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Assessment of Farmers' Adaptation to the Effects of Climate Change in Kenya: the Case of Kyuso District

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Abstract

The study was carried out to assess how farmers in Kyuso District have adapted to the effects of climate change. Survey data was collected from 246 farmers from six locations that were sampled out through a multistage and simple random sampling procedure. The probit regression model was fitted into the data in order to assess factors influencing farmers' adaptation to the effects of climate change. The analysis revealed that 85% of the farmers had adapted in various ways to the effects of climate change. In this regard, the age of the farmer, gender, education, farming experience, farm income, access to climate information, household size, local agro-ecology, distance to input/output market, access to credit, access to water for irrigation, precipitation and temperature were found to have significant influence on the probability of farmers to adapt to climate change. The study suggests that more policy efforts should thus be geared towards helping all the farmers in the district to adapt to climate change.

Key words: climate change, adaptation, probit regression model, Kyuso District.

1. Introduction

In Kenya, frequent droughts and floods have not only claimed lives but also decimated livestock and reduced farm output (GOK, 2007; USAID, 2007; Obunde, 2007). As noted by Maitima *et al.* (2009), Kenya has in the last 100 years recorded 28 major droughts with three of them occurring 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 that has experienced severe drought impacts over the last decade. Located in the Eastern Province of Kenya, the district experienced four consecutive seasons - 2004/2005, 2005/2006, 2006/2007, 2007/2008 - of low amounts of rainfall with total crop failure for the main crops such as maize, sorghum, millet, beans and peas occurring in the 2005/2006 season. As noted by Gullet *et al.* (2006) and Maitima *et al.* (2009), prolonged periods of high temperatures and increasingly poor rainfall in the district between 2004 - 2008 were primarily responsible for the surge in crop and livestock diseases, total crop failure, livestock deaths and increased food insecurity as well as rising poverty levels. This has adversely affected the livelihoods of the people who entirely depend on land for agriculture and livestock production.

Despite the availability of information on the impacts of drought in Kyuso District, how different sections of the community in the district have adapted to the drought effects of climate change is not very well known. It is this dearth of information that necessitated this study to be carried out so as to better understanding how farming communities have adapted to drought conditions. This would help the Kenya Government to formulate relevant policy interventions for the farmers whose livelihoods have been destabilized by the adverse effects of recurring droughts caused by change climate.

In the following sections, the paper first outlines the theoretical framework, which is followed by a brief review of literature. The methodology for the study is discussed in section four followed by the results and discussion in section five. Section six gives conclusions and policy recommendations from the study.

2. 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 climate as a motivator of the farmers to innovate and ultimately adapt to climate change in Kyuso District. The fundamental insight of this theory is that investment in adaptation is a function of change that enters into the farm's production function. Whereas adaptation in agriculture does not evolve with respect to climatic conditions alone, non-climatic factors such as economic and political environment have significant implications for adaptation in agriculture.

While operating within this theoretical framework, the study examined the effects of drought as the necessary incentives for the farmers to be innovative and hence 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 the immediate environment in which they operate, 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 immediate environment, therefore, may solicit an adaptive response whereby farmers adjust land use and farm management techniques and the allocation of resources to offset the adverse effect of climate change.

In this study, it is argued that innovations towards farm production in Kyuso District are made in response to variable climatic conditions, holding the non-climatic factors constant. It is thus assumed that variability in climate 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 adaptation strategies are an innovative measure devised by the farmers to reduce farming risks emanating from climate change.

It is also hypothesized that as pressure to grow food from climatically stressed area increases, the marginal cost of production rises. Ultimately, the farmer reaches a stage where adaptation becomes the only appropriate means of enhancing farm incomes. This may involve the development and use of knowledge that takes care of climate change through the adoption of location specific crop varieties and livestock or a combination of land use and farm management strategies, such as the use of irrigation and agroforestry among others. Therefore, undertaking this study in Kyuso District would provide meaningful insights with regard the relationships between climate change and farmers' adaptations in order to safeguard against adverse effects of climate change.

