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Analysis of Farmers' Perceptions of the Effects of Climate Change in Kenya: The Case of Kyuso District

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Abstract

A cross-sectional analysis was carried out to evaluate how farmers in Kyuso District have perceived climate change. Data was collected from 246 farmers from six locations sampled out through a multistage and simple random sampling procedure. The logistic regression analysis was carried out to assess factors influencing farmers' perceptions of climate change. The analysis revealed that 94% of farmers in Kyuso District had a perception that climate was changing. In this regard, age of the household head, gender, education, farming experience, household size, distance to the nearest input/output market, access to irrigation water, local agro-ecology, access to information on climate change, access to extension services, off farm income and change in temperature and precipitation were found to have significant influence on the probability of farmers to perceive climate change. Since the level of perception to climate change revealed by the study was found to be high (94%), the study suggests that more policy efforts should thus be geared towards helping farmers to adapt to climate change.

Key words: *Climate change, Perceptions, Logistic regression model, Kyuso District.*

Introduction

Agriculture lays a heavy burden on the environment in the process of providing humanity with food and fibres (IPCC, 2007b). Besides, it offers a range of positive externalities such as the environmental services and amenities through the creation and maintenance of rural landscapes (World Agroforestry Centre, 2009). However, agriculture, food systems as well as the rural economies around the world have, in the last two decades, been experiencing major transformation emanating from climate change (Oxfam, 2007). In the Sub-Saharan Africa, climate change has drastically reduced agricultural production through extreme weather events, such as recurrent droughts and floods (Hassan and Nhemachena, 2008; Deressa *et al.,* 2008).

In Kenya, frequent droughts and floods have not only claimed lives but have also decimated livestock and reduced farm output (GOK, 2007; USAID, 2007; Obunde, 2007). Maitima *et al*. (2009) observe that Kenya has in the last 100 years recorded 28 major droughts with three of them having occurred during the last decade. These droughts have led to widespread economic losses, energy crisis, water shortages and food insecurity, particularly among the people in the arid and semi arid lands (ASALS) where annual rainfall is sporadic and periodical droughts are part of the climate system.

Kyuso is one of the ASAL districts located in the Eastern Province of Kenya that has experienced severe drought impacts in the last decade (Maitima *et al.,* 2009). For four consecutive seasons – 2004/2005, 2005/2006, 2006/2007, 2007/2008 - the district experienced low amounts of rainfall with total crop failure for the main crops like maize, sorghum, millet, beans and peas being experienced in the 2005/2006 season. As Gullet *et al.* (2006) put it; prolonged periods of high temperatures and increasingly poor rainfall in the district were primarily responsible for the surge in crop and livestock diseases, total crop failure, livestock deaths, increased food insecurity as well as rising poverty levels. In turn, the livelihoods of the people who entirely depend on land for agriculture and livestock production were adversely affected.

Despite there being a lot of information on the impacts of drought in Kyuso District little is known about how different sections of the community in the district perceive climate change and the related drought events. It is this knowledge gap that necessitated this study to be carried out so as to better understanding how sections of the Kenyan community and dry land farmers in particular, have perceived the drought conditions. This would help relevant government agencies to formulate suitable policy interventions for the farmers whose livelihoods have been undermined by the adverse effects of recurring droughts caused by change climate.

This paper is organized as follows. Section two outlines the theoretical framework. Section three presents the methodology. Section four discusses the results and section five gives conclusions and policy recommendations.

Theoretical framework

This study was grounded on the theory of induced innovation adopted from Netra *et al.* (2004), which is used to examine the central role of drought conditions as a motivator of the farmers to perceive, innovate and ultimately adapt to climate change in Kyuso District. Climate is one of the important resources for crop growth and development. By altering crop growth and development, which is seen in the form of changes in the length of growing season, soil moisture regimes and heat stress to the plant, climate change, according to theory of induced innovation, may provide appropriate signals to farmers to devise strategies suitable for the new environment.

