Assessment of Farmers' Perception to the Effects of Climate Change on Water Resources at Farm Level: The Case of Kakamega County, Kenya

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Invited poster presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia

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Abstract

In the face of climate change, a number of climate variables such as temperature, precipitation, wind speed, humidity and solar radiation tend to affect water resources. This has led to changes in soil moisture, reduced stream run off, reduced ground water recharge and increased transpiration which ultimately causes deterioration of on-farm water resources. Deteriorating water resources at farm level as a result of climate change has led to decreased crop yields in sub Saharan Africa and threatens food security, livelihoods as wells as water security. Understanding factors affecting farmers' perception of climate change effects on water resources is key in informing policies that can transform smallholder agriculture in Africa to be more resilient to the effects of climate change. This study assesses farmers' climate change perceptions on water resources at farm-level in Kakamega County, Kenya. Using data collected from 159 farm households in Kakamega County, ordered probit was employed to assess factors affecting farmers' perception of climate change based on water resources. The results indicate that gender, farm size, distance to the main water source, extension services, access to climate change information through radio and wealth status significantly explained levels of farmers' perception of climate change based on water resources. The findings inform policies aimed at increasing awareness of climate change effects on on-farm water resources and consequently enhance adaptive water management strategies among smallholder farmers.

Key words: perception, climate change, ordered probit, water resources

1. Introduction

Climate change is a major global challenge and has greatly affected countries that largely depend on agriculture for food and livelihood, particularly in sub Saharan Africa (Dixon et al. 2001). Climate change is projected to have a range of impacts that adversely affects agriculture and water resources. For example, reduced water availability, and more frequent extreme weather conditions are associated with climate change (IPCC 2007). Climate change threatens the realization of food security and economic growth in sub-Saharan Africa (Parry et al.2005), since rain fed agriculture remains the principal source of staple food production and a source of livelihood to majority of the population in Kenya. This makes the majority of households to be vulnerable to climate change.

Water as a natural resource faces constraints from rapid increase in population, pollution and destruction of water catchment areas. These constraints are compounded by climate change effects mainly through increase in temperature which causes water loss by evaporation as well as increased frequency of drought and flood occurrences (IPCC 2001). These effects have significant negative implications on water resources at farm level leading to low agricultural productivity. Moreover, water availability for agricultural production is under threat from changing climate given possible decrease in precipitation. It is also projected that water demand should rise by between 12-27 percent to meet the growing demand of food by 2025 (IWMI 2000).Therefore water at the farm level should be an important issue in food security and poverty alleviation policy agenda.

IPCC (2007) report indicates that 75 to 250 million people worldwide will be affected by water scarcity aggravated by climate change by the year 2020. Furthermore, rain fed agricultural production and access to food in several African countries is expected to decline by 50 percent leading to poverty, food insecurity and loss of livelihoods (IPCC 2007). This has already been observed in Kenya. For instance, the country's famine cycles have been reducing significantly from 20 years in 1964-1984, to 12 years in 1984-1996, two years in 2004-2006 and yearly in 2007, 2008 and 2009 due to increased frequency of droughts (GoK 2010 a). Livestock and agriculture sectors were the most affected by the 2008 drought, with decline in productivity of about 72 percent. (GoK 2012 a).This is critical given that agriculture is one of the six sectors that were identified to have potential to contribute to the 10 percent growth in the GDP as envision by the Kenya Vision 2030 (GOK. 2008).

These evidence available that climate has changed and the projections that climate will continue to change in the future underscores the need to understand farmers' perception and adaptation to climate change. Farmers' knowledge about climate change is key and largely determines what strategies they adopt in their attempt to reduce adverse effects of climate change. A number of studies (Deressa et al. 2009; Gbetibouo, 2009; Benedicta et al., 2010), have been carried out on perceptions and adaptation to climate change in sub Saharan Africa. Most farmers observed an increase in temperature and a decrease in the amount of rainfall over the years.