3. Overview of Literature

Nhemachena and Hassan (2007) consider the adoption of agricultural technologies in agriculture to be synonymous with the adaptation measures that farmers undertake against the adverse effects of climate change. Therefore, adoption literature can be used in the climate change adaptation studies. That way, Adesina and Forson (1995) and Gbetibouo (2009) note that there is no agreement in the adoption literature on the effect of age in the adoption of agricultural technologies since the effect of age is generally location or technology specific. The expected result of age effect is an empirical question. On one hand, age may negatively influence the decision to adopt new technologies simply because older farmers are more risk-averse and less likely to be flexible than younger farmers. On the other hand, age may positively influence the decision to adopt because older farmers have more experience in farming and are better able to assess the characteristics of a new technology than younger farmers.

Asfaw and Admassie (2004) note that male headed households have a higher probability of getting information about new farming technologies and also undertake more risky ventures than female headed households. Furthermore, Tenge and Hella (2004) point out that female headed households are less likely to adopt soil and water conservation measures since women may have limited access to information, land, and other resources due to traditional social barriers. However, a study by Nhemachena and Hassan (2007) finds contrary results to the effect that female headed households are more likely to adopt climate change adaptation methods.

Norris and Batie (1987) argue that a farmer with higher level of education is more likely to have access to information on improved technologies for higher productivity. Observation by Igoden *et al.* (1990) and Lin (1991) shows that there is a positive relationship between the education level of the household head and the adoption of improved technologies and adaptation to climate change. Therefore, farmers with higher levels of education are more likely to perceive climate change and adapt better. Studies by Maddison (2006) and Nhemachena and Hassan (2007) indicate that experience in farming increases the probability of uptake of adaptation measures to climate change. The current study hypothesizes that experience increases the probability of adapting to climate change.

A study by Yirga (2007) observed that the influence of household size on the use of adaptation methods could be seen from two perspectives. The first perspective holds that households with large families may be forced to divert part of the labor force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family. The other perspective observes that a large family size has a higher labor endowment, which is likely to enable a household to accomplish various agricultural tasks. As such, Croppenstedt *et al.* (2003) argue that households with a larger pool of labor are more likely to adopt an agricultural technology and use it more intensively because they have fewer labor shortages at peak times. Here, it is expected that households with large families are more likely to either adapt or not to climate change.

Farmers' access to extension services and climate change information is another important factor that may influence adoption of agricultural technologies. Maddison (2006) and Nhemachena and Hassan (2007) established that farmers' awareness of changes in climate attributes, whether temperature or precipitation or both, is important for adaptation decision making. In this study, it was expected that farmers who have access to climate change information were more likely to notice changes in climate and were more likely to take up adaptation measures. Farm and nonfarm income represent farmer's wealth. Research by Knowler and Bradshaw (2007) and Franzel (1999) agree that farmers' income (whether farm or nonfarm) has a positive relationship with the adoption of agricultural technologies as the latter requires sufficient financial wellbeing.

Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties, and irrigation facilities. Research by Caviglia-Harris (2002), Yirga (2007) and Pattanayak *et al.* (2003) on adoption of agricultural technologies show that there is a positive relationship between the level of adoption and the availability of credit. As well, this study also hypothesized that there would be a positive relationship between availability of credit and adaptation. Market access is another factor that influences adoption of agricultural technologies. Maddison (2006) observes that long distances to markets decreases the probability of farm adaptation in Africa and that markets provide an important platform for farmers to gather and share information. A study by Nyangena (2007) shows that in Kenya, distance to markets negatively and significantly affected the use of soil and water conservation technologies.

Maddison (2006) and Nhemachena and Hassan (2007) agree that different households dwelling in different agro-ecological settings may use different adaptation methods. This is because climatic conditions, soil, and other factors vary across different agro-ecologies and may therefore influence different farmers' perceptions of climate change and their decisions to adapt. Thus, the study hypothesized that farmers in the study area would perceive and adapt to climate change depending on their agro-ecological settings.

4. Methodology

4.1 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).

4.2 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.

4.3 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.