While operating within this theoretical framework, the study analyzed the effects of drought and hence the perceptions on drought as necessary incentives for the farmers to be innovative in seeking solutions to adapt to the negative effects of climate change. One assumption made by the induced innovation theory is that when agents of production (e.g. farmers) experience problems with changes in resource endowments, such as that brought about by climate change, they are likely to seek new knowledge that will help to overcome these constraints. The change in resource endowment, therefore, may solicit an adaptive response whereby farmers may adjust land use and farm management techniques and the allocation of resources to offset the adverse effect of climate change.

Given the non-climatic factors, it is argued in this study that innovations towards farm production in Kyuso District are made in response to the farmers' perceptions of variable climatic conditions. It is thus assumed that variability in climate also prompts the adaptation process among the households so as to cope with the negative impacts of climate change on farm production. The study hypothesizes that, in Kyuso District, climate change is a constraint to the productive capacity of the farm households and that farmers' perceptions of the changing climate is a signal for innovative adaptation strategies to be undertaken by the farmers so as to reduce farming risks emanating from climate change. In other words, farmers' perceptions about climate change are induced by the recurrent drought conditions in the district.

Therefore, undertaking this study in Kyuso District would provide meaningful insights with regard to the relationships between climate change and farmers' perceptions about climate change in order to safeguard farmers against adverse effects of climate change.

Methodology

Study area

Kyuso District is one of the twenty-eight districts in Eastern Province with an area of 4,814.90 Km^2. It has 4 administrative divisions, namely: Mumoni, Ngomeni, Kyuso and Tseikuru; 16 locations and 53 sub-locations. To the South, it borders Mwingi central District; to the West, it borders Mbeere District; to the North West, it borders Tharaka District and bordersTana River District to the East. The district falls within the arid and semi-arid eco-climatic zones of Kenya with a transitional part in between. It has an altitude ranging from 400 to 1,747 m above sea level. Thus, its topography covers both the western part of Kyuso with higher climate that offers greater rainfall and increased crop cultivation; and the eastern part of Kyuso that has lower and drier climate that is popular with livestock production. Hot and dry for most of the year, Kyuso's temperature ranges from a minimum of 14-22° centigrade to a maximum of 26-34° centigrade. February and September are the hottest months of the year, with generally low and unreliable rainfall. It has long rains between March and May, and short rains between October and December. The short rains are more reliable than the long rains and that is when farmers get their main food production opportunity.

The Kyuso district has three main livelihood zones, namely: the mixed farming which is mainly found in Mumoni Division located on the western side of the district; the marginal mixed farming, which is found in Kyuso, Ngomeni and Tseikuru Divisions located on the eastern part of Kyuso; and the formal employment/casual waged labour found in Kyuso town and the various market centres. All farmers in eastern part of Kyuso keep some form of livestock - cattle, sheep and goats. When necessary, they sell the livestock to buy food. Core crops include pigeon peas, maize, cowpeas, green grams, sorghum, beans, millet, cassava and sweet potatoes. There has been a lot of emphasis on growing hybrid maize, which has caused problems because it requires more rainfall. Although beekeeping has been a traditional activity in this area, the government has recently started promoting it as an alternative economic activity (Kyuso District Development Report, 2008).

Study population

According to Kyuso District Development Report (2008), the district has an estimated population of 138,040 persons with an annual population growth rate of 2.4%. Urban population accounts for 5% of the total population in the district, with the rest living in the rural areas. Kyuso population operates within three main livelihood zones, namely: mixed farming; marginal mixed farming and formal employment/casual waged labour. The study population was mainly drawn from farming households operating from two livelihood zones, that is: mixed farming and marginal mixed farming livelihood zones residing in the rural areas.

