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Transforming Agricultural System under Socio-economic Change, Climate Change and Ecosystem Change

Hiroataka Matsuda¹⁾, Yuka Ogata²⁾, Akira Takagi³⁾ and Hisashi Kurokura⁴⁾

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2) Niigata Prefectural Government Inland Fisheries Experimental Station

3) Ministry of Education, Culture, Sports, Science and Technology; MEXT

4) Graduate School of Agriculture and Life sciences, The University of Tokyo

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I . Introduction

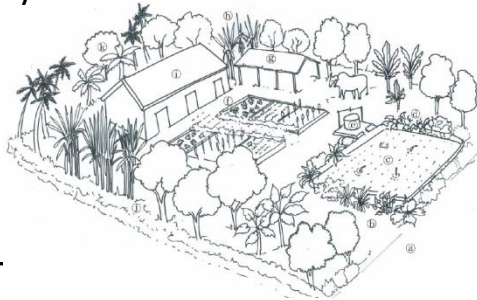
- **Definition of Resilience**

- Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker et al (2004)).

- **Strategy of farmers in developing country**

- Combining traditional system with modern system
 - VAC system in Vietnam: Vuon-Ao-Choung (VAC) system, which is garden–pond–livestock pen in the Red River delta and the midlands of northern Vietnam

VAC system in Vietnam

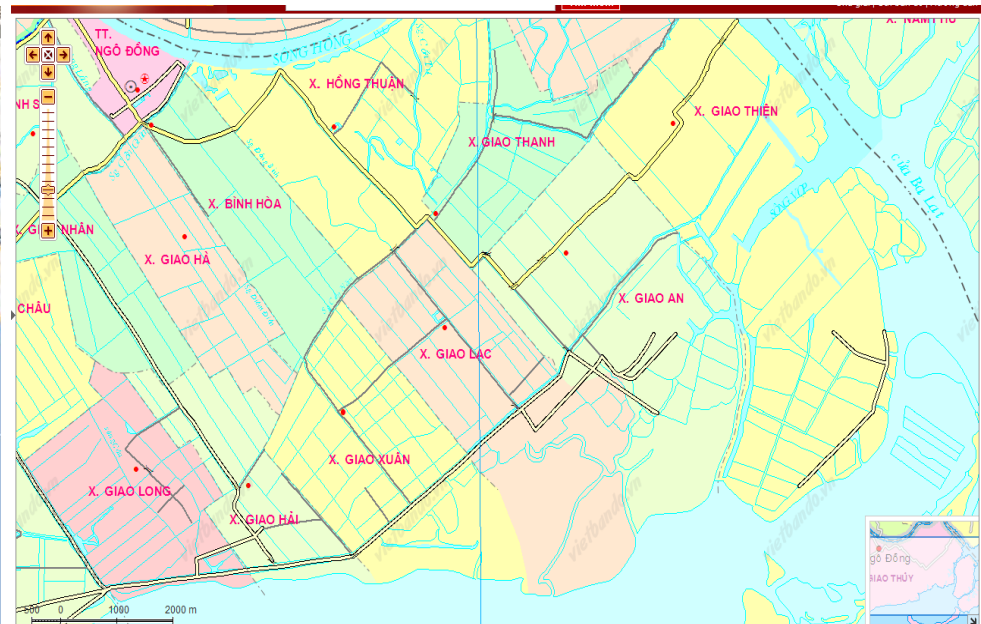


- Currently, structure of the combination has been changed in order to respond to introducing market economy.
- It is difficult to adopt risks including climate change and loss of economical benefit because of loss of those diversity.

- study investigates behaviors of farmers who are much vulnerable in developing countries to enhance their resilience to respond to Socio-economic change, Climate change and Ecosystem change.

