

Determinants of Farmers' Decisions to Adopt Adaptation Technologies in Eastern Uganda

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Abstract

Using the Heckman sample selectivity model, this study identified farmers' perception and adaptation to climate variability in Eastern Uganda, in order to support development of public policy and investment that can help increase adaptation to climate variability. The study was based on the premise that farmers who perceive change in climate and respond (or fail respond) share some common characteristics, which are important in understanding the reasons underlying their response (or failure to respond). Stratified random sampling was used to obtain a sample of 353 households across the three agro-ecological zones in Eastern Uganda, from which data was collected. In addition, 9 focus group discussions and 23 Key Informants Interviews were conducted, targeting smallholder farmers and agricultural stakeholders in the region. Results indicate that farmers' decisions to adopt adaptation technologies are primarily determined by their perceptions of rainfall adequacy (subjective index). The probability of adoption of adaptation technologies by male headed households and those with more members showed a 12% and 23% higher chance of adaptation respectively as compared to their counterparts. These factors relate to labour endowment, implying the need to build strong social protection mechanisms at household and community levels. The probability of responding to climate variability also varied by location with a 15% and 6% smaller chance for location in Mbale and Sironko respectively as compared to Pallisa. Access to weather information is the single most important factor affecting farmers' perceptions of climate variability, implying the need to develop and dissemination appropriate weather information to guide farmers in making adaptation decisions.

Key words: Adaptation, Climate Variability, Eastern Uganda

1. Introduction

The agricultural sector in sub-Saharan African (SSA) continues to be confronted with multiple shocks and crises, threatening the endowment of the sector and impeding efforts at attaining the millennium development goals (MDGs), and core Comprehensive African Agriculture Development Programme (CAADP) pillars (Chuku and Okoye, 2009; WDR, 2009). An extensive literature has been developed on the impacts of climate change and variability on agriculture in Africa, with the earliest focusing primarily on the vulnerability of the sector (for example Mendelsohn *et al*., 1996; Kurukulasuriya *et al.*, 2006; Seo and Mendelsohn, 2006; Kurukulasuriya and Mendelsohn, 2008). In Uganda, climate variability has been reported as having a significant impact on rural livelihoods, with many parts of the country especially in the North and North East experiencing significant increases in hunger and malnutrition (Apuuli *et al*., 2000; GOU, 2009; James, 2010).

The general message from this literature is that the degree of vulnerability of the agricultural sector to climate variability and change is contingent on a wide range of local environmental and management factors: biological conditions such as soil content, type of crop, extent of knowledge and awareness of expected changes in climate, type and objectives of the management regimes prevalent in agriculture, the extent of support from government and other agencies, and the ability of key stakeholders to undertake the necessary remedial steps to address climate concerns (Kurukurasuriya and Rosental, 2003).

Based on this background, this paper focused on answering the following three questions in the context of Eastern Uganda: How do farmers perceive climate variability and change? What response mechanisms do they employ to adapt to the perceived climate variability? What factors determine farmers' decisions to adopt adaptation mechanisms? This study is based on the premise that adaptation to climate change requires that farmers using traditional techniques of agricultural production first notice that the climate has altered, then identify potentially useful adaptations and implement them. Further, recent studies suggest the need to focus on adaptation research that seeks to investigate actual adaptations at the farm level, as well as the factors that appear to be driving them (Maddison, 2006). Better understanding of this is essential for designing incentives to enhance adaptation, as well as supporting development of public policy and investment that can help increase the adoption of adaptation measures.

2. Materials and Methods

2.1 Study area and sampling procedure

The study was carried out in Eastern Uganda. The region comprises 32 districts in three distinct agro-ecological zones (AEZs) – Lake Victoria Crescent, South East Lake Kyoga and Mount Elgon agro-ecologies respectively (Wortmann and Eledu, 1999). The AEZs are largely determined by the amount of rainfall, which drives the agricultural potential and farming systems and range from sub-humid to semi-arid (GRID, 1987). They also capture variability in altitude, soil productivity, cropping systems, livestock systems, and land use intensity. Stratified random sampling was used for the study where the AEZs formed the study strata. Using random sampling technique, one district was selected from each of the AEZs, nine sub counties selected (three per district), and one village per sub-county from which respondents were drawn. Sample size was obtained using coefficient of variation method (Nassiuma, 2000). Three hundred and fifty three household (HH) surveys, nine focus group discussions (FGDs), and 23 key informant interviews (KIIs) were conducted (Table 1).