Sampling procedure

Multistage and simple random sampling procedure was employed in selecting a sample of 246 respondents from the district. The four administrative divisions in the district, namely: Mumoni, Kyuso, Ngomeni and Tseikuru were first categorized into two: those from mixed farming livelihood zone (western side) and those from marginal mixed farming livelihood zone (eastern side). Thereafter, simple random sampling procedure was used to select two divisions - one from the mixed farming zone and the other from the marginal mixed farming zone. As such, Mumoni and Kyuso divisions were selected. In the second stage, 6 locations - 3 from each of the two livelihood zones - were thereafter randomly selected for the interviews. They were: Kakuyu, Katse and Mutanda from the mixed livelihood zone; and Kamangao, Kyuso and Kamuwongo from the marginal mixed livelihood zone. Subsequently, 41 farming households from each of the 6 locations were selected at random for the interview process. This sampling method was chosen because of its merit in ensuring a high degree of representativeness by providing the respondents with equal chances of being selected as part of the sample.

The Analytical Framework: The logistic regression model

In the logistic regression model, the dependent variable is usually qualitative and dichotomous in nature, taking a value of 1 or 0. Although Ordinary Least Squares (OLS) can also be used to compute the estimates for the binary choice models, certain assumptions of the classical regression model are violated. These include non-normality of the disturbances, heteroscedastic variances of the disturbances and questionable value of R^2 as the measure of goodness of fit (Gujarati, 2004). For instance, given:

$$y_i = \beta_0 + \beta_i X_i + e_i \qquad (1)$$

Where: y_I=1 if a farmer perceives climate change and y_I=0 if a farmer does not; β_0 is the intercept; β_i are the parameters to be estimated; X_i are the variables in question and e_i is the disturbance term. This model is a typical linear regression model but because the regressand is binary or dichotomous, it is called a linear probability model (LPM). However, in the regression model, when the dependent variable is dichotomous in nature, taking the value 1 or 0, the use of linear probability models is a major problem. This is because the predicted value can fall outside the relevant range of zero to one probability value. Thus, if linear probability models are used, the results may fail to meet the statistical assumptions necessary to validate the conclusions based on the hypothesis tested (Feder *et al.,* 1985).

Therefore, to overcome the problem associated with the linear probability model, logit and probit models have been recommended (Gujarati, 2004). These models, which use Maximum Likelihood Estimation (MLE) procedures, ensure that the probabilities are bound between 0 and 1. Both logit and probit transformations estimate cumulative distribution, thereby eliminating the interval 0, 1 problem associated with LPM. The logistic cumulative probability function can be represented by

$$P_i = F(Z_i) = \frac{1}{1 + e^{-z_i}} \qquad (2)$$

Where P_i is the probability that the i^{th} person will be in I the first category, Zi= β_0+ $\beta_i X_i$+ e_i where β_0 is the intercept of the model; β_i are the model parameters to be estimated; X_i are the independent variables and e represents the base of natural logarithms which is approximately equal to 2.718. In equation (2), Z can range from positive infinity to negative infinity. The probability of a perceiving climate change lies between 0 and 1. If we multiply both sides of the equation (2) by $1 + e^{-z_i}$ we get:

$$(1 + e^{-z_i}) P_i = 1 \qquad (3)$$

Dividing by P and then subtract 1 leads to:

$$e^{-z_i} = \frac{1}{P_i} = \frac{1 - P_i}{P_i} \qquad (4)$$

By definition however, $e^{-z_i} = \frac{1}{e^{-z_i}}$ so that the equation (4) becomes:

$$e^{-z_i} = \frac{P_i}{1 - P_i} \qquad (5)$$

By taking the natural logarithm of both sides of equation (5), we get:

$$Z_i = log\{\frac{P_i}{1 - P_i}\} \qquad (6)$$

In other words:

$$log(\frac{P_i}{1 - P_i}) = Z_i = \beta_0 + \beta_i X_i \qquad (7)$$

This makes the logistic probability model. Therefore, it can be noted that the logistic model defined in the equation (7) is based on the logits of Z, which constitutes the stimulus index. The marginal effects can also be computed to show the change in the probability when there is a unit change in the independent variables. The marginal effects are computed as follows:

$$\frac{\partial P_i}{\partial X_i} = \frac{\beta_i e^{-z_i}}{(1 + e^{-z_i})^2} \qquad (8)$$

In this study, factors influencing peoples' perception of climate change were examined through such logistic regression model framework.