II. Agriculture in Research Area, Vietnam

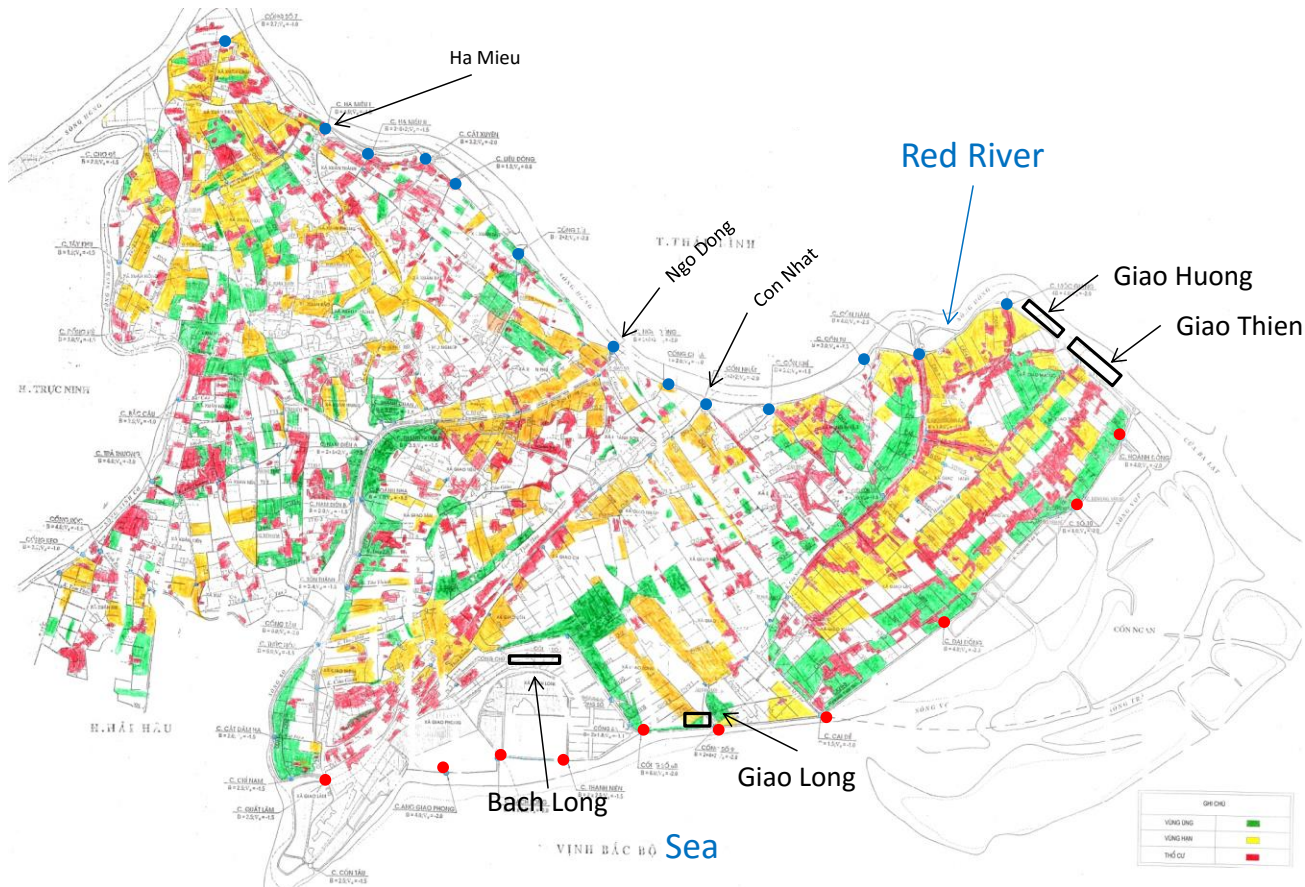
- Research Area



	Duration	Sample
Giao Long	03-22 Dec, 2012	149
Giao Xuan	14-21 Jan, 2013	151
Giao Thie	22-29 Jan, s013	150

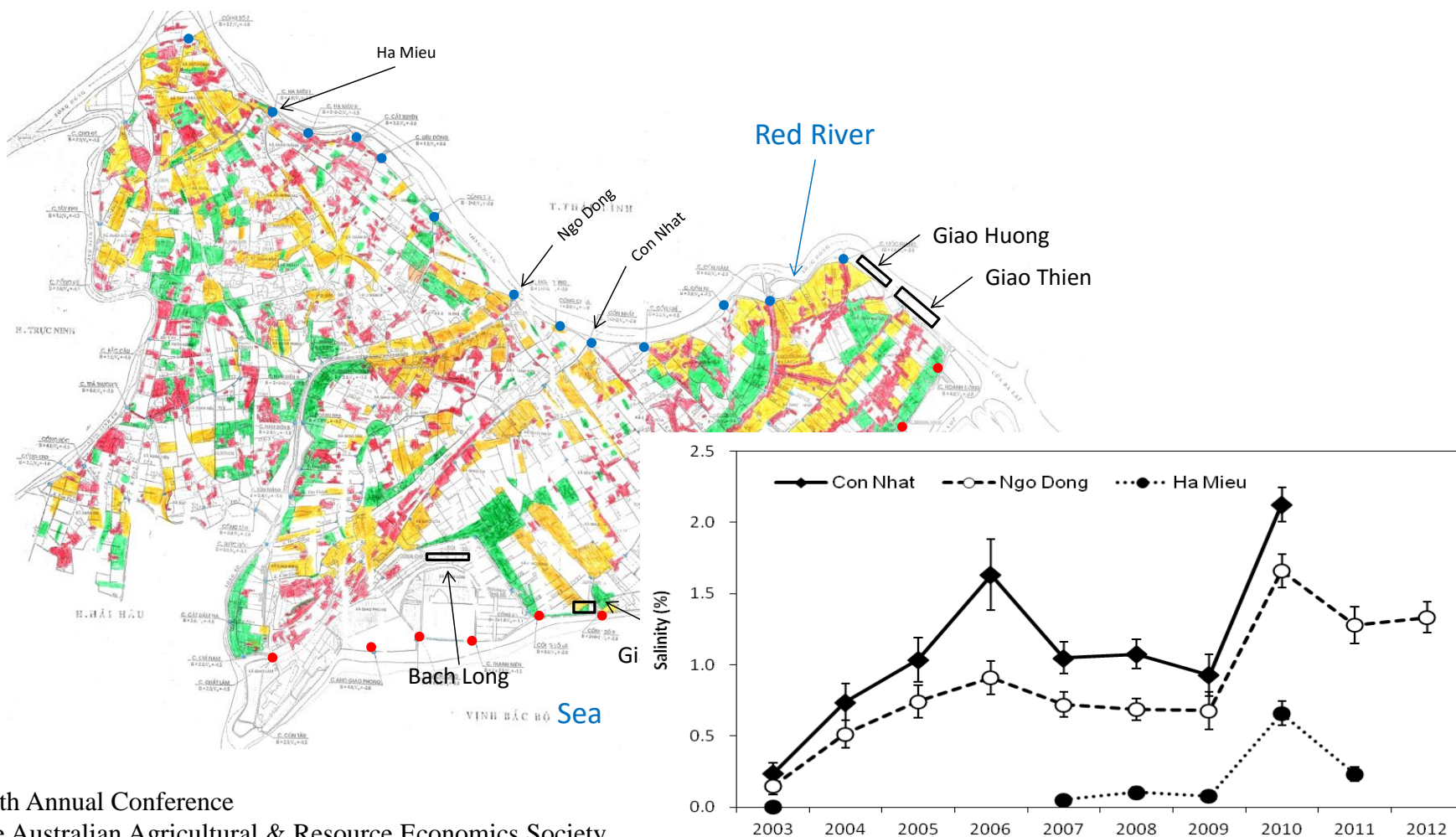
Impact of climate change for Agriculture