Other studies have gone further and assessed the accuracy of farmers' perception to climate change. For instance, Gbetibouo (2009), compared farmers' perception of long-term changes in temperature and precipitation with climate trends recorded at the nearby meteorological stations. The study found out that the farmers' perceptions were in line with the actual climate data. The literature on adaptations also makes it clear that perception is a necessary requirement for adaptation (Maddison 2006). More studies have reported that most farmers who perceive that climate is changing, respond by adapting to the adverse effects caused by climate change (Ishaya and Abaje 2008; Thomas et al. 2007; Mertz et al. 2009).

Although a number of studies have been carried out on perception and adaptation to climate change in developing countries (Nhemachena and Hassan 2007; Deressa 2007; Kitinya et al. 2012), these studies do not particularly put emphasis on climate change perception and its linkage to water resources at farm level. Assessment of perception is significant since farmers' subjective judgment of climate change effects on water resources is likely to influence how they respond to the adverse impacts of climate change by adopting to adaptive water management strategies. Whereas it is important to understand farmers' perception of climate change, there is still a gap in understanding climate change perception based on on-farm water resources and its linkages to adaptive water management. Assessing different levels of farmers' perception is therefore necessary for successful efforts to combat negative effects of climate change on water resources at farm level. Similarly, perception of the severity of climate change effect of on-farm water resources is important in the adaptation of climate change since it can influence the willingness of the farmers to respond to climate change effects (Patt and Schroter 2008). In Kenya, many studies on climate change have also concentrated in arid and semi-arid areas where the effects of droughts is easily manifested, while farmers in areas that receives an average annual rainfall above 1000 mm (such as the study area) are usually neglected. This study also addresses this gap and is likely to have a policy implication on climate change and its effects on on-farm water resources.

Kakamega county as one of the major food production regions in Kenya (Nyoro et al. 2004) is experiencing adverse effects of climate change that threatens water resource for agricultural production (GoK 2012a). Despite receiving high average annual rainfall, the area is characterized by erratic rainfall where unusual early rains that are followed with weeks of dry period have characterized the planting seasons in the study area. Moreover, there has been increased intensity of rainfall received and delay of onset rain which tend to affect agricultural production making farmers more vulnerable to climate risk. In light of these uncertainties, there is a looming threat to both food security, water security and sustainable livelihoods among farmers.

The government of Kenya over time has come up with various strategies and policies (WATER ACT 2002, forest policy of 2007, National Climate Change Response Strategy) to reduce the effect of climate change in agriculture and water resources. Notwithstanding the various policies, lack of better understanding of climate change perception based on farm-level water resources among policy decision makers and other stakeholders has led to poor decision making with regards to policy. This study addresses the research gaps by assessing factors that influence farmers' perception of climate change effects on water resources at farm level. The study also supports realization of Sustainable Development Goal-2 that is, to end hunger, achieve food security and improved nutrition and promote sustainable agriculture by 2030 as well as Sustainable Development Goal -13 which seeks to urgently combat climate change and it is impacts.

2. Objective

The objective of the study was to assess factors influencing farmers' perception of climate change effects based on water resources at farm-level in Kakamega county.

3. Methodology

Theoretical Framework

This study uses theoretical framework from the utility maximization theory. Based on random utility theory, a random utility model (RUM) describes a choice decision in which individual i has a set of alternative j from which to choose (McFadden 1978). In this case, farmers are asked to score there level of perception based on on-farm water resources using likert scale. The level of utility U_i from a specific choice is a latent variable known only to the decision maker (farmer i) and observed through the scores made by the farmers denoted as Y_i. In this case the *j* ordered categories are 1(strongly disagree), 2 (disagree), 3 (somewhat agree), 4 (agree), 5 (strongly disagree).