Table 1: Study area and sample size

AEZ	Biophysical characeristics	Sampled district	Sampled HH (#)	# in FGDs	KIIs
Lake Victoria Crescent	Bimodal high rainfall >1,200 mm/year; banana, coffee farming system, mean altitude is 1174m.a.s.l., Petric Plinthosols (Acric) soils, and population density of 166.3/km^2 (431/sq mi)	Mbale	115	35	7
South East Lake Kyoga	Bimodal high rainfall >1,200 mm/year; Finger millet, banana, maize; Mean altitude is 1075m.a.s.l.; Gleysols soils; population density of 252/km^2 (650/sq mi)	Pallisa	132	36	8
Mount Elgon	Bimodal high rainfall (>1,200 mm/year); banana, potato, and vegetables; mean altitude of 1299 – 1524m.a.s.l.; Vertisols soils and population density of 770/km^2 (2,000/sq mi)	Sironko	106	33	8
		Total	**353**	**104**	**23**

Source: Based on Wortmann and Eledu (1999)

2.2 Model Specification

Analytical approaches that are commonly used in adoption decision studies involving multiple choices are the multinomial logit (MNL) and multinomial probit (MNP) models. Binary probit or logit models are employed when the number of choices available is two (whether to adopt or not). These models have been employed in climate change studies pertaining to the conceptual similarities in agricultural technology adoption and climate change. For example, Nhemachena and Hassan (2007) employed the multivariate probit model to analyse factors influencing the choice of climate change adaptation options in Southern Africa. Other studies that analyse such joint endogenous decisions include use of multinomial logit model for crop selection (Kurukulasuriya and Mendelsohn, 2006a), livestock choice (Seo and Mendelsohn, 2006), and adaptation strategies (Hassan and Nhemachena, 2008).

When decision process by farmers to adopt a new technology requires more than one step, models with two-step regressions are employed to correct for the selection bias generated during the decision making processes (Heckman, 1976). For instance William and Stan (2003) employed the Heckman's two- step procedure to analyse the factors affecting the awareness and adoption of new agricultural technologies in the United States of America. Other studies employing the same methodologies include; Kaliba *et al*. (2000), Maddison (2006), Kurukulasuriya and Mendelsohn (2006b), Yirga (2007), and Deressa *et al*. (2008).

This study used the Heckman's two- step probit model to analyse factors determining farmers' decision to adopt adaptation technologies. For model estimation, the first step involved analysis of perceptions of climate variability (selection model) and the second step is adoption of adaptation technologies, conditional on the first stage of perceived change in climate (outcome model). The probit model for sample selection assumes that there exists an underlying relationship between the selection and outcome models given by:

$$Y_1 = b'X + U_1$$
$$Y_2 = g'Z + U_2$$

Where, X is a k-vector of regressors, Z is an m-vector of repressors; the error terms U_1 and U_2 are jointly normally distributed, independently of X and Z with zero expectations. The independent variable Y_1 is only observed if $Y_2 > 0$. Thus the actual dependent variable is:

$$Y = Y_1 \text{ if } Y_2 > 0, Y \text{ is a missing value if } Y_2 \leq 0$$

The latent variable Y_2 itself is not observable, only its sign. $Y_2 > 0$, if Y is observable, and $Y_2 \leq 0$ if not. If the sample selection problem is ignored and Y regressed on X using the observed Y*'s* only, then the Ordinary Least Squares (OLS) estimator of b will be biased, because:

$$E[Y1|Y2 > 0, X,Z] = b'X + rsf(g'Z)/F(g'Z)$$

Where F is the cumulative distribution function of the standard normal distribution, f is the corresponding density, s^2 is the variance of U_1, and r is the correlation between U_1 and U_2. When $r \neq 0$, standard probit techniques yield biased results. Thus, the Heckman probit model provides consistent, asymptotically efficient estimates for all parameters in such models (StataCorp 2003).

2.3 Predicted impact of selected explanatory variables

The dependent variables analysed in this study are; adoption of adaptation technologies (Outcome model), and perception of climate variability (Selection Model). Table 2 shows the distribution of the model variables and predicted impact of explanatory variables on the outcome model. This study hypothesizes that male-headed households are more likely to take up adaptation methods as they have more access to resources and information as opposed to their female counterparts.