- salinity intrusion



Impact of climate change for Agriculture

- salinity intrusion



Trend of Paddy Yield in Research Area



Question for capturing risk behaviour

- **Q. If you were to choose a business with different returns, which one of the following would you choose?**

- Game 1. Initial investment cost is: 2000 VND
- Game 2. Initial investment cost is: 10000 VND

Payoff for Investment Game 1 & 2

Business Type	1	2	3	4	5
Fail	100,000	80,000	60,000	40,000	0
Succeed	100,000	240,000	300,000	320,000	6,000,000

- Game 3. Initial investment cost is: 20000 VND
- Game 4. Initial investment cost is: 200000 VND

Payoff for Investment Game 3 & 4

Business Type	1	2	3	4	5
Fail	200,000	160,000	100,000	40,000	0
Succeed	200,000	340,000	500,000	680,000	1,000,000

Question for capturing risk behaviour

- Q. If you were to choose a business with different returns, which one of the following would you choose?

- Game 1. Initial investment cost is: 2000 VND
- Game 2. Initial investment cost is: 10000 VND

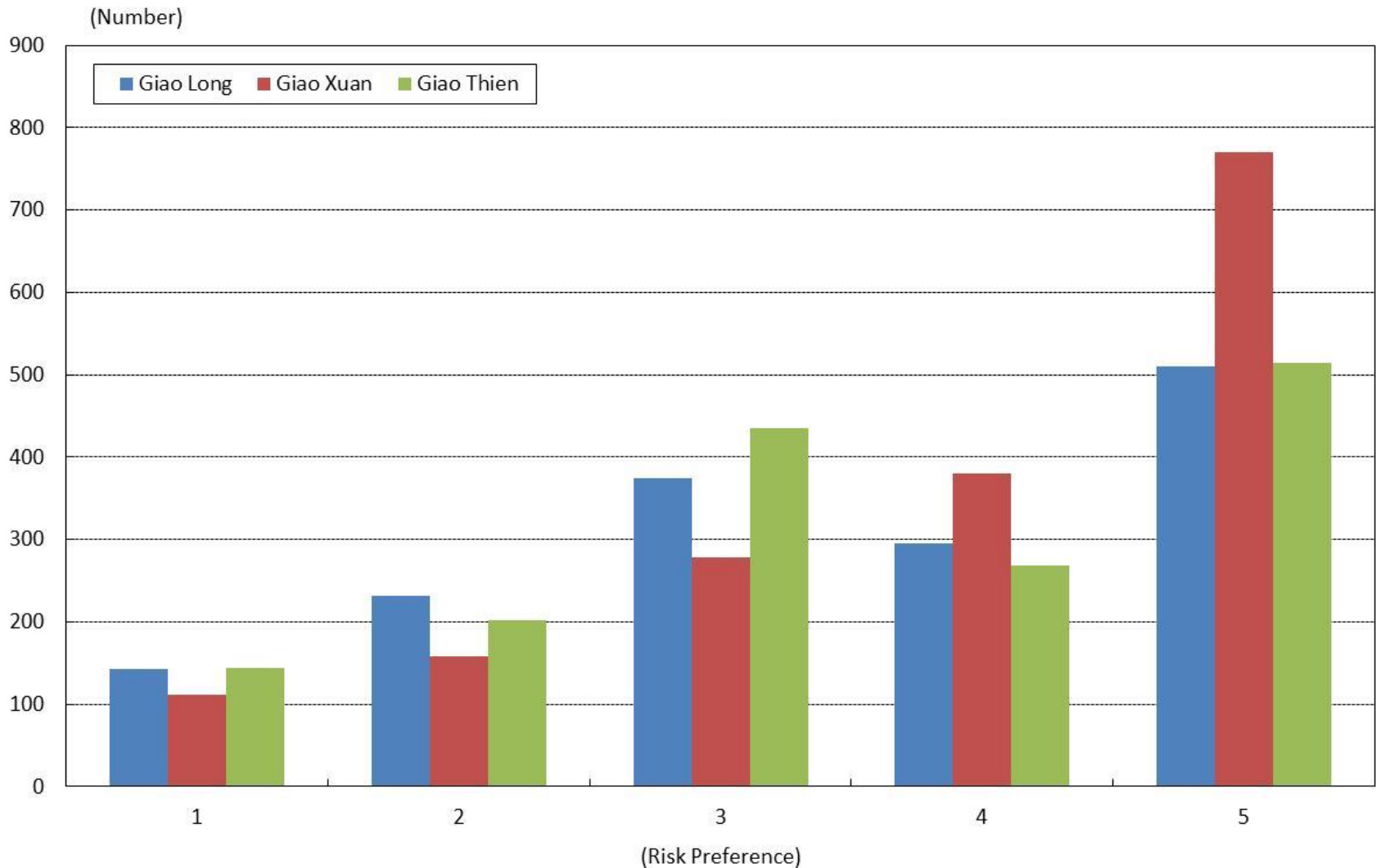
- 1: Extreme Risk Averter
 - 2: Severe Risk Averter
 - 3: Moderate Risk Averter
 - 4: Inefficient Risk Averter
 - 5: Risk neutral or lover
- Expected payoff of 4 is same with 3. However, variance is larger.