Empirical model for the study

As mentioned earlier, the regressand in this study was farmers' perception of climate change, which is a binary variable indicating whether or not a farmer has perceived climate change. It was regressed on a set of relevant explanatory variables whose choice was based on theory and literature. These explanatory variables include the age of the farmer, gender, education, farming experience, farm income, off-farm income, access to extension services, access to climate information, household size, local agro-ecology, distance to input/output market, perceived fertility of the soil, access to credit, access to water for irrigation, precipitation and temperature. The logistic regression model is specified as:

$$\mathbf{Z_i = (\beta X_i) + \varepsilon} \quad \text{...} \quad (6)$$

Where: Z_i = the perception by the i^{th} farmer that climate is changing.

X_i= the vector of explanatory variables of probability of perceiving climate change by the i^{th} farmer.

β = the vector of the parameter estimates of the regressors hypothesized to influence the probability of farmer is perception about climate change.

Consequently, the empirical specification of the logistic regression model is:

$$\begin{aligned} \mathbf{Z_i} = {} & \boldsymbol{\beta_0 + \beta_1 age + \beta_2 gender + \beta_3 education + \beta_4 fexperience + \beta_5 hhsize} \\ & \boldsymbol{+ \beta_6 irrwater + \beta_7 marketdistance + \beta_8 agroecology} \\ & \boldsymbol{+ \beta_9 farmincome + \beta_{10} soilfertility + \beta_{11} climinform} \\ & \boldsymbol{+ \beta_{12} extenservice + \beta_{13} credit + \beta_{14} offarmincome} \\ & \boldsymbol{+ \beta_{15} precipitation + \beta_{16} temperature + \varepsilon} \end{aligned}$$

These model parameters were estimated by maximum likelihood using STATA Software v11.0.

Empirical Results and Discussion

Descriptive Analysis: Farmers' perceptions of climate change

In order to understand farmers' perception towards climate change in Kyuso District, farmers were asked to indicate what they had noted regarding long term changes in temperature and precipitation. They were asked to specify whether or not they had noted: (i) changes in climate (ii) increases in temperature (iii) decreases in temperature (iv) extended periods of temperature (v) no change in temperature levels (vi) increases in precipitation (vii) decreases in precipitation (viii) changes in the timing of rains (ix) increases in the frequency of droughts and (x) no change in precipitation patterns. The results of this analysis are presented below and furthermore in Table 2.

Overall, the study established that 94% of the farmers in the district had noted changes in climate while 6% had not. While 43% of the respondents noted an increase in the levels of temperature, about 70% observed a decrease in precipitation. Nobody is reported to have either perceived a decrease in temperature or an increase in precipitation. Considering patterns of precipitation, 61% of the respondents pointed out that they had observed changes in the timing of rains while 70% noted that the frequency of droughts had increased overtime. This implies that majority of farmers in the district are well aware of climate change.

A cross tabulation between the age of the household head and the farmers' perceptions of climate change elucidated that majority of farmers who perceived changes in climate were in the age group between 31 and 60 years (80%), compared to farmers below the age of 30 years (6%) or above the age of 60 years (8%). While 36% of farmers in the age group 31-60 years observed an increase in the levels of temperature, only 3% and 4% of farmers in the age group below 30 years and above 60 years, respectively, noted increases in temperature. In contrast, no one from the three age groups indicated to have either observed a decrease in temperature or an increase in precipitation. Regarding patterns of precipitation, 51% of farmers in the age group 31-60 years agreed that they had observed changes in the timing of rains, compared to 4% and 6% of the farmers in the age groups below 30 years and above 60 years, respectively.

The study further established that most farmers who perceived climate change had attained post primary (61%) education compared to 33% who had up to primary education. While 34% of farmers with post primary education noted increases in temperature, only 9% of farmers with up to primary education noted that there was an increase in the levels of temperature. Regarding perceptions about extended periods of temperature, 47% of farmers with post primary education indicated to have observed long periods of temperature compared to only 8% of farmers with up to primary education.

