Journal of Rural Development 35(2): 53~72

AN ANALYSIS ON DETERMINANTS OF FARMERS' ADAPTATION TO CLIMATE CHANGE IN KOREA

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Keywords
climate change, adaptation measures, farmers, agriculture, multinomial logit model

Abstract
The purpose of this study is to analyze the determinants affecting Korean farmers' choice of adaptation measures to climate change using multinomial logit model. The major findings of this study are summarized as follows. First, the results indicate that 70.7 percent of farmers have adapted to climate change and 29.3 percent of farmers have not adapted to climate change. Second, the results show that farmers prefer changing the varieties and the seed/harvest time in order to adapt to climate change. Third, the findings also indicate that experience, cultivated area, successor to farming, use of computer and Internet, number of farmer organizations, farm household income, extensional education, and use of smartphone have a significant impact on adaptation to climate change.

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I. Introduction

Policy response to climate change can be divided into mitigation and adaptation. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects to moderate harm or exploit beneficial opportunities (IPCC, 2001). Adaptation has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts. Climate change adaptation as well as climate change mitigation are necessary tools in dealing with climate change.

Agriculture is extremely vulnerable to climate change. Climate change is expected to negatively affect agricultural production. Actually, the agricultural cultivation area has been extended northward, and the damage by blight and harmful insects during the winter has increased, resulting in the decrease in agricultural productivity (Kim et al. 2008).

Therefore, proper adaptation measures in agricultural sector are required to minimize negative impacts of climate change. Adaptation to climate change involves changes in agricultural management practices in response to changes in climate conditions. It often involves a combination of various individual responses at the farm level and assumes that farmers have access to alternative practices and technologies available in the region (Nhemachena and Hassan, 2007).

To adapt to climate change at the farm level, the decision-making of farmers is important. Farmers' responses to climate change or their choice of adaptation methods is dictated by a host of socioeconomic and environmental factors. The knowledge of these socioeconomic and environmental factors assists policy to strengthen adaptation through investing on these factors (Deressa et al. 2009). Therefore, it is necessary to examine farmers' adaptation to climate change. Also, it is necessary to analyze the determinants affecting adaptation to climate change of farmers.

Therefore, the purpose of this study is to analyze the determinants affecting farmers' choice of adaptation measures to climate change using multinomial logit model. This study is based on a survey from farmers in Korea. The remainder of the paper is structured as follows. The next section presents the review of previous studies on adaptation to climate change in agriculture. Section 3 describes the empirical model and data. Section 4 presents the empirical results. Section 5 concludes with a summary of results and policy implications.

II. Literature Review

Recent literature on the analysis of farmers' adaptation to climate change include Nhemachena and Hassan (2007), Maddison (2007), Hassan and Nhemachena (2008), Bryan et al. (2009), Deressa et al. (2009), Gbetibouo (2009), Kurukulasuriya and Mendelsohn (2007), Seo and Mendelsohn (2008), Seo et al. (2010), Seo (2010), Hisali et al. (2011), Di Falco and Veronesi(2011), Kim et al. (2008), and Kim et al. (2009).

Nhemachena and Hassan (2007) examine the determinants of farm-level adaptation strategies to climate change in Southern Africa using a multivariate probit model. Results show that access to credit and extension and awareness of climate change are some of the important determinants of farm-level adaptation. An important policy message from these results is that enhanced access to credit, information (climatic and agronomic) as well as to markets (input and output) can significantly increase farm-level adaptation.

Maddison (2007) examines the perception of and adaptation to climate change of farmers in 11 African countries. Using Heckman's sample selectivity probit model, econometric investigation reveals that although experienced farmers are more likely to perceive climate change, it is educated farmers who are more likely to respond by making at least one adaptation. Farmers who have enjoyed free extension advice and who are situated close to the market where they sell their produce are also more likely to adapt to climate change.