Business Type	1	2	3
Fail	100,000	80,000	60,000
Succeed	100,000	240,000	300,000

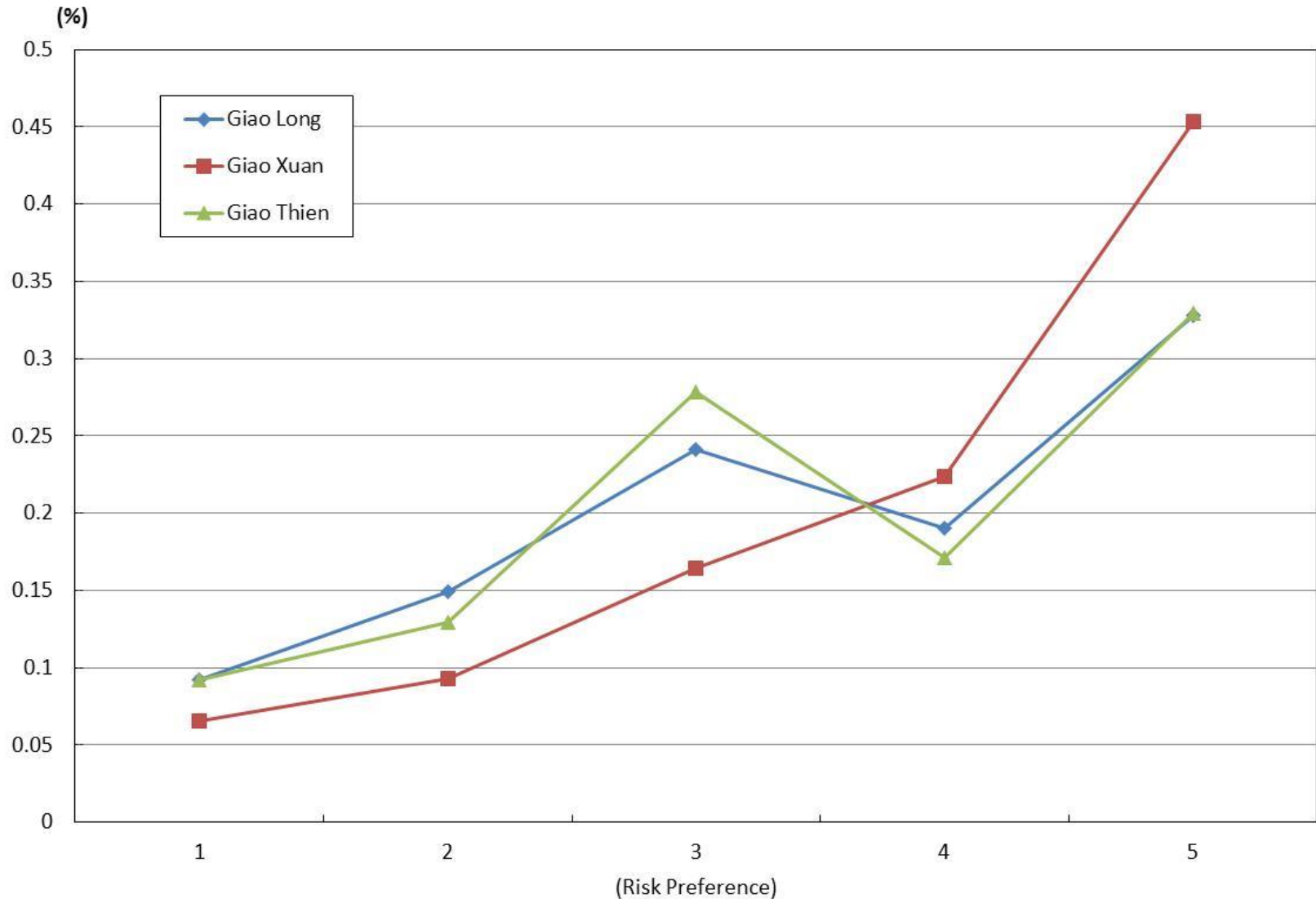
- Game 3 In case of fail: 80,000 VND is received
- Game 4 In case of success: 240,000 VND is received

Business Type	1	2	3	4	5
Fail	200,000	160,000	100,000	40,000	0
Succeed	200,000	340,000	500,000	680,000	1,000,000

Distribution of risk preference of farmers



Distribution of risk preference of farmers



III. Estimation of Risk preference, Animal Feeding and Production change

• Estimation of Risk Behaviour

$$y_i^* = \beta' X_i + \varepsilon_i \quad \text{with} \quad \beta' (\beta_1, \beta_2, \dots, \beta_K)$$

y_i^* : respondent's propensity to choose a specific alternative in the Game

X_i : K-vector of known constants, includes all of household i's characteristics

$\varepsilon_i \sim (0, \sigma^2)$ iid, mean 0 and variance σ^2

- The ordered probit model is hired to estimate
- For the jth probability, the marginal effects of change in the independent variables:

$$\frac{\partial P_r(y_i = s_j)}{\partial X_K} = \left[\phi \left(\frac{\mu_{j-1} - \beta' X_i}{\sigma} \right) - \phi \left(\frac{\mu_j - \beta' X_i}{\sigma} \right) \right] \frac{\beta_K}{\sigma}$$

$\phi(\cdot)$: the normal density function

X_K : Kth independent variable

Estimation of Animal Feeding and Responding to production change

- **Animal feeding**

$$\text{Prob}(y_i = j) = \frac{\exp(\boldsymbol{\beta}'_j \mathbf{x}_i)}{\sum_{k=0}^J \exp(\boldsymbol{\beta}'_k \mathbf{x}_i)} \quad \text{for } j = 0, 1, \dots, J$$