The model assumes that the scores represent an ordered segment of the utility distribution. Therefore, an individual farmer chooses an alternative from the set of available alternatives that maximizes utility. Further, it is assumed that the farmer's utility is a function of socio-economic characteristics. A discrete choice model (ordered probit model) was used to analyze factors affecting farmers' perception of climate change on water resources as opposed to linear model since the dependent variable takes values that are not continuous but discrete and ordered in nature (Greene 2000).

Let;
Y_1 = "Strongly disagree"
Y_2 = "Disagree"
U_1 = Utility a farmer gets from choosing "strongly disagree"
U_2 = Utility a farmer gets from choosing "disagree"
Based on RUM, the farmer will chooses Y_2 instead of Y_1 if Y_2 leads to a higher utility than Y_1 (Greene, 2003).

Model specifications

To ascertain perceived impact of climate change on water resources at farm-level, respondents were asked to rate the severity of climate change effects on water resources in terms of climate change perception levels using a five point Likert scale. The likert scale was as follows; 1.strongly disagree, 2. Disagree, 3. Somewhat agree 4. Agree, and 5. Strongly agree. Therefore the responses (the dependent variable) were ordered and discrete, making ordered probit model the appropriate for the empirical estimation (Greene 2003).

Ordered probit model assumes that the value of the dependent variable Y_i^* is unobservable. It assumes an underlying utility function:

$$Y_{im}^* = X_{im}\beta + \varepsilon_{im} \qquad 3.2$$

Where;

Y_{im}^*= The latent unobserved variable that corresponds climate change perception level,

X_{im}= The is a vector of socio-economic characteristics of the i^{th} farmer,

β = The unknown parameter to be estimated while,

ε_{im}= The random term of the latent utility function.

Following (Greene 2003) Y_{im}^* is unobservable and we therefore observe:

$$Y_i = \begin{cases} 0 \text{ if } Y_{im}^* \leq 0 \\ 1 \text{ if } Y_{im}^* 0 \leq Y_{im}^* \leq \mu_1 \\ 2 \text{ if } \mu_1 \leq Y_{im}^* \leq \mu_2 \end{cases} \qquad 3.3$$

Where Y_i = when a farmers 'agrees', 'somewhat agrees' or 'disagrees' with perception statement that climate change is affecting water resources at farm level

The μ_s are unknown parameters which are jointly estimated with β-coefficients. It assumed that the random term of the ordered probit model follows a standard normal distribution. The model is estimated using maximum likelihood estimation methods with the probability specified as follows;

$$P(y = 0|X) = F(-\beta X_I), \qquad 3.4$$

$$P(y = 1{:}\,|X) = F(\mu_1 - \beta X_I) - F(-\beta X_I),$$

$$P(y = 2|X) = F(\mu_2 - \beta X_I) - F(\mu_1 - \beta X_I)$$

Where F (˙) = The cumulative standard normal distribution function

P (.) = Probability of farmer choosing either 'agree', 'somewhat agree' or 'disagree' given the X variables

X = Vector of independent variables that affect the farmers perceptions levels

β = Vector of unknown parameters to be estimated

Marginal Effect

Ordered probit model is a non-linear regression model and therefore, the coefficients from the regression are not the marginal changes in dependent variables as independent variables change. To evaluate marginal change in an ordered probit model, marginal effects are calculated. The marginal effects were computed as follows;

$$\frac{\partial p(y = 1|X)}{\partial X_j} = f(\mu_1 - X_i\beta)\beta_j \qquad 3.5$$

$$\frac{\partial p(y = 2|X)}{\partial X_j} = f(\mu_1 - X_i\beta)\beta_j - f(\mu_2 - X_i\beta)\beta_j$$

$$\frac{\partial p(y = 3|X)}{\partial X_j} = f(\mu_2 - X_i\beta)\beta_j - f(\mu_3 - X_i\beta)$$

Where f (.) is a density function of a standard normal variable.

$$\frac{\partial p(.)}{\partial X_j} = \text{the change in Y given X as independent variable of the jth probability}$$

However, the marginal effects for dummy variables are calculated as the difference between the two resulting probabilities when the dummy variables equals to two values, 0 and 1

Table 1 provides a description of independent variables that were used in ordered probit regression model and there expected signs.