Hassan and Nhemachena (2008) examine determinants of farm-level climate adaptation measures in Africa using a multinomial choice model. The results indicate that better access to markets, extension and credit services, technology and farm assets (labor, land and capital) are critical for helping African farmers adapt to climate change.

A study of farmers in Ethiopia and South Africa by Bryan et al. (2009) indicates that the most common adaptation strategies include use of different crops or crop varieties, planting trees, soil conservation, changing planting dates, and irrigation. Results from a probit model indicate that farmers across both countries were more likely to adapt if they had access to extension, credit, and land.

Deressa et al. (2009) show that 58 percent of farmers in the Nile Basin of Ethiopia have adapted to climate change. Results from the multinomial logit model indicate that the level of education, gender, age, and wealth of the head of household, access to extension and credit, information on climate, social capital, agroecological settings, and temperature influence farmers' choices.

Gbetibouo (2009) examines the determinants of adaptation to climate change and variability using Heckman probit and multinomial logit models. He finds that only approximately 30 percent of farmers in the Limpopo river basin of South Africa have adjusted their farming practices to account for the impacts of climate change. The results highlight that household size, wealth, farm size, farming experience, perception of soil fertility, extension, access to credit, off-farm activities, property rights, high temperature, and low rainfall are the factors that enhance adaptive capacity to climate change.

Above this, Kurukulasuriya and Mendelsohn (2007) examine whether the choice of crops is affected by climate in Africa. Seo and Mendelsohn (2008) explores how South American farmers adapt to climate by changing crops. Seo and Mendelsohn (2008) estimate a multinomial logit model of farmers' choice of livestock species in Africa. Seo et al. (2010) examine how South American farmers' choices of livestock species vary across the range of climate. Seo (2010) examines whether an integrated farm that owns both crops and livestock is more resilient under global warming than a specialized farm in crops. Hisali et al. (2011) examine adaptation strategies and factors governing their choice in Uganda's agricultural production using the multinomial logit model. Di Falco and Veronesi(2011) investigate the impact of climate change adaptation on farm households' downside risk exposure in the Nile Basin of Ethiopia.

In Korean studies, Kim et al. (2008) indicate that the farmers in Korea have generally recognized climate change for 5 years and have seriously worried about its negative impacts. The results also indicate that the farmers didn't prepare a specific countermeasure to climate change.

Also, Kim et al. (2009) find that farmers' awareness of climate change appeared to be high (about 75.4 percent) and they felt unusual changes in weather and an increase in diseases and harmful insects. The survey results also showed that farmers had a keen interest in the countermeasures to climate change. They showed a high willingness to participate in the adaptation plan at the farmhouse level in the future, but there were bottlenecks such as lack of techniques and knowledge, insufficient information, and shortage of labor. But these studies in Korea present an important limitation since there are no studies on the determinants affecting adaptation to climate change of farmers in Korea.

III. Model and Data

1. Model

This study uses a multinomial logit (MNL) model[1] to analyze the determinants of farmers' choice of adaptation measures in Korea. This method has now been used to analyze farmer adaptation decisions (Hassan and Nhemachena, 2008; Gbetibouo, 2009; Deressa et al. 2009; Hisali et al. 2011). Also, this method has been used to analyze crop and livestock choices as methods to adapt to the negative impacts of climate change (Kurukulasuriya and Mendelsohn, 2007; Seo and Mendelsohn, 2008; Seo et al. 2010) and to analyze portfolio diversification in African agriculture (Seo, 2010).