- **Responding to production change of rice**

$$\Delta y = X\boldsymbol{\beta} + \boldsymbol{\varepsilon}$$

$$\boldsymbol{\beta} = (\beta_1, \beta_2, \dots, \beta_k) \quad \Delta \mathbf{y} = (\Delta y_1, \dots, \Delta y_n)^T$$

$$X = \begin{pmatrix} x_i \\ \vdots \\ x_n \end{pmatrix} = \begin{pmatrix} 1 & x_{11} & \dots & x_{1k} \\ \vdots & \vdots & & \vdots \\ 1 & x_{n1} & \dots & x_{nk} \end{pmatrix} \quad \boldsymbol{\varepsilon} = (\varepsilon_1, \dots, \varepsilon_n)^T$$

Δy : reducing amount of rice yield

X_i : K-vector of known constants, includes all of household i's characteristics

$\varepsilon_i \sim (0, \sigma^2)$ iid, mean 0 and variance σ^2

MCMC for Estimation of responding to production change

$$p(\mathbf{y}|\beta, \tau) \sim N\left(X\beta, \frac{1}{\tau}I\right)$$

$$\tau = 1/\sigma^2, \quad e/v = \sum_{i=1}^n e_i^2/v, \quad \hat{\sigma}^2 = S = e \quad df: v = n - k$$

- Conjugate prior distribution of parameter β and τ

$$p(\beta|\tau) \sim N(b_0, (1/\tau)B_0)$$

$$p(\tau|\mathbf{y}) \sim G\left(v_0/2, v_0S_0/2\right)$$

- Posterior distributions follow normal distribution and Gamma distribution, respectively

$$p(\beta|\tau, \mathbf{y}) \sim N(b_1, B_1)$$

$$p(\tau|\beta, \mathbf{y}) \sim G\left(v_1/2, v_1S_1/2\right)$$

$$v_1 = v_0 + v, \quad v_1S_1 = v_0S_0 + (\mathbf{y} - Xb_1)^T(\mathbf{y} - X\beta)$$

$$b_1 = B_1(B_0^{-1}b_0 + \tau X^T \mathbf{y}), \quad B_1^{-1} = B_0^{-1} + \tau B$$

- b_0, B_0, v_0, S_0 can be defined arbitrary.

- $b_0=0, B_0=0.001, v_0=0.001, S_0=0.001, \text{burn in}=1000$

IV. Estimation Results : Risk Behaviour

Variable ID		Game 1	Game 2	Game 3	Game 4
<i>age</i>	<i>Age of respondent</i>	-0.01 (-1.57)	-0.01 (-1.64)	-0.01 * (-1.91)	-0.01 * (-1.71)
<i>sex</i>	<i>1 if respondent is female</i>	0.34 * (1.83)	0.27 (1.45)	0.30 (1.61)	0.22 (1.18)
<i>edu</i>	<i>year of education</i>	0.10 ** (2.81)	0.06 * (1.80)	0.07 ** (2.12)	0.06 (1.65)
<i>native</i>	<i>1 if respondent born in the village</i>	0.38 * (1.72)	0.44 ** (1.97)	0.49 ** (2.13)	0.47 * (2.01)
<i>house_area</i>	<i>Area of household</i>	-0.07 (-1.22)	-0.09 (-1.54)	-0.07 (-1.20)	-0.08 ** (-1.26)
<i>paddy_area</i>	<i>Area of paddy field</i>	0.06 * (1.81)	0.09 *** (2.74)	0.05 * (1.77)	0.07 (2.37)
<i>network</i>	<i>Numer of accuitance to ask about farming (maximu number is five)</i>	-0.12 ** (-2.07)	-0.13 ** (-2.27)	-0.17 *** (-2.92)	-0.20 *** (-3.36)
<i>variety_animal</i>	<i>variety of animalsiin the household</i>	-0.04 (-0.46)	-0.11 (-1.17)	-0.13 (-1.37)	-0.11 (-1.12)
<i>d_gt</i>	<i>1 if Gio Thien</i>	0.32 (1.50)	0.33 (1.55)	0.33 (1.53)	0.36 (1.61)
<i>d_gx</i>	<i>1 if GioXien</i>	0.46 * (1.77)	0.60 ** (2.33)	0.68 *** (2.57)	0.77 (2.83)
<i>Log likelihood</i>		29.73	30.4	33.4	33.7
<i>Psudo R2</i>		0.06	0.06	0.07	0.07
<i>Observation</i>		194	194	194	194

Absolute value of z-statistics in parentheses.

* significant at 10% level; ** significant at 5% level; *** significant at 1% level.

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Absolute value of z-statistics in parentheses.

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Estimation Results: Animal Feeding

	<i>Area</i>	<i>Education</i>	<i>Risk</i>	<i>Network</i>
<i>Pig</i>			+	
<i>Chicken</i>				
<i>Duck</i>				
<i>Pig+Chi</i>	<i>Xuan (-)</i>			
<i>Pig+Duc</i>		+		
<i>Pig+Oth</i>				
<i>Chi+Duc</i>	<i>Xuan (-)</i>		-	+
<i>Chi+Oth</i>	<i>Thien (-)</i>	-		
<i>Pig+Chi+Duc</i>	<i>Xuan (-)</i>	-		
<i>Pig+Chi+Duc+ Oth</i>				

Estimation Results: Animal Feeding

	<i>Area</i>	<i>Education</i>	<i>Risk</i>	<i>Network</i>
<i>Pig</i>			+	
<i>Chicken</i>				
<i>Duck</i>				
<i>Pig+Chi</i>	Xuan (-)			
<i>Pig+Duc</i>		+		
<i>Pig+Oth</i>				
<i>Chi+Duc</i>	Xuan (-)		-	+
<i>Chi+Oth</i>	Thien (-)	-		
<i>Pig+Chi+Duc</i>	Xuan (-)	-		
<i>Pig+Chi+Duc+Oth</i>				