4.4 The Analytical Framework: The probit regression model

The probit regression model follows the cumulative distribution function (CDF) to explain the behaviour of a dichotomous dependent variable. Given the assumption of normality, the probability that y_i^* is less than or equal to y_i can be computed from the normal CDF as (Akinola and Owombo (2012) :

$$\begin{aligned}\mathbf{Prob_i} &= \mathbf{Prob\{y = 1|x\}} \\ &= \mathbf{Prob\{y_i^* < y_i\}} \\ &= \mathbf{Prob\{Z_i < \psi_1 + \psi_2 X_i\}} \\ &= \mathbf{F\{\psi_1 + \psi_2 X_i\}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)\end{aligned}$$

where y^* is the critical or threshold level of the index, such that if y_i exceeds y^*, the farmer adapts to the adverse drought effects of climate change, otherwise the farmer does not. $\mathrm{Prob}\{y = 1|x\}$ is taken as the probability that the drought event occurs given the values of explanatory variables X, and where $\mathbf{Z_i}$ is the normal variable $\mathbf{Z_i} \sim \mathrm{N}\,(0, \sigma^2)$. The probit model is thus defined as:

$$\mathbf{Prob\{y = 1|x\} = \{\omega(x\psi)\}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(2)}$$

where $\boldsymbol{\omega}$ is the standard cumulative normal probability distribution and $\mathbf{x\psi}$ is the probit score. Since $\mathbf{x\psi}$ has a normal distribution, the interpretation of the probit coefficients imply that a one-unit increase in the predictor variable leads to an increase in the probit score by $\boldsymbol{\psi}$ standard deviations. This means that it is harder to interpret the probit coefficients and as such, marginal values are usually computed. The probit model in equation (2) above can be re-written to obtain the log-likelihood function as:

$$\mathbf{\ln (L) = \textstyle\sum_{w_j} \ln \Phi\{x_j\psi\} + \sum_{w_j} \ln 1 - \Phi\{x_j\psi\}} \ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(3)}$$

where w_j denotes optional weights. Equation (3) is estimated using the Maximum Likelihood Estimation (MLE) procedure. In this study, since the coefficients from the probit model could not be interpreted in the same manner as in OLS regression, marginal effects were computed to ease the interpretation of the output from (3) above.

4.5 Empirical models for the study

The regressand in this study was farmers' adaptation to climate change, which is binary indicating whether or not a farmer has adapted to 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 empirical probit regression model was specified as:

$$\mathbf{W_i = (\psi X_i) + \varepsilon} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(4)}$$

where: $\mathbf{W}_i$ = the adaptation by the i^{th} farmer to climate change.
$\mathbf{X_i}$ = the vector of explanatory variables of probability of adapting to climate change by the i^{th} farmer.
$\boldsymbol{\psi}$ = the vector of the parameter estimates of explanatory variables hypothesized to influence the probability of farmer i_s adaptation to climate change. Thus, the linear specification of the probit regression model, which was estimated using STATA software v11.0, was given as:

$$\mathbf{W_i = \psi_0 + \psi_1 age + \psi_2 gender + \psi_3 education + \psi_4 fexperience + \psi_5 hhsize + \psi_6 irrwater + \psi_7 marketdistance + \psi_8 agroecology + \psi_9 farmincome + \psi_{10} soilfertility + \psi_{11} climinform + \psi_{12} extenservice + \psi_{13} credit + \psi_{14} offarmincome + \psi_{15} precipitation + \psi_{16} temperature + \varepsilon}$$

5. Empirical Results and Discussion

5.1 Descriptive Analysis: Farmers' adaptation to climate change

To know whether or not farmers' in Kyuso District had responded (adapted) to their own perceptions about the changing climate, they were asked to point out to what adaptation methods they had employed to cope with changes in temperature and precipitation patterns. They were requested to indicate whether or not they had adapted by using any of the following methods: (i) planting different crops (ii) planting different varieties (iii) crop diversification (iv) using different planting dates (v) shortening length of growing season (vi) migrating to a different site (vii) changing land under cultivation (viii) switching from crops to livestock (ix) switching from livestock to crops (x) adjusting number and management of livestock (xi) switching from farming to non-farming (xii) switching from non-farming to farming (xiii) increased use of irrigation (xiv) increased use of fertilizers and pesticides (xv) increased use water conservation practices (xvi) practicing soil conservation, mulching and use of manure (xvii) increased use of shading/sheltering/tree planting (xviii) use of prayers. The results of this analysis are presented here below.

By and large, the study established that 85% of farmers in Kyuso District had actually adapted to climate change compared to 15% who chose not to adapt. Various adaptation methods were employed by farmers, with the most common adaptation methods being planting different crops and changing land under cultivation, each comprising 64% of the respondents. The least employed adaptation methods by farmers were switching from non-farming to farming (9%) and increased use of irrigation (8%).