The effect of age is both positive and negative, because it's assumed that with age, farmers accumulate more knowledge and personal capital and, thus, show a greater likelihood of investing in innovations (Uaiene *et al.*, 2009), although it may also be that younger household heads are more flexible and hence likely to adopt new technologies, while older ones are less efficient to carry out demanding farm operations resulting in low technology adoption. Education and farming experience are predicted to have positive coefficients because it's expected that more educated farmers are better able to process information and search for appropriate technologies to alleviate their production constraints. Likewise, as one becomes more experienced in farming, it's highly likely that he/she will adopt new and improved technologies, based on the experience with previous technologies.

Non-farm income, farm size and livestock ownership are considered to represent wealth. It is regularly hypothesized that the adoption of agricultural technologies requires sufficient financial well- being (Knowler and Bradshaw, 2007). On this line of argument, other studies, which investigated the impact of income on adoption, revealed a positive correlation (Franzel, 1999). Farmers with bigger land holding size are assumed to have the ability to purchase improved technologies and the capacity to bear risks if the technology fails. Non-farm income, farm size and livestock ownership are hypothesized to increase adoption of adaptation technologies.

Table 2: Summary Statistic for Study Variables

Variable	Description	Mean	Std. Dev.	Predicted sign
Dependent variables				
Technology adoption (T_{AD})	Set of technological options employed by farmers to reduce climate-induced production risk. Dummy = 1 if farmer reported utilization of given technology	0.71	0.46	
Farmer perception of CV	Farmer has perceived climate change, measured by rainfall variability and adequacy (1=Yes, 0=No)	0.91	0.28	
Independent variables				
Gender	Gender of household head (1=Male, 0=Female)	0.84	0.36	+
Age	Age of the household head in years	44.93	14.89	+/-
Experience	Farming experience of the household head in years. Years of farming as the primary source of livelihood.	19.71	14.89	+
Education	Level of education of the household head measured on a scale where 1=none, 2=Primary, 3=Secondary, 4=Tertiary	2.14	1.13	+
Household size	Number of household members	7.05	3.75	+
Off farm income	Farmer has off farm income source (1 = Yes, 0=No)	0.52	0.50	-
Livestock	The number of cattle, sheep and goats owned by the Household (TLUs)*	0.90	0.06	+
Credit	Farmer has access to credit formal or informal (1=Yes, 0=No)	0.44	0.50	+
Farm size	Total farm size in hectares	1.06	0.94	+
Extension	Farmer has access to extension services (1=Yes, 0 = No)	0.39	0.49	+
Weather information	Farmer has access to weather forecast information (1=Yes, 0=No)	0.70	0.46	+
Input market	Distance to input market in km	4.81	4.19	+
Output market	Distance to output market in km	3.84	5.59	+
Rainfall index	Subjective index constructed from responses of a set of questions related to rainfall timeliness, amount and distribution (1 is the desired situation, and 0 otherwise)	0.19	0.11	+
Local agro-ecology	Local agro-ecology represented by the study districts. Dummy = 1 if Pallisa			+

*TLU: Total Livestock Unit; **conversion factors**: cattle (0.50), sheep and goats (0.10), pigs (0.20), and poultry (0.01). Source: FAO (2005); Chilonda and Otte (2006)
Source: Field data, 2011

Extension on crop and livestock production and information on climate represent access to the information required to make decisions on adaptation to climate variability. Thus, this study also hypothesizes that access to extension services and weather information increases chance of adopting adaptation technologies. Availability of credit eases the cash constraints and allows farmers to use purchased inputs such as fertilizer, improved crop varieties and irrigation facilities. Likewise, this study also hypothesizes that there is a positive relationship between availability of credit and adaptation. Distance to market is assumed to play an important role in technology adoption. The hypothesis here is that, the further away a village or a household is from input and output markets, the smaller is the likelihood that they will adopt new technology.

Rainfall variables were also included in the model. Detailed analysis of the relationships between climatic variables such as temperature and rainfall on adaptation requires a time series data of how farmers have behaved over time in response to changing climatic conditions (Maddison, 2006). As this type of data of farmers' response over time is not available, this study assumed that cross- sectional variations can proxy temporal variations. This study therefore relied on rainfall subjective index constructed from asking farmers a number of questions related to rainfall adequacy in the previous season. It is hypothesized that there is a positive relationship between adoption of adaptation technologies and perception of rainfall patterns.

For the selection model, it was hypothesized that, gender, age, farming experience, and education of head of household, access to weather information, and access to extension services, influence the awareness of farmers to climate variability and change. The argument on the likely impact of education, age of household head on perception is more or less similar to the case with technology adoption; in that they make farmers to access more information. Thus, the likely relationships follow the same as put in the outcome equation. The case of information on climate change from either extension agents or any other organization is self-explanatory in that it is meant to create awareness. A set of dummy variables describing the local AEZs (represented by study districts) were included in anticipation of climate variability and change being more pronounced in some AEZs than in others.