The probability that farmer i will choose adaptation measure j among the set of adaptation measures follows the logistic distribution.

$$\mathrm{Pr}ob(Y_i = J|x_i) = \frac{e^{x_i{}' \beta_j}}{1 + \sum_{k=1}^{J} e^{x_i{}' \beta_k}}, \quad j = 1, 2, \ldots, J \tag{1}$$

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[1] The logit model for binary outcomes extends to the case where the unordered response has more than two outcomes. Examples of unordered multinomial responses include occupational choice, choice of health plan, and transportation mode for commuting to work. In each case, an individual chooses one alternative from the group of choices, and the labeling of the choices is arbitrary(Wooldridge, 2002). The MNL model compares any given outcome with a reference outcome and permits the analysis of decisions across more than two outcomes. The advantage of the MNL model is its computational simplicity in calculating the choice probabilities that are expressible in analytical form (Tse, 1987). The model provides a convenient closed form for underlying choice probabilities, with no need for multivariate integration, making it simple to compute choice situations characterized by many alternatives.

where x denotes the set of explanatory variables that influence the choice of the adaptation measure, j denotes adaptation measures, and β is parameter to be estimated.

The empirical model for farmers' adaptation to climate change is as follows:

$$\begin{aligned}\Pr ob\, j = {} & \beta_o + \beta_1 \mathrm{exp}erience + \beta_2 area + \beta_3 successor + \beta_4 computer \\ & + \beta_5 farmer\, \mathrm{or}ganizations + \beta_6 income \\ & + \beta_7 extensional\, education + \beta_8 smartphone\end{aligned} \tag{2}$$

In equation (2), we hypothesize that experience, area, successor to farming, use of computer and Internet, number of farmer organizations, farm household income, extensional education, and use of smartphone have a significant impact on farmers' choice of adaptation measures to climate change. Explanatory variables included in this study are mainly based on the review of studies on farmers' adaptation to climate change and we will continue this later.

2. Data

This study is based on a survey of data from farm households in Korea. A questionnaire developed in this study is based on the review of studies on farmers' adaptation to climate change (Gbetibouo, 2009; Deressa et al. 2009; Kim et al. 2008; Kim et al. 2009). The questionnaire includes questions on farmers' perception of and their adaptation to climate change and farmers' socioeconomic characteristics.

Farm-level data was collected from 1,000 farm households in Korea during the period between August and November 2011. The formats of the survey were face-to-face and via e-mail. The sample was allocated in proportion to farm population by province. There are a variety of crops, such as rice, fruit, vegetables, flowers and so on. A total of 1,000 respondents participated, a total of 832 of which was used in the analysis after some questionnaires were removed due to a lack of credibility.

Summary statistics of farmers' socioeconomic characteristics are provided in Table 1. The average farming experience of respondents is 21.4 years. The average cultivated area is 2.29 hectares. 22 percent of the respondents have a successor to farming. Most of the respondents (71.6 percent) use computer and internet. The average number of farmer organizations is 2.33. The average yearly farm household income is 30 million won - 39.99 million won. With regard to number of annual extensional education, 72.1 percent are 1~5 number. 30.9 percent of the respondents use smartphone.

TABLE 1. Summary statistics of farmers' socioeconomic characteristics

	Minimum Value	Maximum Value	Mean	Standard Deviation
Experience (Years)	2	55	21.40	12.63
Area (Hectares)	0.02	10.92	2.29	1.99
Successor to farming (No=0, Yes=1)	0	1	0.22	0.41
Use of computer and Internet (No=0, Yes=1)	0	1	0.72	0.45
Number of farmer organizations (Number)	0	9	2.33	1.39
Farm household income*	1	8	4.57	2.34
Extensional education**	1	4	2.39	0.69
Use of smartphone (No=0, Yes=1)	0	1	0.31	0.46

* Under 9.99 mil.won = 1; 10 mil.won ~ 19.99 mil.won = 2;
20 mil.won ~ 29.99 mil.won = 3; 30 mil.won ~ 39.99 mil.won = 4;
40 mil.won ~ 49.99 mil.won = 5; 50 mil.won ~ 59.99 mil.won = 6;
60 mil.won ~ 69.99 mil.won = 7; Above 70 mil.won = 8

** 0 number = 1, 1~5 number = 2, 6~10 number = 3, Above 11 number = 4

Farmers' perception of climate change due to global warming is presented in Table 2. Most of the respondents (94.4 percent) have perceived climate change and 5.6 percent have not perceived climate change. Therefore, farmers' perception of climate change appears to be high.