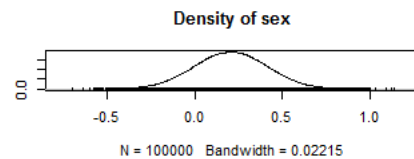
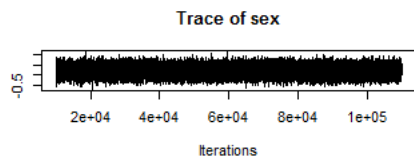
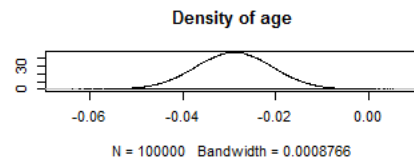
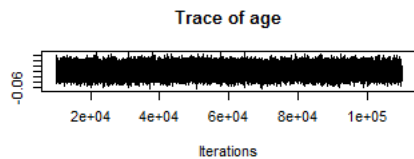
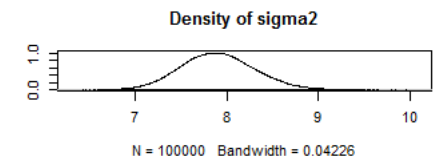
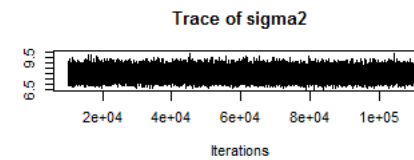
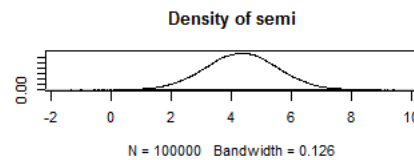
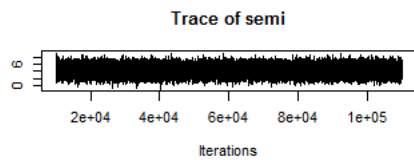
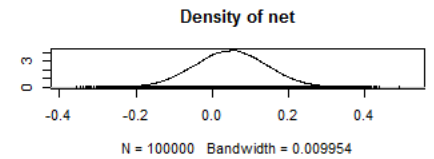
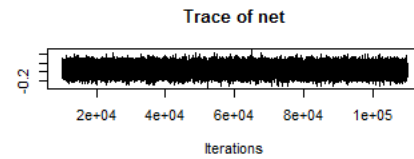
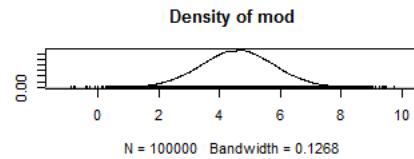
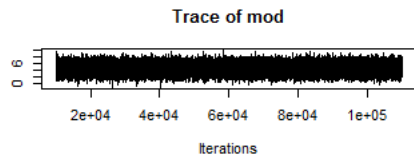
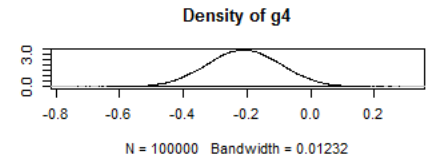
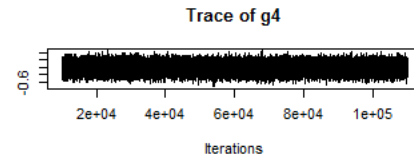
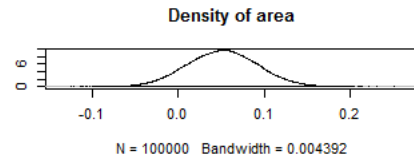
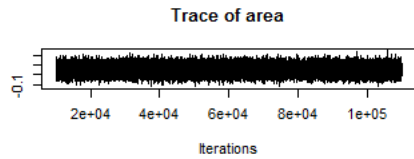
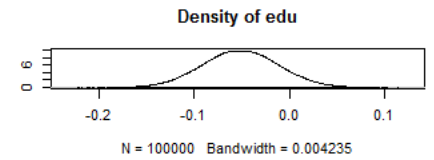
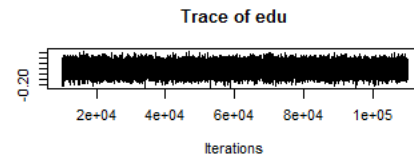
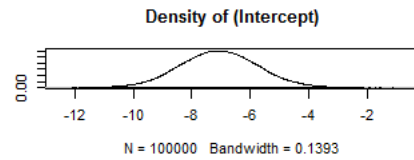
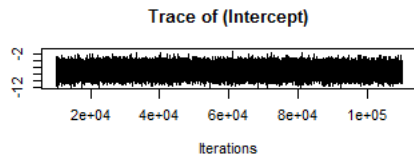
- Risk lover choose pig.

- Risk averter choose chicken and duck.

Estimation Results : Production Change (1)

