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Farmers Perception and Adaptation to Climate Change: An Estimation of Willingness to Pay

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Abstract

This paper assesses farmers' perception and adaptation to climate change to enhance policy towards tackling the challenges climate change poses to the farmers in Ghana. With regards to farmers' perception and methods of adaptation, majority of the farmers perceived increase in temperature and decrease in rainfall pattern. Farmers' level of adaptation was found to be relatively high with majority of the farmers using changing planting dates, different crop varieties, soil conservation and water harvesting as the major adaptation measures to climate change impacts. However, access to water, high cost of adaptation, lack of information, lack of knowledge on adaptation, insecure property rights, insufficient access to inputs and lack of credits were identified as the major barriers to adaptation. The probit regression estimation results indicated that the probability of willingness to pay for climate change mitigation policies increases with age, years of education and ownership of farm land.

Key words

Perception, adaptation, climate change, willingness to pay, probit regression.

Introduction

Climate change is expected to pose a serious threat on environment, agricultural production and food security of most developing countries including Ghana. In particular, rural farmers, whose livelihoods depend on the use of natural resources, are likely to bear the brunt of adverse consequences. This is largely because most developing countries experience high poverty incidence and as a result are incapable to adapt to climate change. However, the extent of climate change impacts on agriculture can be ameliorated by the perception and level of adaptation of farmers. Studies have shown that African perception and understanding of climate change are poor. For instance, Taderera (2010) reported that South African awareness of climate change was literally interpreted as "changing weather" and this may influence the extent of adaptation. Adaptation is widely recognized as a vital component of any policy response to climate change. It is a way of reducing vulnerability, increasing resilience, moderating the risk of climate impacts on lives and livelihoods, and taking advantage of opportunities posed by actual or expected climate change.

Farmers perception of climate change is crucial for their choice of adaptation and hence their willingness to pay for climate change mitigation action. However, perceptions are influenced not only by actual conditions and changes, but are also influenced by other factors. A study by Gbetibouo (2009) found that having fertile soil and access to water for irrigation decrease the likelihood that farmers will perceive climate change; however, education, experience, access to extension services increase the likelihood that farmers perceived climate change.

Despite the importance of perceptions and adaptation to climate change, in the context of Ghana, a very few studies have examined farmers perceptions and adaptation and consequent effect on their willingness to pay for climate change mitigation policy action. This study therefore analyzes how farmers perceive and adapt to climate change and their willingness to pay for climate mitigation policy. Specifically, the study seeks to (1) examine the socioeconomic characteristics of the farmers; (2) analyze their level of awareness of climate change; (3) analyze farmers perception of

climate change; (4) examine the various choice of adaptation measures among the farmers; (5) identify the barriers to adaptation among the farmers; (6) analyze the socio-economic determinants of farmers willingness to pay for climate change mitigation policy.

Literature review

In response to perceived long-term changes in climate, farm households implemented a number of adaptation measures to reduce the vulnerability of climate change impacts. Analysis of the impacts of climate change and adaptation on food production in Ethiopia (Yesuf et al., 2008) revealed changing crop variety, soil and water conservation, water harvesting, planting of trees and changing planting and harvesting periods as the choice of adaptation measures by the farmers. Among these methods of adaptation, planting trees was the dominant measure adopted by most of the farmers. However, about 42% of the farmers did not use any adaptation method for climate change impacts. Using two separate models to examine the factors influencing farmers' decision to adapt to perceived climate changes, Yesuf et al. (2008) confirmed that household wealth represented by farm and nonfarm income and livestock ownership, increases the likelihood of climate change awareness and adaptation. Deressa (2008) identified that age of household head, wealth, information on climate change, social capital and agro ecological settings have significant impact on the perception of farmers to climate change. Farmers in areas with higher annual mean temperature over the period of survey were more likely to adapt to climate change.

Numerous factors have been identified as barriers to adaptation: lack of information on choice of adaptation option, lack of financial resources, shortage of land, poor potential for irrigation and labour constraints (Deressa et al., 2008). However, lack of information on choice of adaptation option was the major barrier to adaptation. Madison (2006) and Nhemachena and Hassan (2008) showed that access to information through extension increases the chance of adapting to climate change.