TABLE 2. Farmers' perception of climate change

	Number of respondents (Persons)	Percent of respondents (Percent)
Yes	785	94.4
No	47	5.6
Total	832	100.0

Farmers' adaptation to climate change is presented in Table 3. 70.7 percent of farmers have adapted to climate change and 29.3 percent of farmers have not adapted to climate change.

TABLE 3. Farmers' adaptation to climate change

	Number of respondents (Persons)	Percent of respondents (Percent)
Yes	588	70.7
No	244	29.3
Total	832	100.0

Farmers' adaptation measures against climate change are presented in Table 4. 15.5 percent of farmers chose to change “varieties”, 14.4 percent to change “seed/harvest time”, 9.3 percent to change “cultivation crops”, and 9.1 percent to control “the use of agricultural chemicals and/or fertilizers”. These results indicate that farmers prefer changing the varieties and the seed/harvest time in order to adapt to climate change.

TABLE 4. Farmers' adaptation measures to climate change

	Number of respondents (Persons)	Percent of respondents (Percent)
Variety change	129	15.5
Seed time/harvest time change	120	14.4
Controlled use of agricultural chemicals/fertilizers	76	9.1
Crop disaster insurance	66	7.9
Cultivation crop change	77	9.3
Crop diversification	62	7.5
Other	58	7.0
No adaptation	244	29.3
Total	832	100.0

Ⅳ. Empirical Results

1. Empirical specifications of model variables

The dependent variable in the empirical estimation for this study is the choice of adaptation measures listed in Table 4. In this analysis, “no adaptation” is used as the base category.

The explanatory variables for this study include: experience, area, successor to farming, use of computer and Internet, number of farmer organizations, farm household income, extensional education, and use of smartphone. The descriptions of the explanatory variables used for empirical estimation are provided in Table 5.

TABLE 5. Description of independent variables

Variable	Description
Experience	Number of years of farming experience (Years)
Area	Cultivated area (Hectares)
Successor to farming	If farm household has successor to farming (No=0, Yes=1)
Use of computer and Internet	If farmer uses computer and Internet (No=0, Yes=1)
Number of farmer organizations	Number of farmer organizations that farmer joined as a member (Number)
Farm household income	Yearly farm household income (Under 9.99 mil.won = 1; 10 mil.won ~ 19.99 mil.won = 2; 20 mil.won ~ 29.99 mil.won = 3; 30 mil.won ~ 39.99 mil.won = 4; 40 mil.won ~ 49.99 mil.won = 5; 50 mil.won ~ 59.99 mil.won = 6; 60 mil.won ~ 69.99 mil.won = 7; Above 70 mil.won = 8)
Extensional education	Number of annual extensional education (0 number = 1, 1~5 number = 2, 6~10 number = 3, Above 11 number = 4)
Use of smartphone	If farmer uses smartphone (No=0, Yes=1)

Hypotheses on how the explanatory variables influence adaptation to climate change are presented below.

Farming experience is an important factor affecting adaptation to climate change of farmers. Various studies have shown that farming experience is significantly and positively related to farmers' adaptation to climate change (Gbetibouo, 2009; Nhemachena and Hassan, 2007; Hassan and Nhemachena, 2008). Farming experience increases the probability of uptake of all adaptation options because experienced farmers have better knowledge and information on changes in climatic conditions and crop and livestock management practices (Nhemachena and Hassan, 2007). This study hypothesizes that farming experience will positively influence farmers' decisions to take up adaptation measures.

With regard to cultivated area, households with a larger area of land were more likely to adapt (Bryan et al. 2009). Farm size positively and significantly leads to an increase in the likelihood of adapting to climate change and large-scale farmers are more likely to adapt because they have more capital and resources (Gbetibouo, 2009). We expect that farm households with a larger area of land are more likely to adapt to climate change.