With regard to the farming experience, the study found out that the majority (83%) of farmers who perceived that climate was changing had high farming experience (above 10 years) compared to 11% who had low farming experience (1-10 years). As 51% of the farmers with high farming experience observed a considerable change in the levels of temperature, only 6% of farmers with low farming experience indicated to have noticed changes in temperature levels. Concerning the frequency of droughts, majority (62%) of farmers with high farming experience indicated to have observed an increased number of droughts in the last decade compared to their counterparts (8%) with low farming experience.

On the relationship between farmers' perception to climate change and the distance to the nearest input and output market, the study established that majority (77%) of farmers who lived close (1-15 Kms) to the nearest input/output market perceived that climate was change, compared to those farmers (17%) who resided in places longer than 15Kms to the nearest market. Regarding precipitation patterns, about 54% of farmers residing between 1-15Kms to the nearest market noted that the timing of rains had changed while another 62% observed that the number of recurring droughts had increased. In contrast, only 7% and 8% of farmers residing longer than 15 Kms distance to the nearest input/output market had noted changes in the timing of rains and increased frequency in the occurrence of droughts, respectively.

Econometric Analysis: Farmers' perceptions of climate change

In the study, the regressand was a binary variable, representing whether or not a farmer perceived climate change. This dependent variable was regressed on a set of explanatory variables as discussed in the previous section. Table 3 below presents the results from the ML estimation together with the marginal effects - the expected change in the probability of perceiving climate change given a unit change in an independent variable from the mean value, ceteris paribus. Only results that were statistically significant at 10 percent level or greater are reported.

The results indicate that the age of the household head, gender, education, farming experience, household size, distance to the nearest input/output market, access to irrigation water, local agro-ecology, access to information on climate change, access to extension services, off farm income and change in temperature and precipitation influenced the possibility of a farmer to perceive climate change.

In relation to the age of the household head, the results came out as expected i.e. the age of the household head would be positively and significantly related to farmers' perception of climate change. The study found out that older farmers had a higher probability of perceiving climate change than it is for younger farmers ($\boldsymbol{\beta} = 0.0032, p<0.01$). This is probably because older farmers have more experience in farming and are therefore better placed to assess changes in the environment than younger farmers.

As for the gender of the household head, the study established that the probability of a male headed household to perceive climate change was higher than that of a female headed household ($\boldsymbol{\beta} = 0.0151, p<0.05$). This finding came out as expected and the possible reason is that male headed households have a higher probability of acquiring more information than female headed households.

Regarding the education level of the farmers, the study established that the probability of more educated farmers to perceive climate change was also higher than that of less educated farmers ($\boldsymbol{\beta} = 0.0255, p<0.05$). This is because higher education was more likely to expose farmers to any available information on climate change. Education was likely to enhance the farmers' ability to receive, decipher and comprehend information relevant to making innovative decisions in their farms.

With respect to farming experience, the study found out that more experienced farmers were also more likely perceive climate change than farmers with low farming experience (**β** = *0.020, $p<0.01$)*. This is because experienced farmers have high skills in farming techniques and management and therefore be able to detect any change in climatic conditions or changes in crop and livestock production levels resulting from variability in climate.

As for the size of the households, the study established that larger households were less likely to perceive climate change than smaller households (**β** = *-0.0447, $p<0.05$*). This is probably because household size is a proxy to labour availability and therefore, larger households are likely to have a lower probability to perceive climate change since households with many family members are likely to have more off-farm activities to supplement farm production.

The study also established an inverse relationship between farmers' perception to climate change and their access to irrigation water. It was found out that farmers with access to irrigation water were less likely to perceive climate change than farmers without access to irrigation water (**β** = *-0.0421, $p<0.05$*). This is because the warming factor and the lack of irrigation water enhances the vulnerability of farmers to risks associated with climate change and hence their probability to perceive that climatic conditions are changing.