Climate mitigation strategies must be seen as a collective concern for sustainability of agricultural production and livelihoods of many people especially those in developing countries. Consequently, individual willingness to contribute to climate issues is vital in such endeavour. As a result some studies have analyzed the willingness to pay for climate change mitigation policy using different models. The impact of uncertainty associated with climate change on individual decisions regarding support for climate change policy was first examined by Cameron (2005). That study used a Bayesian information updating model in a single bounded contingent valuation framework to estimate individual option price for future climate change using a convenience sample of college students. Empirical results revealed a quadratic relationship between expected future temperature changes and individual support for climate change policy. Thus, the respondents were willing to pay more with increased expected future temperature change but the amount increased at a decreasing rate.

Sonia Akter and Jeff Bennett (2009) analyzed the determinants of households' willingness to pay for Carbon Pollution Reduction Scheme (CPRS) in Australia. The willingness to pay for climate change mitigation was found to be significantly reduced by the uncertainty associated with the expectations of future temperature increases. Furthermore, the willingness to pay for Carbon Pollution Reduction Scheme was found to be negatively affected by respondents' lack of confidence in the CPRS being effective in slowing down climate change.

Analysis of the perception and willingness of graduate students to pay for gas tax (Viscusi & Zeckhauser, 2001) revealed that a major factor that may influence willingness to pay, holding risk estimates constant, is whether a respondent feels scientific uncertainty motivates a more aggressive or less aggressive approach to climate change policy. Han et al. (2010) estimated the willingness to pay for environmental conservation by tourists in China, using a contingent valuation method. The results indicated that willingness to pay increases with income, education level, and age.

Bamidele Fakayode et al. (2010) analyzed the factors affecting farmers' ability to pay for irrigation facilities in Nigeria. Empirical results from a logistic regression analysis revealed age of the farmers, education level acquired, farm household income and the size of farmers' household size as the major factors explaining farmers' ability and willingness to pay for irrigation scheme.

However, the perceptions of farmers on their choice of adaptation and willingness to pay for climate change mitigation policies in the Ghanaian context have not been extensively analyzed. Most studies on climate change concentrates on the causes and impacts of climate change with little attention on perceptions and willingness to pay for mitigation strategies. This present study examines farmers' perception and adaptation and employs a probit regression model to analyze farmers' willingness to pay for climate change mitigation policy.

Methodology

Study area description

Dunkwa lies in Shama in the Western part of Ghana and its geographical coordinates are 50 7' 0" North and 10 37' 0" West. It has an estimated population over 1500 and the main occupation in the area is farming.

Sampling and sample size

The sample for the study consists of 98 farmers in Dunkwa, a town in the Shama Ahanta East Municipality in the western region of Ghana. Random sampling technique was used to select the sample.

Data analysis

An interview schedule was the main tool of data collection while descriptive statistics and probit regression analysis were the main analytical techniques. Data was analyzed using the Statistical Product and Service Solution (SPSS) software version 15.0 and the R Statistical Programming Language. The probit regression analysis involves modeling the binary response using a cumulative standardized normal distribution. The standardized normal distribution is one with mean zero and a unit variance. The basic model of the probit estimation involves defining a variable Z that is a linear function of the variables that determine the probability:

$$Z = \beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k \quad (1)$$

F(Z), the cumulative standardized normal distribution, gives the probability of the event occurring for any value of Z:

$$p_i = F(Z_i) \quad (2)$$

The maximum likelihood analysis is used to obtain estimates of the parameters. The marginal effect of X_i is $\partial_p/\partial X_i$ and is computed as:

$$\frac{\partial p}{\partial X_i} = \frac{dp}{dZ}\frac{\partial Z}{\partial X_i} = f(Z)\beta_i \quad (3)$$

Since F (Z) is the cumulative standardized normal distribution, f (Z), its derivative, is just the standardized normal distribution itself:

$$f(Z) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}Z^2} \quad (4)$$

This research uses information criteria as technique for providing the basis for model selection. Most widely used information criteria such as Akaike Information Criteria (AIC) and the Bayesian Information Criteria are employed. The idea of AIC (Akaike, 1973) is to select the model that minimizes the negative likelihood penalized by the number of parameters as specified in the equation (5).

$$AIC = -2\log(L) + 2p \quad (5)$$

Where L refers to the likelihood under the fitted model and p is the number of parameters in the model. Specifically, AIC is aimed at finding the best approximating model to the unknown true data generating process and its applications draws from (Akaike, 1973; Bozdogan, 1987; Zucchini, 2000).