Existence of successor to farming is whether or not farmer has farming successors in farm household. Farm households with farming successors have sustainability and foundation of farm management and can play a major role in response to climate change. Therefore, we expect that existence of successor to farming also will influence farmers' adaptation to climate change.

A study of farmers in South America by Seo and Mendelsohn (2008) included a dummy variable for computer as an explanatory variable. Their results indicate that farms with computers are more likely to choose potatoes and rice to adapt to climate change, but the results are not statistically significant. Farmers who use computer and Internet have excellent ability in collecting information about farm management than farmers who don't use them. Therefore, farmers who use computer and Internet can get various information about climate change quickly than farmers who don't use them. This study hypothesizes that use of computer and Internet will positively influence farmers' adaptation to climate change.

The number of farmer organizations that farmer joined as a member represents social capital. Informal institutions and private social networks play three distinct roles in adoption of agricultural technologies (Hogest, 2005, recited in Deressa et al. 2009). First, they act as conduits for financial transfers that may relax the farmer's credit constraints. Second, they act as conduits for information about new technology. Third, social networks can facilitate cooperation to overcome collective action dilemmas, where the adoption of technologies involves externalities. Deressa et al. (2009) show that social capital which was represented by farmer-to-farmers extension and the number of relatives in local area affects adaptation to climate change positively. Therefore, this study hypothesizes that number of farmer organizations will positively influence farmers' adaptation to climate change.

Also, this study hypothesizes that farm household income will positively influence farmers' adaptation to climate change. Deressa et al. (2009) indicate that farm income of the households has a positive and significant impact on conserving soil, using different crop varieties, and changing planting dates. Gbetibouo (2009) indicate that wealthier households are more willing to adapt by changing their planting dates, using irrigation, and changing the amount of land. Nhemachena and Hassan (2007) find that income per cap and private property positively influence farmers' decisions to take up adaptation measures.

Various studies have shown that extensional education is significantly and positively related to farmers' adaptation to climate change (Nhemachena and Hassan, 2007; Hassan and Nhemachena, 2008; Gbetibouo, 2009; Bryan et al. 2009; Deressa et al. 2009). Gbetibouo (2009) find that extension has a positive and significant impact on portfolio diversification. We expect that extensional education will positively influence farmers' adaptation to climate change.

In recent years, smartphone has quickly become popular and farmers are no exception. Farmers use smartphone to check weather, monitor pesticides, and get information about climate change. Therefore, we include a dummy variable for smartphone as an explanatory variable and expect that farmers with smartphone are more likely to adapt to climate change.[2]

2. Estimation results and discussions

Results from the multinomial logit model of the determinants affecting adaptation to climate change are presented in Table 6.[3] The chi-square results show

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[2] The results of survey show that use of smartphone is closely related to farmers' adaptation to climate change. Results from the cross-tabulation indicate that 77.8 percent of farmers using smartphone have adapted to climate change. It means that farmers using smartphone respond to climate change more actively. The farmers can get more useful information of weather, pesticides, and farming techniques, due to using smartphone application for adapting to climate change.

[3] We used the Hausman test to check for the validity of the IIA assumption, using STATA software. The results from the Hausman test indicate that we fail to reject

that likelihood ratio statistics are highly significant, suggesting the model has a strong explanatory power.

The coefficient on farming experience is significant and positively related to several adaptation measures to climate change. Farming experience increases the probability of changing variety and seed time/harvest time, controlling use of agricultural chemicals/fertilizers, and changing cultivation crop. This result implies that experienced farmers are more likely to adapt to climate change. Experienced farmers have high skills in farming management and techniques. Therefore, they are able to cope with difficulties when facing climate change.