		Mean	SD	2.5%	25%	50%	75%	97.5%
<i>(Intercept)</i>		-7.070	1.314	-9.638	-7.958	-17.074	-6.189	-4.468
<i>paddy_area</i>	<i>Area of paddy field</i>	0.051	0.041	-0.030	0.023	0.051	0.079	0.133
<i>Modern Irrigation</i>	<i>1 if modern irrigation system is used</i>	4.589	1.196	2.236	3.786	4.594	5.395	6.923
<i>Semi-Modern Irrigati</i>	<i>1 if semi-modern irrigation system is used</i>	4.339	1.189	2.001	3.540	4.343	5.139	6.654
<i>age</i>	<i>Age of respondent</i>	-0.029	0.008	-0.045	-0.035	-0.029	-0.023	-0.013
<i>sex</i>	<i>1 if respondent is female</i>	0.206	0.209	-0.205	0.066	0.206	0.348	0.616
<i>edu</i>	<i>year of education</i>	-0.052	0.040	-0.130	-0.079	-0.052	-0.025	0.027
<i>5 in the Game</i>	<i>Choosing 5 in the Game; Risk neutral or lover</i>	-0.210	0.116	-0.437	-0.289	-0.210	-0.132	0.016
<i>network</i>	<i>Numer of accuitance to ask about farming (maximu number is five)</i>	0.048	0.094	-0.136	-0.015	0.048	0.111	0.231
<i>sigma2</i>		7.906	0.399	7.163	7.632	7.894	8.166	8.725
<i>1 in the Game</i>	<i>Choosing 1 in the Game; Extreme Risk Averter</i>	-0.195	0.114	-0.417	-0.271	-0.195	-0.118	0.027
<i>2 in the Game</i>	<i>Choosing 2 in the Game; Severe Risk Averter</i>	-0.204	0.110	-0.419	-0.278	-0.204	-0.130	0.009
<i>3 or 4 in the Game</i>	<i>Choosing 3 or 4 in the Game; Moderate Risk Averter</i>	-0.219	0.115	-0.443	-0.297	-0.220	-0.142	0.004

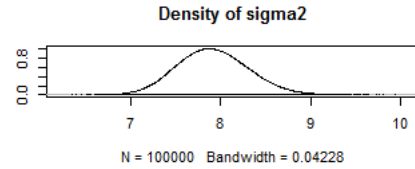
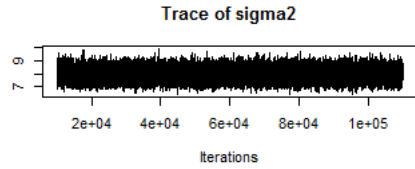
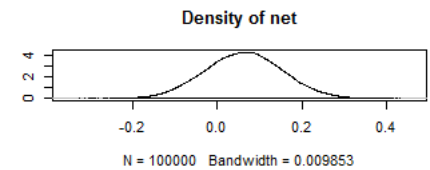
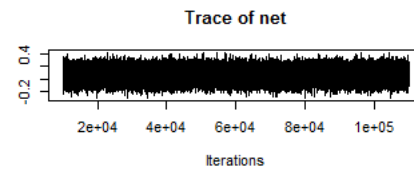
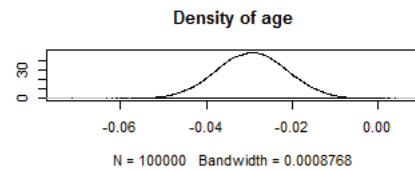
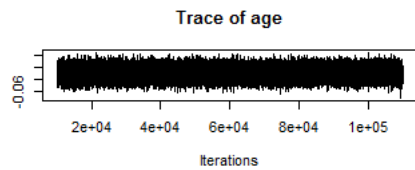
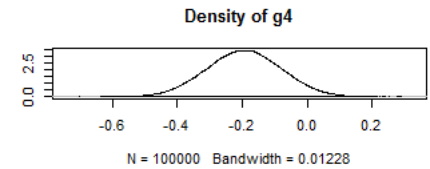
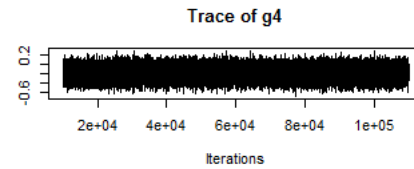
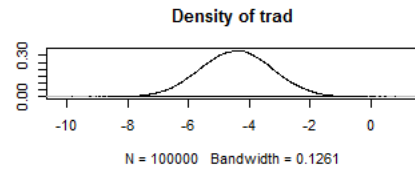
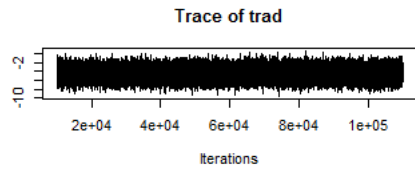
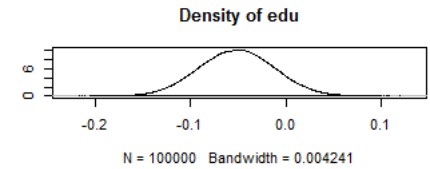
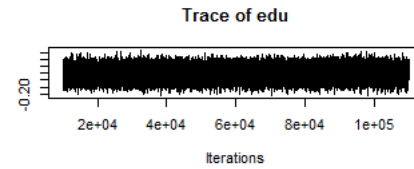
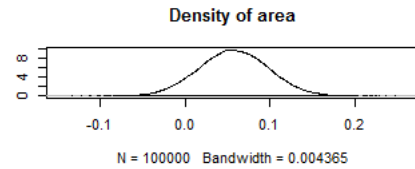
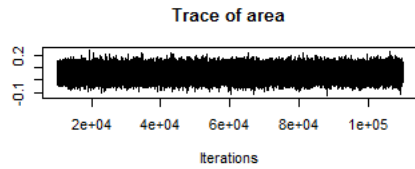
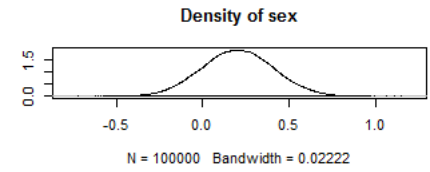
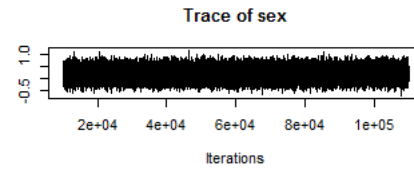
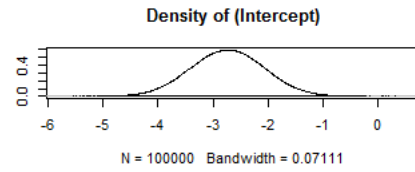
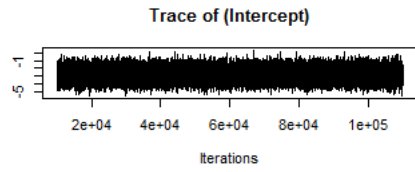
		Mean	SD	2.5%	25%	50%	75%	97.5%
<i>(Intercept)</i>		-7.070	1.314	-9.638	-7.958	-17.074	-6.189	-4.468
<i>paddy_area</i>	<i>Area of paddy field</i>	0.051	0.041	-0.030	0.023	0.051	0.079	0.133
<i>Modern Irrigation</i>	<i>1 if modern irrigation system is used</i>	4.589	1.196	2.236	3.786	4.594	5.395	6.923
<i>Semi-Modern Irrigation</i>	<i>1 if semi-modern irrigation system is used</i>	4.339	1.189	2.001	3.540	4.343	5.139	6.654
<i>age</i>	<i>Age of respondent</i>	-0.029	0.008	-0.045	-0.035	-0.029	-0.023	-0.013
<i>sex</i>	<i>1 if respondent is female</i>	0.206	0.209	-0.205	0.066	0.206	0.348	0.616
<i>edu</i>	<i>year of education</i>	-0.052	0.040	-0.130	-0.079	-0.052	-0.025	0.027
<i>5 in the Game</i>	<i>Choosing 5 in the Game; Risk neutral or lover</i>	-0.210	0.116	-0.437	-0.289	-0.210	-0.132	0.016
<i>network</i>	<i>Numer of accuitance to ask about farming (maximu number is five)</i>	0.048	0.094	-0.136	-0.015	0.048	0.111	0.231
<i>sigma2</i>		7.906	0.399	7.163	7.632	7.894	8.166	8.725
<i>1 in the Game</i>	<i>Choosing 1 in the Game; Extreme Risk Averter</i>	-0.195	0.114	-0.417	-0.271	-0.195	-0.118	0.027
<i>2 in the Game</i>	<i>Choosing 2 in the Game; Severe Risk Averter</i>	-0.204	0.110	-0.419	-0.278	-0.204	-0.130	0.009
<i>3 or 4 in the Game</i>	<i>Choosing 3 or 4 in the Game; Moderate Risk Averter</i>	-0.219	0.115	-0.443	-0.297	-0.220	-0.142	0.004



