81	**49.56**	15.04	18.58
Disease	7.96	32.30	19.91	39.82
Pest (rat, golden apple snail)	3.98	26.11	18.58	**51.33**
Weedy rice	6.19	7.08	10.18	**76.55**
Low rice price	19.03	37.61	20.35	23.01
High input cost	9.73	10.18	14.60	**65.49**

Source: survey 2013

Table 4:Rating Frequency of Agricultural Risks [0= Not occur, 1= Occur in some year (1-2 in 5 years) 2= Occur almost every year (3-4 in 5 years) and 3= Occur every year (5 in 5 years)]classified by regions

The results in Table 5 indicated that most of the rice farmers in both areas, about 60.99% of the total respondents in the central region and 53.75% of the respondents in the Northeast took risk prevention or mitigation actions (RPA). The most common activities that the rice farmers in both areas have done was building flooding protection system such as building road ridge or earthen dyke following by changing croping calendar such as grow faster than the previous schedule or using shortern-growing rice variety.

	Central		Northeast		Total	
	Number	%	Number	%	Number	%
Don't take any action	68	39.31	37	46.25	105	41.50
Take any action	105	**60.69**	43	**53.75**	148	58.50
Diversifying off-farm activities	20	11.56	12	15.00	32	12.65
Buying crop insurance	14	8.09	7	8.75	21	8.30
Having saving account	15	8.67	14	17.50	29	11.46
Buying more assets	3	1.73	2	2.50	5	1.98
Having crop diversification	11	6.36	5	6.25	16	6.32
Reducing rice areas	3	1.73	2	2.50	5	1.98
Changing rice cropping calendar	39	**22.54**	14	**17.50**	53	20.95
Changing rice growing techniques	14	8.09	5	6.25	19	7.51
Building flooding protection system	76	**43.93**	34	**42.50**	110	43.47
Total	**173**	**100.00**	**80**	**100.00**	**253**	**100.00**

Table 5:Numbers and percentage of rice farmersclassified bytakingrisk management actions and regions

Note: A farmer reported more than 1 risk prevention or mitigation action

The empirical results of the study shown in Table 6 indicated the corresponding explanatory variables included in the logit models have the expected signs. It also showed that rice farming hosueholds with higher share of rice income are more likely to take RPA. This factor is statistically significant at 95% confidence intervel in both regions. The margial effect is 0.0037 for the central region and 0.0034 for the northeastern region. That is, the probability of farmers in the central area to take RPA increases by 0.37% as the share of rice income increases while that in the northeastern area increases by 0.34 percentage points.

In addition, the expansion of rice planted areas and the increase of expected number of flooding in the future are statistically significant for central region. Rice farmers in the central area are more likely to take RPA if the rice planted areas increase.The incease in the expected number of flooding in the future (next ten years) will increase the probability of taking RPA by 0.8 percentage points. In addition, farmers with larger rice farm size are more likely to take RPA compared with those with smaller rice farm size. This factor also has a positive impact but not statistically significant at 5% level of significance on the probability to take actions in flooding prevention practices for those rice farmers in the Northeast.

The result also expressed that the location and the ability to cope with flood is statistically significant at 10% level of significance in the case of central area (flood-prone area). The marginal effect of this determinant indicated that the likelihood to take RPA by farmers in the central area whose rice planted area located in lowland area is 13.79 percentage point higher than those whose rice planted area located in upland. In addition, the probability of taking RPA for respondents who judged that theycan protect themselves from flood risk is 8.49 percentage point higher than those judged that they cannot protect at all. However, in the case of the farmers in the northeastern areas, it is not statistically significant.

Comparing marginal effects among explanatory variables in the central region and those in the northeastern region reported in table 6, all marginal effect of all determinants on probability of taking RPA of the farmers in the central region is higher than those from rice farmers in northeast region.For the central region, the ability to cope with flooding has the highest influence on the likelihood to take RPA, followed by the area characterstics, whether the rice planted area is lowland and the expected number of flooding in the next ten years.

Explanatory variables	The central region			The northeastern region		
	Coefficient	p-value	Marginal Effect	Coefficient	p-value	Marginal effect
Constant	-3.0006	0.000		-0.9677	0.122	
Gender	-0.5573	0.163	-0.1135	-0.1801	0.594	-0.0437
HH members	0.0588	0.617	0.0116	0.0380	0.661	0.0093
Rice income share	**0.0187****	0.000	**0.0037**	**0.0140****	0.002	**0.0034**
Rice production area	**0.0257****	0.017	**0.0051**	0.0086	0.302	0.0021
Area characteristics	**0.7072***	0.057	**0.1379**	0.0599	0.855	0.0146
Flooding frequency	0.5459	0.182	0.1084	0.2416	0.464	0.0594
Expected number of flooding in the future	**0.2516****	0.008	**0.0497**	0.0760	0.285	0.0186
Cost of taking RPA	-0.0026	0.591	-0.0005	-0.0022	0.441	-0.0005
Ability to cope with flooding	**-0.8049****	0.049	**-0.1661**	-0.1567	0.625	-0.0384
LR Chi Square		60.41			31.76	
Pseudo R^2		0.2455			0.1078	

Remarks: ** significant at 95% confidence interval (5% level of significance)
* significant at 90% confidence interval (10% level of significance)

Source: from own calculation by using statistical software package EViews

Table 6:Estimated coefficients and marginal effects of the logit modelsby using maximum likehood estimation

6. Conclusion and Recommendation

The study indicated that farmers in different regions will face the production risk differently such as the farmers in the central areas faced with river flooding, pest and high temperature, respectively. While rice farmers in the northeastern areas faced with the drought, pest and disease outbreaks. Most of the rice farmers in these two regions has done flooding protection management such as building road ridge or earthen dyke and changing croping schedule by growing faster than the previous schedule or using shortern-growing rice variety.

Based on the results of the logit models, the most important and significant determinants of taking flooding protection activities are the ability to deal with flooding, location of rice farm, the expected number of flooding in the future, rice land size, and rice income share, respectively. The result of the impact of ability to deal with flooding on the probability of taking RPA was the same as the study result of Takasaki et al. (2002),Samal and Pandey (2005), and Hung et al. (2007) and the expected number of flooding in the future provided the same answer of the study of Sebstad and Cohen (2000). The positive impact of rice income share on the probability to take RPA can be convinced by the study of Dercon (2000)and Tongruksawattanaet al. (2010)which implied that the more income from rice production, the less likely to take high risk and the more likely to take RPA.
These findings confirm our research expectation and also confirm that the rice farmers in central area or in flood-prone area are more likely to take RPA than those farmers in the northeast or in non flood-prone area due to the fact that flood occurred almost every year in the flood-prone area, they have to use shorten-growing rice variety or changing their cropping calendar to harvest before the flood occurred, usually in September of the year

Recommendations

Strengthening the risk awareness and promoting RPA to rice farmers in northeastern region or non flood prone areas are necessary. In addition, the results of the study found that the small-scale farmers are less likely to take RPA. Therefore, the government should support small-scale farmers, particularly in the northeastern region with relatively low rice income share, by providing the support of credits and knowledge, including providing basic risk management manual or try to solidate the small-scale farmers to be big plantation and support them with the community risk management project.

7. Limitation of the Study and Direction for Future Research

Due to the limitation of the study that focuses on the risk management decision in response to flood, future research should explore factors affecting risk management decision in response to other perils such as drought.

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