With respect to the age of the household head, the study found out that majority (71%) of farmers who adapted to climate change were in the age group between 31 and 60 years with only 6% and 8% of the farmers being below 30 years and above 60 years, respectively. In addition, majority of farmers in this age group employed various methods of adaptation, with the most popular adaptation methods being planting different crops and changing land under cultivation. Each comprised 54% of the respondents. The least popular adaptation methods among the farmers were switching from non-farming to farming (6%) and the increased use of irrigation (5%).

In relation to the education level of the household head, it was established from the study that majority (63%) of the farmers who adapted to climate change had attained post primary education in comparison to those who had upto primary level education (22%). The most popular adaptation methods among farmers with post primary education, other than planting different crops (50%) and changing land under cultivation (50%) were crop diversification (43%) and migrating to a different site (44%). The least popular methods of adaptation other than switching from non-farming to farming (7%) and the increased use of irrigation (6%) was switching from livestock to crops (8%).

As regards farming experience, the study revealed that majority (74%) of farmers who adapted to climate change had a lot of farming experience (above 10 years) in comparison to 11% who had low experience (below10 years). Among the popular adaptation methods for farmers with more farming experience included: planting different crops (56%), changing land under cultivation (56%), crop diversification (49%), planting different varieties (46%), shortening length of growing season (46%) and increased shading/sheltering/tree planting (45%). The methods of adaptation that were least employed by highly experienced farmers included: increased use of fertilizers and pesticides (20%), switching from non-farming to farming (8%) and increased use of irrigation (8%).

The study also established that majority (76%) of farmers who adapted to climate change lived close (1-15Kms) to the nearest input/output market. Only a few farmers (9%) living beyond the 15Km range from the nearest market had adapted. Planting different crops (61%), changing land under cultivation (61%), crop diversification (52%), migrating to a different site (52%), planting different varieties (49%) and shortening the length of growing season (48%) were the main adaptation strategies adopted by farmers residing close (1-15Km) to the nearest market. On the other hand, switching from livestock to crops (8%), increased use of irrigation (8%) and switching from non-farming to farming (9%) were the least popular adaptation strategies used by farmers.

5.2 Econometric Analysis: Farmers' adaptation to climate change

In the study, the dependent variable, which was binary representing whether or not a farmer adapted to climate change, was regressed on a set of explanatory variables as discussed in the previous section. Table 1 below presents the results from the ML estimation together with the marginal effects - the expected change in the probability of adapting to 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.

In relation to the age of the household head, the study found out that age had a positive relationship with the probability of farmers to adapt to climate change ($\psi = 0.0034, p<0.05$). Adesina and Forson (1995) and Gbetibouo (2009) attest to these findings when they observed, in their respective studies, that there was a positive relationship between age of the household head and the adoption of improved agricultural technologies. They note that older farmers have more experience in farming and are better able to assess the attributes of a modern technology than younger farmers. Hence, older farmers have a higher probability of adapting to climate change.

As for the gender of the household head, the study established that the probability of a male headed household to adapt to climate change was lower than that of female headed households ($\psi = -0.0037, p<0.1$). Nhemachena and Hassan (2007) came up with the same finding which was attributed to the fact that in most rural smallholder farming communities, much of the agricultural work is done by women because men are more often based in towns. Since women do much of the agricultural work, they are more likely to adapt based on available information on climatic conditions and other factors such as markets and food needs of the households.

In relation to the education level of the farmers, the study established that the probability of more educated farmers to adapt to climate change was higher than that of less educated farmers ($\psi = 0.0100, p<0.01$). This is because higher education was more likely to expose farmers to available information on climate change. These findings are confirmed by studies undertaken by Norris and Batie (1987) and Igoden *et al.* (1990) who have noted that higher education was likely to enhance information access to the farmer for improved technology up take and higher farm productivity. They have also observed that education is 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 more likely to adapt to climate change than the low experienced farmers ($\psi = 0.0031, p<0.05$). These findings are similar to those arrived at by Nhemachena and Hassan (2007) that farming experience enhances the probability of uptake of adaptations as experienced farmers have better knowledge and information on changes in climatic conditions, crop and livestock management practices. Since the experienced farmers have high skills in farming techniques and management, they may be able to spread risk when faced climate variability across crop, livestock and off farm activities than less experienced farmers.