The coefficient on cultivated area is significant and positively related to two adaptation measures to climate change. Cultivated area increases the probability of changing seed time/harvest time and choosing crop disaster insurance as an adaptation measure. This result implies that farm households with a larger area of land are more likely to adapt to climate change. Large farm sizes allow farmers to diversify their crop options and help spread the risks of loss associated with changes in climate. Indeed, large-scale farmers are more likely to adapt because they have more capital and resources. Therefore, they can easily invest in irrigation technologies, which demand high investment costs. A previous study also shows that the cultivated area is an important factor in taking out crop disaster insurance, and farm households with a larger area of land prefer taking out crop disaster insurance (Ji and Kim, 2010).

The coefficient on existence of farming successors is significant and positively related to two adaptation measures to climate change. Existence of farming successors increases the probability of changing variety and cultivation crop. This result implies that farm households with farming successors are more likely to adapt to climate change. As mentioned earlier, farm households with farming successors have sustainability and foundation of farm management and can play a major role in response to climate change. Also, nurturing farming

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the null hypothesis of independence of the adaptation measures under consideration. The results implied that the application of the MNL specification to model the determinants of adaptation measures was justified. We tested the model for multicollinearity using the variance inflation factor (VIF). The variance inflation factors of all variables are less than 10 (1.04 - 1.90), which indicate that multicollinearity is not a serious problem in this model.

successors is necessary for the future of Korean agriculture.

The coefficient on use of computer and Internet is significant and positively related to two adaptation measures. Use of computer and Internet increases the probability of controlling the use of agricultural chemicals/fertilizers, and using other adaptation measures. This result implies that farmers using computer and Internet are more likely to adapt to climate change. During the interview, a farmer answered that he gets information about climate change on television at first and then use the Internet to know specific information about climate change.

The coefficient on number of farmer organizations that a farmer has joined as a member is significant and positively related to other adaptation measures. Farmers are more likely to take up other adaptation measures by joining a farmer organization, working as a member, and interacting with other farmers. But number of farmer organizations is statistically significant on using other adaptation measures only.

The coefficient on farm household income is significant and negatively related to changes in cultivation crop. It can be inferred that farmers with lower income try to adopt a new cultivation crop more easily than plant an existing crop.

The coefficient on extensional education is significant and positively related to several adaptation measures. Extensional education increases the probability of changing variety and seed time/harvest time, controlling use of agricultural chemicals/fertilizers, changing cultivation crop, and using crop diversification and other adaptation measures. This result implies that farmers with extensional education are more likely to adapt to climate change. Therefore, extensional education is an important factor affecting adaptation to climate change of farmers.

The coefficient on use of smartphone is significant and positively related to three adaptation measures. Use of smartphone increases the probability of changing variety and cultivation crop, and using crop diversification. This result implies that farmers using smartphone are more likely to change variety and cultivation crop because of their characteristics that push for changes and introduce a new equipment more easily.