As pertaining to the distance to the nearest input/output market, the study results indicate that farmers residing further away from the nearest input/output market were less likely to perceive climate change than farmers residing closer to the market (**β** = *-0.0061, $p<0.01$*). This is probably because markets provide an important platform for farmers to gather and share information.

Also established in the study was a positive relationship between local agro-ecological conditions and farmers' perception of climate change. It was revealed that farmers living in lower agro-ecological zones were more likely to perceive changes in climate than farmers living higher agro-ecological zones (**β** = *0.0280, $p<0.05$*). The likely reason could be that each agro-ecology has its own set of conditions known to the farmer and hence a small change in these conditions has a higher likelihood of influencing the farmer to perceive climate change.

With regard to the off-farm income, the study results showed a negative relationship between off-farm incomes and the probability of farmers to perceive climate change (**β** = *-0.0216, $p<0.01$*). This observation is probably because off-farm income generating activities may sometimes undermine on-farm production and therefore unlikely to influence on-farm perception by farmers that climate is changing.

The study further unveiled that farmers' access to information on climate change through extension services had a higher likelihood of influencing the farmer to perceive climate change (**β** =*0.0113, p<0.1*). This relationship arises because farmers' access to information on climate change broadens their information base and hence their probability to perceive changes in climate.

As expected, the study revealed a positive relationship between change in temperature and the famers' perception of climate change. It was found out that farmers who noted a rise in temperature conditions were more likely to perceive climate change (**β** = *0.0110, p<0.01*). This is probably because a rise in temperature in a district, that is already arid and semi-arid, was more likely to hamper farm production and therefore likely to make farmers take note of adverse climate conditions.

As for the precipitation, the results also came out as expected. The study found a negative relationship between change in precipitation and farmers' perception to climate change. That is, a rise in precipitation was less likely to influence farmers to perceive climate change compared to a decline in precipitation (**β** = -*0.0118, p<0.01*). The possible reason for the negative relationship is that Kyuso District is a water scarce area and therefore, increased precipitation in such a water scarce area was unlikely to constrain farm production and therefore unlikely to make farmers take note of adverse climate conditions.

Conclusions and Recommendations

The study set out to analyze farmers' perceptions of climate change in Kenya with special reference to Kyuso District. It was found out that majority of the farmers were well aware that climate was changing and it was the cause of the recurrent droughts that were ravaging the district. Majority of the farmers noted that there was an increase in temperature, extended periods of temperature, a decrease in precipitation, changes in the timing of rains and an increase in the frequency of droughts.

The results from the study also show that the age of the household head, gender, education, farming experience, household size, distance to the nearest input/output market, access to irrigation water, local agro-ecology, access to information on climate change, access to extension services, off farm income and change in temperature and precipitation were crucial factors in influencing the likelihood of farmers to perceive climate change.

Thus, government policies aimed at enhancing the adaptive capacity of the farmers in the study area should thus be formulated while making use the factors mentioned immediately afore.

One of such policies include a policy on dry land irrigation since Kyuso District is water scarce area and as established in the study, the farmers were in dire need of water for irrigation. Such a policy would go a long way in enhancing farm output, food security and the general livelihoods of the people. A different policy is that of women empowerment since the study discovered that farming in the district is mostly carried out by women as men are based in towns carrying out off farm activities. The policy framework could also consider promoting women in terms of access to education and other critical services such as credit supply.

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Table 1: Variables hypothesized to affect the perceptions by farmers with regard to climate change.