As for the size of the households, the study established that larger households were less likely to adapt to climate change than the smaller households ($\psi = -0.0022, p<0.1$). As Teklewold *et al.* (2006) and Tizale (2007) note, household size is a proxy to labor availability. Therefore, larger households are likely to have a lower probability to adopt new agricultural practices since households with many family members are likely to divert labor force to off-farm activities in an attempt to earn more income to ease the consumption pressure imposed by a large family size.

The study also established an inverse relationship between farmers' adaptation to climate change and their access to irrigation water. It was found out that farmers with access to irrigation water were less likely to adapt to climate change than farmers without access to irrigation water ($\psi = -0.0030, p<0.1$). This is because access to irrigation water reduces farmers' the vulnerability of to risks associated with climate change and hence their probability not to perceive that climatic conditions are changing and hence unlikely to undertake adaptation measures like farmers without access to irrigation water.

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 adapt to the changing climate than farmers residing shorter distances to the nearest market ($\psi = -0.0024, p<0.01$). These results are in line with an observation made by Madison (2006) that long distances to markets decrease the probability of farm adaptation in Africa and that markets provide an important platform for farmers to gather and share information. Even Nyangena (2007) made a similar observation that in Kenya, long distances to the markets negatively and significantly influence the adoption of agricultural technologies of soil and water conservation.

Also established by the study was a positive relationship between local agro-ecological conditions and farmers' adaptation to climate change. It was revealed that farmers living in lower agro-ecological zones more likely to adapt to climate change than their counterparts in higher agro-ecological zones ($\psi = 0.0037, p<0.05$). Maddison (2006) and Nhemachena and Hassan (2007) made the same observation that local agro-ecological conditions had a higher likelihood of influencing a farmer to perceive climate change and hence his decision to adapt or not. However, the researchers noted that farmers' decision to adapt or not could vary across different agro-ecologies as each agro-ecology has its own set of conditions.

As to the farm income, the study revealed a positive relationship between farm income and farmers' adaptation to climate change. The study found out that farmers with high farm incomes were more likely to adapt to climate change compared to farmers with lower farm incomes (***ψ*** = *0.0077, p<0.01*). This observation is similar to that by Franzel (1999) and Knowler and Bradshaw (2007) who noted that farmers' incomes (whether farm or off-farm income) have a positive relationship with the adoption of agricultural technologies since the latter requires sufficient financial wellbeing to be undertaken. Nonetheless, off-farm income generating activities may sometimes present a constraint to adoption of agricultural technology because they compete with on-farm activities. Thus, off-farm income is sometimes less likely to influence on-farm adaptation by farmers.

The study further unveiled that farmers' access to information on climate change through extension services had a higher likelihood of influencing the farmer to adapt to climate change. Farmers with access to information were more likely to adapt to climate change compared to their counterparts without access to climate change information (***ψ*** = *0.0049, p<0.05*). A number of studies confirm these results such as those by Adesina and Forson (1995), Gbetibouo (2009), Maddison (2006) and Nhemachena and Hassan (2007) who have separately noted that farmers' access to information on climate change is likely to enhance their probability to perceive climate change, and hence adopt of new technologies and take-up adaptation techniques.

Though access to credit is associated with a positive effect on adaptation behavior (Caviglia-Harris 2002; Gbetibouo, 2009), access to credit in this study was found to be inversely related to farmers' adaptation to changes in climate such that farmers with access to credit were less likely to adapt compared to farmers without access to credit (***ψ*** = *-0.0189, p<0.05*). The possible reason for this is that the adoption of an agricultural technology may demand the use of owned or borrowed funds. Since such an investment in technology adoption may be hampered by lack of borrowing capacity (El Osta and Morehart, 1999), this may negatively end up affecting any perception of the farmers or even the taking up of adaptation measures.

As expected, the study revealed a positive relationship between change in temperature and adaptation by famers. It was found out that farmers who notice a rise in temperature were more likely to adapt compared to those who have not noticed any rise in temperature (***ψ*** = *0.0146, p<0.05*). 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 more likely to promote the need for the farmers to adapt to climate change. Gbetibouo (2009) made the same observation in her study of farmers in Southern Africa.