Table 1: Description of explanatory variables and their expected signs.

Variable	Description and Measure of the variables	Expected sign
Age	Age of the farm household head (years)	+ /-
Household size	Number of people in the household	+ / -
Gender of household head	Dummy variable 1 = Male, 0 = Female	+ / -
Education level	Number of years in formal education	+
Main occupation	Main occupation of household head 1 = Farming 0 = Otherwise	+
Farm size	Size of the farm in acres	+
Extension	If household has access to extension services 1 = Yes, 0 = No	+
Tarmac road	Distance in kilometres to the nearest tarmac road	-
Water distance	Distance in kilometres to the nearest water source	-
Distance_ produce market	Distance in kilometres to the nearest market	-
Radio	If household has access to climate information through rado1 = Yes, 0 = No	+
Wealth status	An index constructed using household asset ownership	+
Own experience	Perceive climate change because of own experience	+

Study area

The study was conducted in Lugari sub-county, Kakamega County in Western Kenya, where 159 farm household were interviewed using semi-structured questionnaires. The region was selected owing to its fragility and sensitivity to climate variability (GoK 2012b). It occupies an area of 368.2 km^2 and is divided into two administrative divisions namely; Lugari and Matete. Lugari division occupies an area of 266.3 km^2 with four locations and eight sub-locations while Matete division has an area of 101.9 Km^2 with two Locations and seven sub-locations. Lugari sub-county lies at an altitude of between 1600-1999 m above sea level and between longitude $34^0$28'and 35^0 East and between latitude 0^0 25' and 1^0 North of the Equator. Climate and rainfall pattern are largely equatorial type with temperatures between 6 –24 degrees centigrade. The annual rainfall averages between 1100-1600 mm distributed between two seasons of March to July and September to November. Late November to late February or early March is traditionally the long dry season, and mid-June to late July is the short one; but this has become variable with frequent drought spells in between (GoK 2012 a).

The sub-county is divided in two agro ecological zones, that is, the Upper Midland zone (UM3-4) and the Lower Midland zone (LM3-4). Lugari division lies in the Upper Midland zone where intensive maize farming is the common crop enterprise whereas Matete division lies in the Lower Midland zone where maize and sugarcane farming are the main crop enterprises. Crop production and livestock keeping are the main economic activities in the area. Maize and bean cultivation is for both commercial and subsistence, coffee, sugarcane and sunflower are the main cash crop in the study area.

4. Results and discussion

4.1 Household's socio economic characteristics

Using Stata, descriptive statistics were generated, farm and household characteristics of the farmers in Lugari sub-county are presented in Table 2

Table 2: Selected farm and household characteristics of farmers in Lugari sub-county

Variable	Mean (Std dev.) n=159	Percentage (%) n=159
Household size	5.91(2.5)	
Age	52.1 (12.4)	
Male		84.28
Female		15.72
Income	255340 (2844890)	
Education	9.4 (3.9)	
Credit access:		28.30
No credit access		71.70
Farming Experience	22.2(12.2)	
Farm size	5.6 (10.1)	
Extension		48.43
No extension		51.57
Group member		61.64
Not a group member		38.36
Produce market distance	4.8 (5.5)	
Tarmac road	7.5 (5.01)	5.01
Water Distance	0.36 (0.8)	0.841

Source: Author's survey 2014

As shown in Table 2, Majority of the households were headed by men (84 percent) and only16 percent were headed by women. On average, a household had 6 members with a minimum family size of 1 person and a maximum of 10 people. This was higher than the national average household size of 4.3 (GoK 2010b). The average age of the household head was 52 years with the range of 28 to 82 years. The result is comparable to the national average age (57 years) of a farmer in Kenya (Momanyi et al. 2012). Moreover, the average years of farming experience of the household head was 22 years, which implies that very few young people are engaging in farming as an economic activity in the study area. This may be attributed to lack of access of agricultural land among the young people. With regard to education, majority of the respondents had secondary education (49 percent), followed by primary education (34 percent). Few farmers had attained tertiary education (11 percent) and only 6 percent of the respondents had no formal education (Figure 1). Generally, the education level of the household head in the study area was better than the national average given that about half of the respondents had attained secondary education compared to the national average of 18 percent. (KNBS 2013).