2.4 Data and measurement procedures

Data for this study were collected during August – September 2011. Primary data were collected on both the dependent and independent variables as described above using researcher adminstered questionnaires and interview guides. The study first established farmers perceptions of long term rainfall, and in particular its adequecy in the preceding agricultural season (August –November 2010, the base season for this study). The questions asked on rainfall adequacy included; whether rain came and stopped on time, whether there was enough rain at the beginning and during the growing season and whether it rained at harvest time. Secondly, information was obtained on farmers' response mechanisms, that is, what technological adaptations they had made in response to the perceived changes in climate. It was assumed that farmers will only make a decision to respond if they perceive any changes in the climate. Data were also obtained on other explanatory variables – use of purchased inputs, household socio-economic characteristics, access to weather information, credit, markets and extension as described above.

Answers to the questions on perception and adaptation were subsequently coded as binary variables. Perceptions of rainfall adequacy were coded either one for the preferred situation or zero otherwise, and an average obtained for the entire set of questions. Descriptive analysis of adaptation measures was done. Heckman's sample selectivity probit model was used to analyse the two step process of technology adoption. The model was first tested for fitness given the predicted variables using the Wald test. The chi-squared value generated by the Wald test was 179.82 with 16 degrees of freedom. The model indicated that the coefficients are not simultaneously equal to zero, thus the model variables statistically improved the fit of the model at $P \leq 0.05$.

3. Results

3.1 Farmers' perceptions of rainfall adequacy

The study revealed that over 90% of the farmers interviewed had perceived change in rainfall pattern, dating as far back as five to 10 years. Table 3 shows farmers' perceptions of rainfall adequacy. Only 19% of the respondents indicated that the rainfall situation in the reference season was desirable, with the majority indicating a non-desirable situation. From the focus group discussions, high variations in rainfall were noted for the major growing season – August to November/December, with very erratic and heavy rainfall. Farmers also noted increasing drying conditions especially for the March-May growing season. Farmers' generally reported late onset of rain, poor distribution within the season, and sometimes early cessation. Differences by district (representing AEZs) exist, with Pallisa and Sironko recording extremes of rainfall events. In Pallisa, respondents highlighted drought in the first season as an increasing problem, and more frequent flash floods as a result of increased rainfall intensity. In Sironko, increased rainfall intensity leading to increased ground water and water logging and landslides was reported.

Table 3: Farmers' perceptions of rainfall adequacy

During the main growing season of 2010	Percentage response (Yes = 1)			
	Mable	Pallisa	Sironko	Average
1. Rainfall came on time	26	10	13	16
2. There was enough rain at the beginning of the season	52	12	25	30
3. There was enough rain during the growing season	56	18	31	35
4. The rains stopped on time	23	7	18	16
5. It rained near the harvest time	2	88	4	31
6. The number of rainfall days changed	26	1	3	10
7. The frequency of heavy rains changed	30	1	1	11
8. The frequency of dry spells changed	7	0	1	3
9. The duration of the growing season changed	38	23	8	23
Average	29	18	12	19

Source: Field data, 2011

3.2 Farmers' response mechanisms

Study results indicated that at least 71% of the respondents employed one or more technologies or management practices in response to the perceived rainfall variability. The technologies were employed either singly or in combination.

Table 4: Proportion of Respondents using various Technologies by District

Adaptation choices	Percent of respondents using technology*			
	Mbale	Pallisa	Sironko	Total
Alter sowing dates	63	100	74	78
Change crop density	35	76	34	48
Change crop varieties	39	28	30	32
Intercropping	55	82	83	73
Mulching	13	30	50	30
Compost manure	36	50	55	47
Inorganic fertilizer	7	8	66	27
Cover crops	11	77	58	48
Crop rotation	6	94	29	43
Soil bunds	48	48	19	38
Terraces	14	16	26	19
Water ways	4	57	14	25
Grass strips	15	36	43	31
Agro-forestry	16	17	41	25

*Multiple responses possible

Source: Field data, 2011

Table 4 (above) shows the adaptation technologies employed by farmers in the study location. Majority of farmers generally changed sowing dates to coincide with onset of rain or planted as and when it rained. Other crop management practices employed include; changing crop density and varieties, and intercropping. Farmers changed crop varieties to include early maturing ones particularly maize, beans and ground nuts. In Sironko, farmers introduced non-traditional crops such as paddy rice and coco yam to cope with increased soil water and logging, while in Pallisa, farmers were moving back to local varieties of finger millet and sorghum which they perceived to be more hardy and tolerant to dry spells as opposed to improved varieties. Cover crops, compost manure and crop rotation were the most common land management practices employed by farmers in the sampled villages. Other land management practices used by farmers included; soil bunds, terraces, mulching, water ways, grass strips, use of inorganic fertilizer and agro-forestry.