As for the precipitation, the results also came out as expected. The study found a negative relationship between change in precipitation and farmers' adaptation. That is, farmers who notice a rise in precipitation were less likely to adapt compared to those farmers who notice a decline in precipitation (***ψ*** = *-0.0135**, p<0.01*). The possible reason for this negative relationship is that farming in Kyuso District is already water scarce and therefore, increased precipitation in such a water scarce area was unlikely to constrain farm production and therefore unlikely to promote the need to adapt to the changing climate. Gbetibouo (2009) also agrees with these results from her study conducted among smallholder farmers in Southern Africa.

6. Conclusions and Recommendations

The study set out to assess farmers' adaptation to climate change in Kenya with special reference to Kyuso District. It was found out that 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. As such, most farmers had undertaken necessary adaptation measures to counter the adverse effects of climate change.

Popular adaptation methods among farmers who perceived increases in temperature were: changing land under cultivation, planting different crops, crop diversification and migration to a different site. Adaptation methods used by those who perceived extended periods of temperature were: planting different crops, crop diversification, increasing water conservation practices, adjusting the number and management of livestock and changing the size of land under cultivation. On the other hand, adaptation measures least employed by farmers who perceived changes in temperature included: switching from livestock to crops, switching from non-farming to farming and increased use of irrigation technology.

As regards precipitation, majority of farmers who noted a decrease in precipitation and an increase in the frequency of droughts migrated to a new site and adjusted the number of livestock and livestock management practices. For those farmers who noted a change in the timing of rains, a majority opted to migrate to a different site while a few others decided to adjust the number of livestock and livestock management practices. The least popular adaptation methods among all farmers who either noted a decrease in precipitation or a change in timing of rains were switching from non-farming to farming and the use of irrigation technology due to scarcity of irrigation water.

The results from the study also show that the age of the farmer, gender, education, farming experience, farm income, access to climate information, household size, local agro-ecology, distance to input/output market, access to credit, access to water for irrigation, precipitation and temperature were crucial determinants of farmers adaptation to climate change in the district. Any policy aimed at enhancing the adaptive capacity of the farmers in the study area should thus consider making use of the factors mentioned afore.

Since Kyuso District is water scarce, the study found out that farmers were in dire need of water for irrigation. Therefore, a policy for dryland irrigation is recommended so as to help farmers adapt their farming systems to the changing climate. This would go a long way in enhancing farm output, food security and the general livelihoods of the people. It was also discovered in the study that farming in the district is mostly carried out by women as men are based in towns carrying out off farm activities. This has important policy implication in that women would therefore need to be empowered through women groups and associations since this could have significant positive impacts for increasing the uptake of adaptation measures by the farmers. The policy framework could also consider promoting women in terms of access to education, assets, and other critical services such as credit, farming technology and inputs supply.

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Table 1: Results of the Probit Regression Model of Farmers' Adaptation to Climate Change in Kyuso District, Kenya

	Regression model		**Marginal effects**	
Explanatory variables	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Age	0.012***	0.001	0.0034**	0.036
Gender	0.008**	0.039	-0.0037*	0.081
Education	0.059***	0.000	0.0100***	0.006
Farm experience	0.023**	0.037	0.0031**	0.042
Household size	-0.026*	0.070	-0.0022*	0.071
Irrigation water	-0.050*	0.084	-0.0030*	0.065
Distance to market	0.007**	0.023	-0.0024***	0.000
Local agro-ecology	-0.070**	0.044	-0.0037**	0.032
Farm income	0.083	0.201	0.0077***	0.001
Fertility of the soil	-0.010	0.121	-0.0181	0.438
Climate information	0.060*	0.059	0.0049**	0.045
Extension services	-0.016	0.825	0.0215	0.566
Access to credit	-0.211***	0.009	-0.0189**	0.028
Off farm income	0.025	0.623	0.0101	0.175
Change in temperature	0.047**	0.043	0.0146**	0.017
Change in precipitation	-0.045**	0.025	-0.0135***	0.001
Econometric Diagnostics				
Likelihood ratio test for zero slopes	*137.38, p > Chi2(15) = 0.0000*			
Pseudo R^2	*0.7671*			
Total observations	*246*			

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