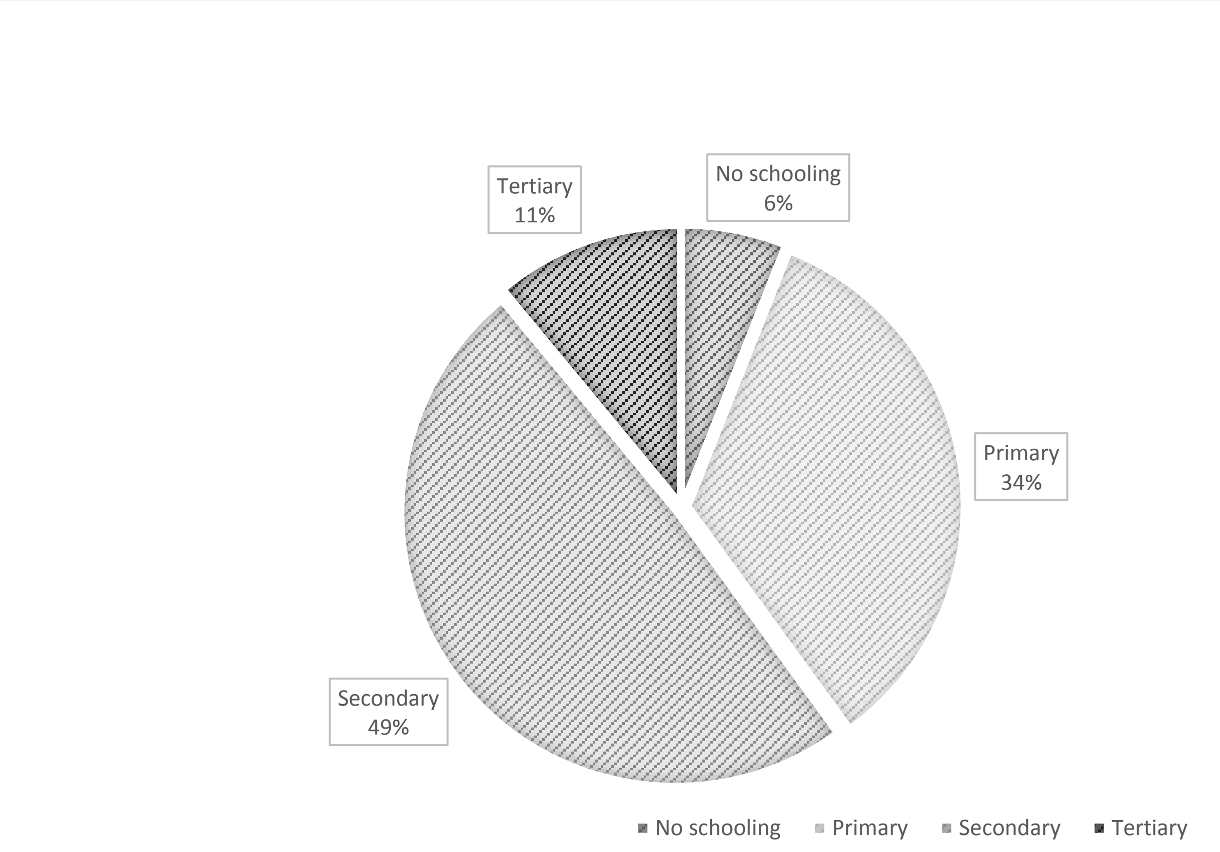

Figure 1: Highest education level attained by the household head in Lugari Sub County

Source: Survey data, 2014

The average farm size was 5.2 acres, with a minimum of 0.25 acres and a maximum 53 acres. Most of the respondents had less than 5 acres of land. Smallholder farmers are defined, as those with operating less than 5 acres of cropland (World Bank 2003), which means that the majority (76 percent) of the farmers interviewed were smallholder farmers. The average distance to main water source was 0.32 kilometres, implying that most farmers are closer to the water source. The likely reason is that the main source of water for about half of interviewed farmers (54 percent) was hand dug wells, often at the homestead.