Results and Discussions

Socioeconomic characteristics of Farmers

The socioeconomic characteristics of the farmers were investigated. Results revealed cereal, vegetables and root/tubers as the types of crops grown by the farmers in the area. However, majority (73.5%) were cereals farmers. Results also revealed that 79.6% of the farmers were males whilst 20.4% were females. The average age of the farmers was 44.92 years with 37.8% in the age range of 34-41 years; 20.4% between 42-49 years; 14.3% between 58-65 years. Only 5.1% of the farmers were in the age range of 66-73 years. 10.2% of the farmers interviewed had obtained senior high school education; 48% had obtained junior high school education; 35.7% had obtained basic education; only 6.1% had no formal education. The average annual income of the farmers was GH¢1403.0612 with 48% earning between GH¢100-GH¢1000; 33.7% between GH¢1100-GH¢2000; 10.2% between GH¢2100-GH¢3000; only 8.2% of the farmers had annual income between GH¢3100-GH¢5000. Given the relatively low annual farming incomes of the farmers, their adaptation and willingness to pay for mitigation policy may be low. The distribution of years of farming experience revealed an average of 17.82 years of farming with 33.7% having between 1-10 years of experience; 32.7% having between 11-20 years of experience; 23.5% having between 21-30 years of farming experience; and 10.2% having between 31-40 years of farming experience. The average household size of the farmers was 6.7 persons with 88.8% having a household size between 4-9 persons; 8.2% having between 10-15 persons; only 1% had a household size between 21-25 persons. However, the distribution of farm size revealed an average of 4.306 acres with majority of the farmers (69.4%) having between 1-4 acres of farmland; 16.3% having between 5-9 acres; 9.2%

between 10-14 acres: only 5.1% had between 15-19 acres of farmland.

Farmers' perception to climate change

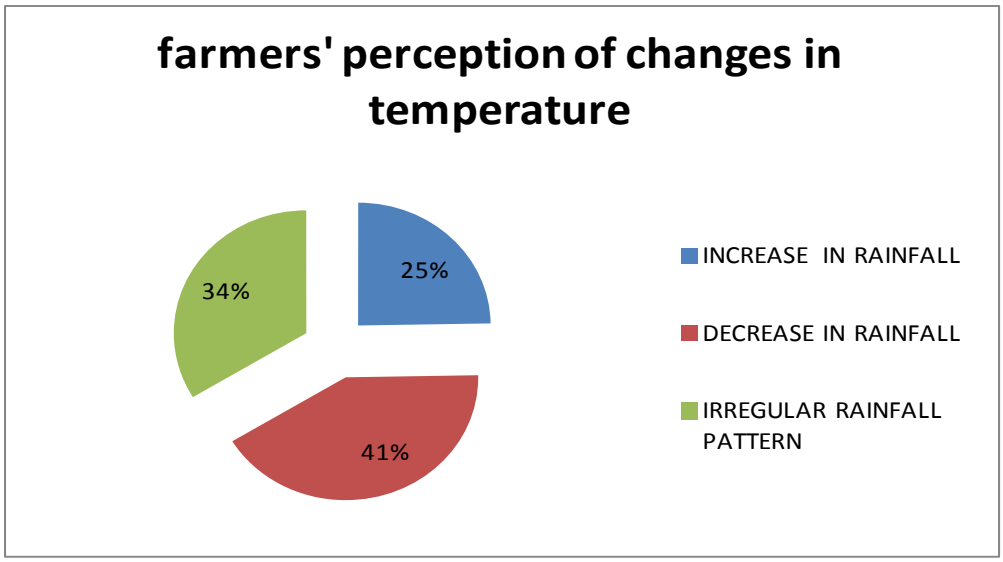
In an attempt to investigate whether the farmers perceive changes in climatic patterns, the farmers were asked questions relating to their perception of temperature and rainfall pattern. Results revealed that 84.7% of the farmers perceived climate change as a serious phenomenon; however, 15.3% did not perceive changes.

Farmers' Perception on temperature changes

About 49% of the farmers perceived increases in temperature whilst 33% of the farmers perceived a decrease in temperature. However, 18% of the farmers did not perceived any change in temperature.