TABLE 6. Results of the multinomial logit adaptation model

Variable	Variety change	Seed time/ harvest time change	Controlled use of agricultural chemicals/ fertilizers	Crop disaster insurance	Cultivation crop change	Crop diversification	Other
	Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)	Coeff. (P-value)
Experience	0.0187* (0.079)	0.0331*** (0.002)	0.0239* (0.058)	0.0104 (0.430)	0.0319*** (0.010)	0.0217 (0.116)	0.0171 (0.229)
Area	0.0660 (0.283)	0.1276** (0.032)	0.0133 (0.860)	0.1402** (0.049)	-0.0603 (0.472)	0.0525 (0.514)	-0.1173 (0.238)
Successor to farming	0.7379*** (0.005)	0.3186 (0.260)	0.0073 (0.983)	-0.0627 (0.868)	0.6442** (0.039)	0.1912 (0.593)	-0.6272 (0.162)
Use of computer and Internet	-0.3408 (0.226)	0.3418 (0.226)	0.6429* (0.066)	0.1858 (0.582)	-0.1167 (0.734)	-0.3195 (0.385)	1.0133** (0.028)
Number of farmer organizations	0.1077 (0.211)	0.0942 (0.283)	-0.0004 (0.997)	0.0896 (0.406)	-0.0162 (0.882)	-0.0457 (0.697)	0.2781*** (0.009)
Farm household income	0.0290 (0.588)	-0.0650 (0.230)	0.0998 (0.105)	0.0386 (0.552)	-0.1133* (0.088)	0.0065 (0.925)	-0.0174 (0.802)
Extensional education	0.3629** (0.049)	0.4802*** (0.010)	0.4706** (0.026)	0.2488 (0.303)	0.3854* (0.077)	0.5270** (0.019)	0.7791*** (0.000)
Use of smartphone	1.0520*** (0.000)	0.4253 (0.121)	-0.4541 (0.199)	-0.5555 (0.159)	1.4392*** (0.000)	1.1392*** (0.001)	0.0988 (0.779)
Constant	-2.7022*** (0.000)	-3.2046*** (0.000)	-3.6481*** (0.000)	-2.8246*** (0.000)	-2.6631*** (0.000)	-3.3048*** (0.000)	-4.7925*** (0.000)
Base category	No adaptation						
Number of observations	832						
LR chi-square	162.27***						
Log likelihood	-1538.8554						
Pseudo-R^2	0.0801						

Note: ***, **, and * indicate significance at the 1%, 5% and 10% level.

Table 7 presents the estimated marginal effects from the multinomial logit model. This compares the choice of adaptation to climate change with no adaptation where the marginal effects and their signs reflect the expected change in probability of preferring to adapt climate change to no adaptation (the base) per unit change in an explanatory variable.

Experience increases the probability of adapting to climate change. As can be seen in Table 7, experience significantly increases seed time/harvest time change as an adaptation method. A unit increase in number of years of experience would result in a 0.26% increase in the probability of seed time/harvest time change. Moreover, most of the marginal values of education are positive across all adaptation options, indicating the positive relationship between experience and adaptation to climate change.

Farm area has a positive and significant impact on seed time/harvest time change and crop disaster insurance. For instance, a unit increases in farm area results in a 0.83% increase in the probability of crop disaster insurance.

The results indicate that successors to farming households adapt more readily to climate change. Successors to farming households were 9.20% more likely to variety change.

Use of computer and Internet increases the likelihood of using controlled use of agricultural chemicals and fertilizers by 4.59%. It appears to decrease the likelihood of variety change by 6.97%.

The farm income of households surveyed has a positive and significant impact on controlled use of agricultural chemicals and fertilizers. A unit increase in farm income increases the probability by 0.94%. Conversely, the results of this analysis reconfirm that decreasing farm income significantly increases the likelihood of cultivation crop change.

Use of smartphone has a significant and positive impact on the likelihood of variety change, cultivation crop change and crop diversification. It appears to decrease the likelihood of crop disaster insurance by 6.41%.

TABLE 7. Marginal effects from the multinomial logit climate change adaptation model.

	Variety change	Seed time/ harvest time change	Controlled use of agricultural chemicals/ fertilizers	Crop disaster insurance	Cultivation crop change	Crop diversification	Other
Experience	0.0004	0.0026**	0.0007	-0.0005	0.0013	0.0004	0.00005
Area	0.0050	0.0142**	-0.0019	0.0083*	-0.0081	0.0014	-0.0088*
Successor to farming	0.0920***	0.0139	-0.0186	-0.0208	0.0403	-0.0028	-0.0400***
Use of computer and Internet	-0.0697*	0.0387	0.0459**	0.0088	-0.0165	-0.0321	0.0459***
Number of farmer organizations	0.0091	0.0068	-0.0045	0.0031	-0.0057	-0.0073	0.0133***
Farm household income	0.0051	-0.0093	0.0094**	0.0033	-0.0095**	0.0008	-0.0008
Extensional education	0.0082	0.0257	0.0145	-0.0048	0.0064	0.0165	0.0273***
Use of smartphone	0.1050***	-0.0020	-0.0676***	-0.0641***	0.1046***	0.0599**	-0.0179

Note: ***, **, and * indicate significance at the 1%, 5% and 10% level.