The average distance to both input and produce market was approximately 5.kilometres. Most farms were also located far away from the tarmac roads, because the average distance to the tarmac roads was 5.01 kilometres. The implication is transaction costs related to the market may acts as a barrier to access input and output markets. There was limited access to credit where majority of respondents (72 percent) had no access to credit for the last three years. Therefore, suggesting poor access to financial services which is likely to limit famers' investment in farming (Gbetibouo 2009). Further, the results show that about half of the respondents (48 percent) had contact with the extension officers. Household heads who belonged to farmer's group were the majority at 62 percent. The farmer group provided pooled farm labour services such as planting and harvesting, farmer groups also enabled farmers to save money and get credit commonly referred as *merry go round*. Membership to a group can also be beneficial because individual farmers can easily access credit, agricultural information as well as access to the market through the farmer groups.

4.2 Determinants of climate change perception on water resources at farm-level

An ordered probit regression was estimated to determine factors influencing farmer's perception of climate change effects on water resources at farm level. Multicollinearity, goodness of fit, and specification tests were carried out. A robust model was also estimated to address the possibilities of heteroscedasticity in the regression model. (StataCorp 2013; Hassan and Nhemachena 2008). The existence of multicollinearity was ruled out using Variance Inflation Factor (VIF) since all the explanatory variables had a VIF less than 2, with a mean VIF of 1.23 Multicollinearity is present in a model if VIF > 10 (Gujarati 2004). The chi-square value for log likelihood function was also highly significant indicating that all the coefficients of independent variables in the model were significantly different from zero. To test for specification, link test was also carried out. The link test is based on the idea that when a regression is properly specified, you should be able to find no additional independent variables that are significant. The null hypothesis is, there is no specification error. For the link test in Stata, it is the significance of hat squared that is interpreted. If the p-value of hat squared is significant, the null hypothesis is rejected and conclude that our model is not correctly specified. In this model the hat-squared was not significant therefore we fail to reject the null hypothesis and conclude that the model is correctly specified. (StataCorp 2013).

From the five level of perceptions, "strongly disagree", "disagree", "somewhat agree", "agree" and "strongly disagree", the marginal effects were computed for only three level of perception out of the possible five levels. This was due to no response.at all or very few respondents assigning those specific levels of perception to climate change. In particular, there was no response for "strongly disagree" category while only three out of 159 respondents chose "strongly agree" as their level of perception. Therefore, the three categories that were used in the regression were; "disagree", "somewhat agree" and "agree". Marginal effects were computed after the regression as presented in Table 3. In ordered probit, the marginal effects are interpreted as effects of changes in the independent variables on the predicted probabilities of being under one category (such as "disagree") of dependent variable.

In general, gender, farm size, distance to the main source of water, contact with an extension officer, access to climate change information through radio and wealth status, significantly explained the level of climate change perception based on water resources. The probability of agreeing that climate change affects water resources increased by about 24 percent in men heading household, whereas the probability of both disagreeing and somewhat agreeing to climate change perception on water resources decreased by 8 percent and 17 percent respectively among men headed households. This is possibly due to the different gender roles of both men and women which exposes men to higher possibility of acquiring information on climate change and consequently affecting their climate change perception. For instance, women are always restricted to household chores and on-farm labour while men are often engaged in non-farm labour and frequently have interactions in the market where they have easy access to information. Similar result was reported by Ndambiri et al. (2012) who found that perception of climate change was higher for men heading households than women heading households. This is implies that policies should be designed and implemented in such a manner that would lead to greater equity and equality by taking into consideration the adaptive capacity of both men and women in relations to the gender their gender roles.