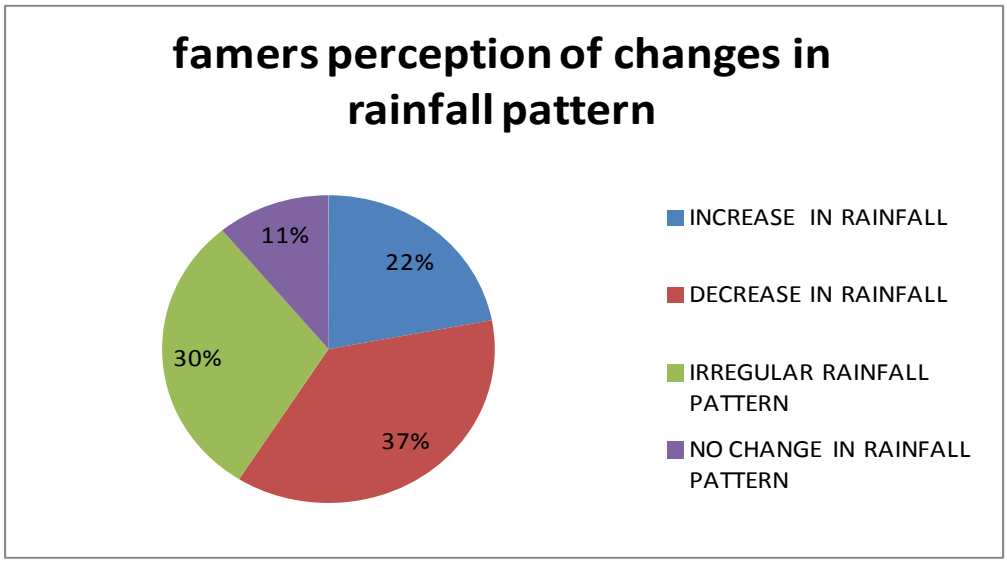
Farmers' Perception on Changes in Rainfall Pattern

The distribution of the perception of the farmers concerning changes in rainfall pattern revealed that 22% perceived an increase in precipitation; 37% perceived a decrease in precipitation; 30% perceived an irregular rainfall pattern. Despite higher perception of the farmers interviewed on changes in rainfall pattern, 11% of the farmers interviewed did not see any change in rainfall pattern.



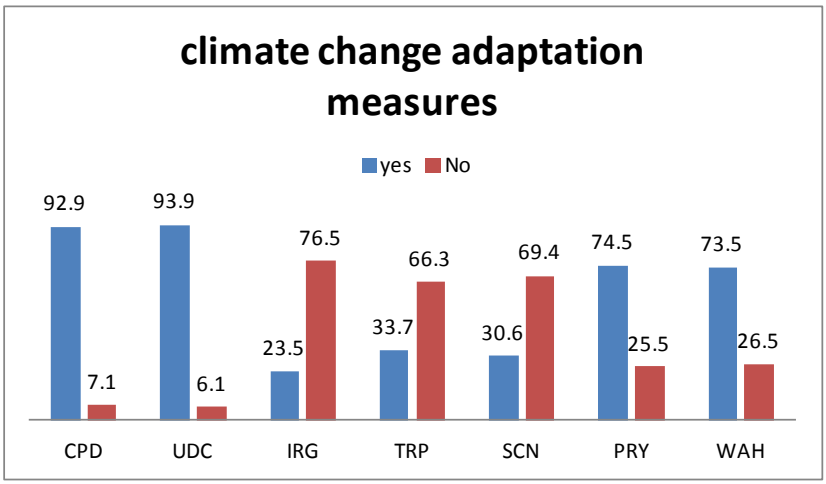
Source: Field data, 2011.

Graph 1



Source: Field data, 2011.

Graph 2



Note: CPD= Changing Planting Dates, UDC= Use of different Crop varieties, IRG= Irrigation Practices, TRP= Tree Planting, SCN= Soil Conservation, PRY= Prayers, WAH= Water Harvesting.

Source: Field data, 2011.

Graph 3

Choice of Climate Change Adaptation Measures

Attempts were made to find out whether the farmers use some climate change adaptation measures and subsequently the types and reasons for their choice of adaptation over the other options. Of the farmers interviewed, 60.2% use some form of climate change adaptation options whilst 39.8% do not use adaptation measures. Changing planting dates, using different crop varieties, tree planting, irrigation practices, soil conservation, water harvesting and prayers were the main adaptation measures used by the farmers. Of the farmers interviewed, 92.9% uses changing planting dates as their method of adaptation whilst 7.1% do not use this method. 93.9% of the farmers used different crop varieties to reduce climate change impacts whilst 6.1% have never used this measure before. 73.5% of the farmers use water harvesting as an adaptation measure whilst 26.5% do not use this method.