3.3 Farmers who perceive climate variability but fail to respond

Despite the fact that over 90% of the respondents claimed they had perceived variability and change in rainfall, only 71% (of total respondents) indicated to have taken action. It is argued that farmers who perceived change and responded (or did not respond) share some common characteristics, which assist in better understanding the reasons underlying their response (or failure to respond) as captured by the Heckman probit model. Tables 5 and 6 show model results indicating the probability of adopting adaptation technologies given perception of climate variability, and the marginal impacts of the various variables on adoption of technologies respectively.

Table 5: Heckman's sample selection model of whether a farmer fails to respond to climate variability

Variables	Technology adoption (Outcome Model)		Perception of climate variability (Selection Model)	
	Coefficient	**Std. Err.**	**Coefficient**	**Std. Err.**
Gender (Male=1)	0.105*	0.063	0.266	0.301
Age	-0.001	0.002	0.002	0.012
Experience	-0.001	0.002	0.014	0.010
Education	0.009	0.018	0.046	0.099
Household size	0.025***	0.006		
Off farm income	-0.005*	0.049	0.118	0.257
Livestock	0.023	0.021		
Credit	0.057	0.046		
Extension	0.065	0.048	-0.302	0.267
Weather information			0.999***	0.269
Output market	0.012**	0.006		
Input market	-0.029***	0.008		
Farm size	-0.010	0.026		
Rainfall index	0.348**	0.143		
Mbale	-0.359***	0.767	-0.683	0.471
Sironko	-0.148*	0.085	-0.936**	0.466
Constant	0.657***	0.122	0.930	0.639
Total observations	291			
Censored	26		Uncensored	265
Rho	0.572		Wald chi2(16)	179.82
Prob > chi2	0.0000			

Statistical significant at the 0.01 (***), 0.05 (**), 0.1 (*) level of probability. Source: Field data, 2011

The results from the sample outcome model (Table 5) indicate that farmers' decisions to adopt adaptation technologies are driven by a number of factors. It's apparent that perception of rainfall variability, gender of the head of household, household size, and access to output markets, significantly increase the probability of the farmer recording an adaptation measure. On the other hand, access to off-farm income, input markets, and location of the farmer negatively affect adoption of technologies. Institutional variables such as extension on crop and livestock, and access to credit are positively correlated with technology adoption, but are not significant in explaining the observed technology adoption at farm level.

Results of the selection model indicate that only access to weather information explains farmer perceptions on climate change. Unlike the a priori expectations, local agro-ecology negatively affected perception of climate variability, with location in Sironko negatively related to farmer perception on climate variability, as compared to Pallisa.

From the marginal impact analysis of the various factors (Table 6), there are marked differences in the ability of farmers from different agro-ecologies to respond to climate variability. The probability of responding to climate variability by farmers in Mbale and Sironko is smaller by about 15% and 6% respectively as compared to Pallisa. Male headed households have more probability of adapting to climate change which is revealed by the fact that a unit change from being headed by a female to male increases the probability of adapting to climate variability by 12%. Increasing household size, by one unit increases the probability of a farmer adopting adaptation technologies by 23%. A farmer who has perceived changes in rainfall has 9% chance of adopting new technologies than one who has not.

Table 6: Marginal impacts of adaptation to climate variability

Variable	δy/δx†	Std. Err.	Z value	P>|z|
Gender (= Male)	0.121*	0.074	1.64	0.101
Age	-0.085	0.132	-0.64	0.521
Experience	-0.038	0.058	-0.66	0.510
Education	0.026	0.053	0.49	0.625
Household size	0.236***	0.056	4.19	0.000
Livestock	0.028	0.026	1.07	0.284
Off farm income	-0.004	0.035	-0.12	0.906
Credit	0.035	0.028	1.24	0.213
Extension	0.035	0.026	1.38	0.167
Output market	0.064**	0.030	2.14	0.032
Input market	-0.189***	0.053	-3.54	0.000
Farm size	-0.014	0.038	-0.37	0.712
Rainfall index	0.090***	0.036	2.45	0.014
Mbale	-0.152***	0.035	-4.31	0.000
Sironko	-0.068*	0.041	-1.67	0.095