Respondents with larger farm size were more likely to agree that climate change is affecting water resources at farm level by 1 percent. While an increase in farm size by an acre of land reduced the probability of farmers disagreeing and somewhat agree by 0.2 percent and 0.8 percent respectively. The possible explanation is a farmer with a larger piece of land would experience greater loss caused by climate change effects on water resource than farmers with smaller pieces of land leading to higher perceptions. With the looming water scarcity at the farm level, farmers with larger pieces of land may not be able to maintain farm productivity leading to yield reductions. This implies is that perceptions depends on the impact of the climate risk to the farmer, therefore awareness of climate change and promotion of adaptive technologies by the government should consider the vulnerability of the farmer towards the climate change risks

Proximity to the water source significantly influenced climate change perception among crop farmers. Contrary to expectation, a kilometer increase in distance to main water source increased the probability of a farmer to both disagree and somewhat agree to the perception of climate change by 3 percent and 12.6 percent respectively, but reduced the probability of respondent to agree that climate change affects water resources by 15 percent. Plausible explanation is that farmers nearer the water sources (mainly hand dug wells and springs) may have noticed more degradation of water sources caused by climate change effects compared to the farmers who are further from the water sources who may hardly attribute degradation of water resources to the effect of climate change This is helpful to the stakeholders such as government and non-governmental organization who can ensure that distance to a water source from the farm is considered in the implementation of policies that can enhance water security among the farmers.

Farmers who had contact with an extension officer were likely to agree that climate change affects water resources by about 13 percent. Similarly, contact with an extension officer reduced the probability of a farmer to somewhat agree that perception climate change affects water resources by about 11 percent. Extension services accelerates information dissemination to the farmers therefore, farmers who have access to extension services could easily have access to climate change information. The results are comparable to those of Nhemachena and Hassan (2007) who found that access to free extension services increases the awareness of changing climatic conditions as wells as the probability of taking up adaptation measures in response to the changing climate in Southern Africa. Similar study by Bryan et al. (2009) showed that access to extension services had a positive influence on climate change adaptation. Since extension services plays and important role in creating awareness of climate change and consequently in the adoption of adaptive practices, the government should invest in extension services by increasing the extension staff to farmer ratio. This is likely to enhance effectiveness of climate change information dissemination to the farmers.

Table 3: Ordered probit marginal effects for the three levels of climate change perception on water resources among farmers

Variable	Disagree		Somewhat agree		Agree	
	dy/dx	p>z	dy/dx	p>z	dy/dx	p>z
Age	-0.001 (0.001)	0.342	-0.002 (0.003)	0.330	0.003 (0.003)	0.327
Gender	-0.080* (0.048)	0.096	-0.169*** (0.057)	0.003	0.240*** (0.092)	0.009
Household size	0.005 (0.004)	0.191	0.019 (0.014)	0.165	-0.023 (0.016)	0.156
Education	-0.001 (0.002)	0.445	-0.006 (0.008)	0.460	0.007 (0.009)	0.453
Main Occupation	-0.023 (0.023)	0.306	-0.080 (0.064)	0.214	0.098 (0.082)	0.229
Farm size	-0.002* (0.001)	0.061	-0.008** (0.004)	0.029	0.010** (0.004)	0.025
Water Distance	0.033*** (0.013)	0.009	0.126*** (0.041)	0.002	-0.150*** (0.044)	0.001
Tarmac Road	-0.001 (0.002)	0.436	-0.006 (0.007)	0.406	0.007 (0.008)	0.409
Produce Market	-0.012 (0.010)	0.230	-0.047 (0.044)	0.277	0.057 (0.050)	0.261
Extension	-0.028 (0.017)	0.101	-0.108* (0.062)	0.084	0.128* (0.073)	0.077
Own Experience	0.018 (0.028)	0.525	0.088 (0.179)	0.625	-0.098 (0.187)	0.599
Radio	-0.068** (0.033)	0.039	-0.172*** (0.059)	0.004	0.231*** (0.080)	0.004
Wealth Index	-0.013*** (0.005)	0.009	-0.049*** (0.015)	0.001	0.059*** (0.017)	0.000