Estimation Results : Production Change (2)

		Mean	SD	2.5%	25%	50%	75%
<i>(Intercept)</i>		-2.734	0.671	-4.047	-3.186	-2.733	-2.281
<i>paddy_area</i>	<i>Area of paddy field</i>	0.057	0.041	-0.023	0.029	0.057	0.085
<i>Traditional Irrigation 1</i>	<i>if traditional irrigation system is used</i>	-4.430	1.189	-6.764	-5.233	-4.426	-3.627
<i>age</i>	<i>Age of respondent</i>	-0.029	0.008	-0.046	-0.035	-0.029	-0.024
<i>sex</i>	<i>1 if respondent is female</i>	0.201	0.210	-0.207	0.061	0.201	0.343
<i>edu</i>	<i>year of education</i>	-0.052	0.040	-0.130	-0.079	-0.051	-0.025
<i>5 in the Game</i>	<i>Choosing 5 in the Game; Risk neutral or lover</i>	-0.194	0.116	-0.421	-0.272	-0.195	-0.116
<i>network</i>	<i>Numer of accuitance to ask about farming (maximu number is five)</i>	0.062	0.093	-0.119	-0.001	0.062	0.125
<i>sigma2</i>		7.913	0.399	7.169	7.638	7.899	8.173
<i>1 in the Game</i>	<i>Choosing 1 in the Game; Extreme Risk Averter</i>	-0.184	0.114	-0.407	-0.260	-0.184	-0.107
<i>2 in the Game</i>	<i>Choosing 2 in the Game; Severe Risk Averter</i>	-0.193	0.110	-0.408	-0.266	-0.193	-0.119
<i>3 or 4 in the Game</i>	<i>Choosing 3 or 4 in the Game; Moderate Risk Averter</i>	-0.206	0.114	-0.430	-0.283	-0.206	-0.129

		Mean	SD	2.5%	25%	50%	75%
<i>(Intercept)</i>		-2.734	0.671	-4.047	-3.186	-2.733	-2.281
<i>paddy_area</i>	<i>Area of paddy field</i>	0.057	0.041	-0.023	0.029	0.057	0.085
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<i>age</i>	<i>Age of respondent</i>	-0.029	0.008	-0.046	-0.035	-0.029	-0.024
<i>sex</i>	<i>1 if respondent is female</i>	0.201	0.210	-0.207	0.061	0.201	0.343
<i>edu</i>	<i>year of education</i>	-0.052	0.040	-0.130	-0.079	-0.051	-0.025
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<i>2 in the Game</i>	<i>Choosing 2 in the Game; Severe Risk Averter</i>	-0.193	0.110	-0.408	-0.266	-0.193	-0.119
<i>3 or 4 in the Game</i>	<i>Choosing 3 or 4 in the Game; Moderate Risk Averter</i>	-0.206	0.114	-0.430	-0.283	-0.206	-0.129



V. Summary

- Rather risk lover prefer to feed large animal, pig, which is more difficult to feed. Rather risk averter prefer to feed smaller animals such as chicken.
- Moderate Risk Averter is able to respond to reducing of paddy yield because of natural disaster.
- Impact of network are not found logically.
- Although, perhaps, person who should be targeted to respond to agricultural production variation can be defined in terms of risk behavior, diffusing those strategy among community is difficult because social network is not so tied in the community.
- Strategies including diffusion process to combine agricultural production, animal feeding and aquaculture have to be established based on empirical results.