Variables and variable Measurement	Mean	Std. Dev.	Min	Max	Expected sign
Age of the head of the farm household in years.	45.29	11.13	25	75	±
Gender of the head of the farm household - dummy (1=male; 0=otherwise).	0.74	0.44	0	1	±
Education attained by the head of the household in years.	9.88	4.20	0	15	+
Farming experience of the household head in years.	20.48	8.86	7	50	+
Household size - number of family members of a household.	5.76	2.12	2	13	±
Access to water for irrigation - dummy (1=access; 0=otherwise).	0.30	0.46	0	1	+
Market distance in kilometres.	2.42	1.54	1	7	+
Local agro-ecology - highland or lowland - dummy (1=highland; 0=otherwise).	0.39	0.49	0	1	+
Farm income of the household in Kenya shillings.	2.61	1.38	1	6	+

Perceived fertility of the soil by household head in dummy (1=fertile; 0=otherwise).	0.10	0.30	0	1	+
Access to climate information - dummy (1=access; 0=otherwise).	0.68	0.47	0	1	+
Access to extension services - dummy (1=access; 0=otherwise).	0.13	0.34	0	1	+
Access to credit - dummy (1=access; 0=otherwise).	0.25	0.44	0	1	+
Off-farm income in Kenya shillings.	0.67	0.47	0	1	±
Temperature – whether farmers perceives affected by changes in annual average temperature - dummy (1=affected; 0=otherwise).	0.57	0.50	0	1	+
Precipitation – whether farmers perceives affected by changes in annual average precipitation - dummy (1=affected; 0=otherwise).	0.39	0.49	0	1	–

Table 2: Farmers' Perception of Changes in Temperature and Precipitation by age, education, farming experience and distance to the nearest input-output market (as a % of respondents).

Farmers' perceptions	Farmers' perceptions by age (as a % of respondents)				Farmers' perceptions by education (as a % of respondents)		Farmers' perceptions by farming experience (as a % of respondents)		Farmers' perceptions by distance to the input/ output market (as a % of respondents)	
	% of re- spon- dent	0-30 years	31-60 years	60+ years	Up to Standard education (1 - 8 years)	Post standard education (9+ years)	Low farm- ing experi- ence (1 -10 years)	High farm- ing experi- ence (10+years)	Distance to the nearest market (1 - 15Kms)	Distance to the nearest market (15+ Kms)
Changes in climate	94	6	80	8	33	61	11	83	77	17
Increases in temperature	43	3	36	4	9	34	6	37	39	4
Decreases in temperature	0	0	0	0	0	0	0	0	0	0
Extended periods of temperature	55	4	45	6	8	47	3	52	48	7
Change in temperature levels	57	5	47	5	13	44	6	51	51	6
Increases in precipitation	0	0	0	0	0	0	0	0	0	0

Decreases in precipitation	70	4	59	7	16	54	8	62	58	12
Changes in the timing of rains	61	4	51	5	13	48	11	50	54	7
Increases in the frequency of droughts	70	5	59	6	16	54	8	62	62	8
Change in precipitation patterns	39	3	32	4	14	25	4	35	29	10
N = 246										

Table 3: Results of the Logistic Regression Model of Farmers' Perception to Climate Change in Kyuso District, Kenya

	Regression model		Marginal effects	
Explanatory variables	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Age	0.089***	0.000	0.0032***	0.006
Gender	0.827***	0.000	0.0151**	0.045
Education	0.134***	0.000	0.0255**	0.049
Farm experience	0.112***	0.000	0.020***	0.001
Household size	-0.133**	0.037	-0.0447**	0.028
Irrigation water	1.180***	0.000	-0.0421**	0.015
Distance to market	0.012	0.792	-0.0061***	0.001
Local agro-ecology	1.355***	0.001	0.0280**	0.036
Farm income	-0.464	0.104	-0.0661	0.572
Fertility of the soil	0.427	0.320	0.0482	0.542
Climate information	0.502**	0.038	0.0113*	0.062
Extension services	1.741***	0.001	0.0467**	0.032
Access to credit	-1.601***	0.000	-0.0223	0.310
Off farm income	-0.252	0.324	-0.0216***	0.001
Change in temperature	0.035**	0.016	0.0110***	0.002
Change in precipitation	-0.017**	0.004	-0.0118***	0.001
Econometric Diagnostics				
Likelihood ratio test for zero slopes	*32.14, p > Chi2(15) = 0.001*			
Pseudo R2	*0.2994*			
Total observations	*245*			

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