† y = Linear prediction (predict) = 0.740

Statistical significant at the 0.01 (***), 0.05 (**), 0.1 (*) level of probability

Source: Field data, 2011

4. Discussion and conclusion

Consistent with adopter perception paradigm (Adesina and Zinnah, 1993) this study showed that there is a significant association between smallholder farmers’ perceptions of extreme climatic events and adoption of adaptation technologies. Decisions to adopt adaptation technologies generally depend on farmers’ perception of the variability in the climatic condition. Results further indicate that there is a higher probability for men to adopt technologies than women. This result is in line with the argument that male-headed households are often considered to be more likely to get information about new technologies and take risky businesses than female-headed households (Asfaw and Admassie, 2004). However, this study observed that most of the technologies employed by farmers generally require labour input, which also explains the significant positive relationship of technology adoption to household size. It can therefore be inferred from the study that gender effect on technology adoption is generally due to the differences in labour endowment between men and women headed households. This is in line with Pender and Gebremedhin (2006) who indicated that female-headed households use significantly less labour, because of labour constraints. As such, they are less likely to apply compost manure and less likely to use contour ploughing, which are generally labour intensive.

Unlike the a priori expectation that more experienced farmers have higher chances of adapting to climate variability, this study showed that the length of farming experience among the respondents is not a very important determinant of adaptation. Saha *et al*. (1994) showed similar results and attributed it to the fact that farmers who have been long in the business are usually older, less educated and are more resistant to change than new entrants, therefore will not adopt new technologies even in the face of changing times. However, this study attributes the result to the fact that the current speed of climate change has modified known variability patterns to the extent that farmers have been confronted with situations they are not equipped to handle, despite their farming experience. This implies the need for anticipatory and planned adaptation at local level.

While access to extension has been linked to adoption of improved technologies by various studies (for example Atta-Krah and Francis, 1987; Maddison, 2006) and adaptation to climate change (Nhemachena and Hassan, 2007), this study shows non-significant effects of extension to technology adoption. This could be attributed to the nature of extension messages and delivery mechanisms. Extension messages need to be tailored to the existing farmer challenges other than general extension on crop and livestock. Other previous studies on extension in Uganda have also indicated less favourable results on the impact of extension on agricultural productivity (Benin *et al*., 2007). More generally, lack of funds and equipment to facilitate the work of extension agents is a common complaint at the local government level (Sserunkuuma *et al*., 2001). Kristin (2008) also cited a combination of a lack of relevant technology, failure by research and extension to understand and involve clientele in problem definition and solving, lack of incentives for extension agents, and weak linkages between extension, research, and farmers.

Farm size also showed negative relationship with adaptation as opposed to the a priori expectation. The probable reason for the negative relationship between adaptation and farm size could be due to the fact that adaptation is plot specific. This means that it is not the size of the farm, but the specific characteristics of the farm that dictates the need for specific adaptation methods. This finding is in line with Deressa *et al*. (2008) who found that farm size was negatively related to adaptation to climate change. Benin *et al*. (2007) also affirmed that reduction in farm size is a major determinant for adoption of improved crop production practices, and improved soil fertility management.

For the selection model, only access to weather information showed positive significant effects on farmers' perceptions of climate variability. This implies that even if the climate is perceived to be changing, at local level availability of information plays a big role in informing farmers' perceptions, attitudes and practices with regard to the observed changes. This is in agreement with Patt *et al*. (2005), who indicated that of the 75% of farmers who reported receiving seasonal rainfall forecast, 57% reported changing their management practices in response. Hansen *et al*. (2011) also reported several examples of use and value of climate forecast information in informing farmers' practices in selected Sub Saharan African countries.

The results obtained here underscore the need for appropriate weather information to guide decision making of which adaptation technologies to adopt. In addition, household socio-economic factors and access to markets should not be ignored in the design and implementation of adaptation measures. This can be supported by building social protection mechanisms at community level, or supporting households to build economic assets if labour is to be hired, or promotion of labour saving technologies such as use of oxen. Lastly, in provision of extension services, the mode of extension service delivery, the messages and the targeting is critical if extension is to contribute to technology adoption and subsequently increased adaptation to climate variability. There is need to climate climate-proof extension messages if they are to appropriately inform adaptation at local level.

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