*significant at 10%** significant at 5% *** significant at 1%
NB:Figures in parentheses are the standard errors

Source: Author's survey 2014

As expected, access to climate change information through radio had significant and negative effect on probability of a farmer to both disagree and somewhat agree to climate change perception by 7 percent and 17 percent respectively. Likewise, access to climate change information through radio increased the probability of a farmer agreeing that climate change affects water resources at farm level by about 23 percent. A study by Mano and Nhemachena (2006) in Zimbabwe also showed that access to weather information is key in shaping farmers' perception of climate change. Therefore, mass media such as radio plays an important role in the dissemination of climate change information. Radio seemed to be more reliable source of information among the farmers in the study area. A combination of extension services with radio programs would be more effective in the dissemination of climate change information, adaptive water management technologies as well as support services to the vulnerable farmers.

Wealth status also influenced farmer's perception of climate change effects on water resources at farm level. The probability of a farmer agreeing that climate change affected water resources increased with the wealth status of the farmer by about 6 percent. Wealth status also negatively influenced the probability of a farmer disagreeing or being neutral by about 1 percent and 5 percent respectively. This therefore means that farmers who are well off are more likely to perceive climate change effects on water resources than poor farmers possibly because wealthier farmers can access information. The result supports Deressa et al. (2008) findings that wealth had significant effect on farmers' perceptions of climate change in Nile basin, Ethiopia. Since wealthier farmers tend to have better access to information and greater access to technology and information, the government should put more effort to increase income of farmers, for example, the government should come up with policies that will increase credit availability to farmers, investing in high-income crop enterprises and creating opportunities for off-farm employment in the study area.

Although age of the household had a negative sign for "disagree" and "somewhat disagree" and a positive sign on "agree" (which implies that older farmers tend to agree that climate change effects on-farm water resources), it did not significantly influence the farmers' perception of climate change head. Nevertheless, age which is a proxy for farming experience shows that more experienced farmers tend to agree more that climate change has an effect on water resources at the farm level. Main occupation also had a negative effects "disagree" and "somewhat agree" and positive sign for "agree", even though the marginal effects were not significant, the results shows that farmers whose main occupation is farming were more likely to perceive climate change has an effect on water resources at farm level.

Distance to the tarmac road and distance to the produce market were not significantly influencing climate change perception based on water resources at farm level. However, due to their negative sign on "disagree" and "somewhat agree" and a positive coefficient on "agree" it can be inferred that farmers closer to the output market and tarmac road were less vulnerable to the effects of climate change on water resources compared to farmers who were far from the tarmac road, thus lower perception on climate change effect on water resources. Distance to tarmac road and distance to output market were proxies for market access. Therefore, this indicates that farmer's access to market can reduce vulnerability to the effects of climate change

Recommendation and policy implications

From results, possible policy interventions can be suggested. Key conclusions and policy implications from the study are as follows:

The level of perception of climate change determines how the farmer will respond to the negative effects of climate change. The study finds that access to climate change information through extension officers or through radio enhances farmer's perception to climate change. The government should therefore put more effort to come up with programs that can help to disseminate climate change information to the farmers since awareness of climate change plays an important role in climate change adaptation. The government should also invest in extension staff to enable farmers to easily access the extension services. Since gender of the household head, farm size and distance to the main source water are found to influence perception of climate change based on water resources, this factors should be considered while designing the policies climate change. Programs and policies on climate change should not only be tailored towards the smallholder farmers, but also designed in a way they can achieve gender equity.

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