V. Summary and Conclusion

Climate change is expected to negatively affect agricultural production. Proper adaptation measures in agricultural sector are required to minimize negative impacts of climate change. To adapt to climate change at farm level, farmers' decision-making is important. Farmers' responses to climate change or their choice of adaptation methods is dictated by a host of socioeconomic and environmental factors (Deressa et al. 2009). It is necessary to analyze the determinants affecting adaptation to climate change of farmers.

The purpose of this study was to analyze the determinants affecting Korean farmers' choice of adaptation measures to climate change using multinomial logit model.

The major findings of this study are summarized as follows. First, the results indicate that 70.7 percent of farmers have adapted to climate change and 29.3 percent of farmers have not adapted to climate change. Second, the results show that farmers prefer changing the varieties and the seed/harvest time in order to adapt to climate change. Third, the findings also indicate that experience, cultivated area, successor to farming, use of computer and Internet, number of farmer organizations, farm household income, extensional education, and use of smartphone have a significant impact on adaptation to climate change. Finally, the marginal effects from the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, were presented for their ease of interpretation.

This study provides several policy implications for countermeasures to climate change in the agricultural sector.

First, proper education and training programs about climate change should be developed for the farmers. Examples of these education and training programs include education about cultivation techniques for new varieties and cultivation crops, public relation about crop disaster insurance, and education about technologies to prevent new blight, pest, and weeds.

Second, policies need to support nurturing of farming successors actively. Results show that farm households with farming successors are more likely to adapt to climate change. Farm households with farming successors can play a major role in response to climate change. Also, nurturing farming successors is necessary for the future of Korean agriculture.

Third, policies need to emphasize the crucial role of information on climate change. Farmers who have access to climate information on equipment such as computer and smartphone will have better chances to adapt to change in climatic conditions. Reliable, prompt information on the climate will help farmers to adapt to climate change.

Fourth, policies need to strengthen farmers' activity in farmer organizations as a social capital. Policies which encourage informal social networks can promote group discussions and better information flows and enhance adaptation to climate change.

Fifth, the results of the empirical analyses confirmed that variety change and seed time/harvest time change were affected by experience, area, successor to farming, extensional education, and use of smartphone. Consequently, policies aiming to promote adaptation to climate change need to emphasize the crucial role of providing extensional education to enable farmers adapt to climate change

Finally, the results from the marginal analysis indicate that household characteristics such as experience, farm area, successor to farming, use of computer and Internet, and use of smartphone which could be enhanced through policy intervention have significant impact on adaptation to climate change. Thus, investment in education systems, sufficient input supply which increases farm income and use of information in the rural areas can be underlined as a policy option in the reduction of the negative impacts of climate change.

One important limitation of this study is that it lumps all crops into one category. Different crop types are affected differently by climate change, hence the need for further disaggregation. While this disaggregated selection of crop types was beyond the scope of this study, given the broad scale of the analysis, it will be necessary as a second step to conduct more crop type-specific analyses as farm-level adaptation is conditioned by local circumstances and the specifics of the available agricultural options.

Acknowledgements

This work was supported by Ministry of Education, Culture, Sports, Science and Technology in Japan. It is part of a larger study on Strategies Research Foundation Program (MEXT strategic promotion for private schools to establish research frameworks. Research project for the sustainable development of economic and social structure dependent on the environment in eastern Asia). And this work was also supported by the Human Resources Development of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korean Ministry of Knowledge Economy (No. 20094010200010).

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Date Submitted: Apr. 2, 2012
Period of Review: Apr. 16～Jun. 19, 2012