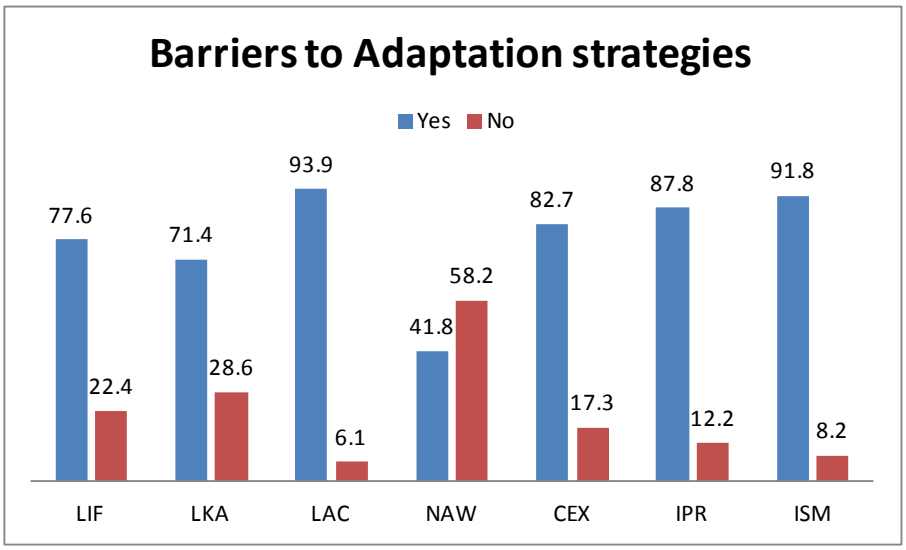
With regards to irrigation and tree planting, 23.5% of the farmers interviewed use irrigation to adapt to climate impacts whilst 76.5% do not use this method; 33.7% of the farmers use tree planting as an adaptation measure whilst 66.3% do not use this measure. Soil conservation was used by 30.6% of the farmers interviewed to adapt to climate change impacts. However, 74.5% of the farmers use prayers as a measure of adaptation and vice versa. The chart below depicts the distribution of various measures of adaptation used by farmers in Shama in the Western Region of Ghana. When asked why they preferred their choice of adaptation over the other options, 67.8% indicated that their choice of adaptation was most economical or less costly to use; 16.9% said their choice of adaptation improves the fertility of the land and prevent erosion; 10.2% said their choice was environmentally friendly; only 5.1% said their choice leads to early maturity of crops.

Barriers to Adaptation Strategies

Barriers preventing farmers from adapting to climate change was investigated. Results as shown in the graph 4 identified lack of information on climate change impacts and adaptation options; lack of knowledge about adaptation measures; lack of access to credit; no access to water, high cost of adaptation; insecure property rights and insufficient access to inputs as the major barriers inhibiting their ability to adapt to climate change impacts.

With regards to lack of information, 77.6% of the farmers identified this as the main barrier to effectively adaptation to climate change; whilst 22.4% did not think so. 71.4% of the farmers identified lack knowledge regarding adaptation measures whilst only 28.6% were aware of adaptation options. 93.9% of the farmers interviewed indicated that access to credit was very low and this had constrained many of them from effective adaptation of climate impacts.

No access to water for irrigation and other farming activities was identified by 41.8% of the farmers as a barrier to adaptation; however, 58.2% did not see access to water as a problem. Cost involved in adapting to climate change impacts was identified by 82.7% of the farmers as the reason explaining their poor adaptation ability whilst 17.3% disagreed. Insecure property rights over land constraints about 87.8% of the farmers from using any adaptation



Note: LIC= Lack of Information on Adaptation options, LKA= Lack of Knowledge on Adaptation options, LAC= Lack of Access to Credit, NAW= No Access to Water, CEX= Changes are Expensive, IPR= Insecure Property Rights, ISM= Insufficient access to Inputs

Source: Field data, 2011.

Graph 4

measure. About 91.8% of the farmers indicated that inadequate access to inputs was a barrier to adaptation. This was attributed to lack of access to credit as well as the expensive nature of adaptation measures.

Willingness to Pay for Climate Change Mitigation Policy

Climate change mitigation policies are necessary if the long term agricultural productivity, food security and the growing needs of increasing population growth are not to be compromised. As a result, the farmers were asked if they were willing to pay for climate change mitigation policies.

Of the farmers interviewed, 55.1% were willing to pay for mitigation policy whilst 44.9% were not. The study identified massive tree planting exercise, provision of irrigation facilities to farmers, training of volunteers to guard against unauthorized cutting of trees and organization of education programmes on climate change as strategies for mitigation action.

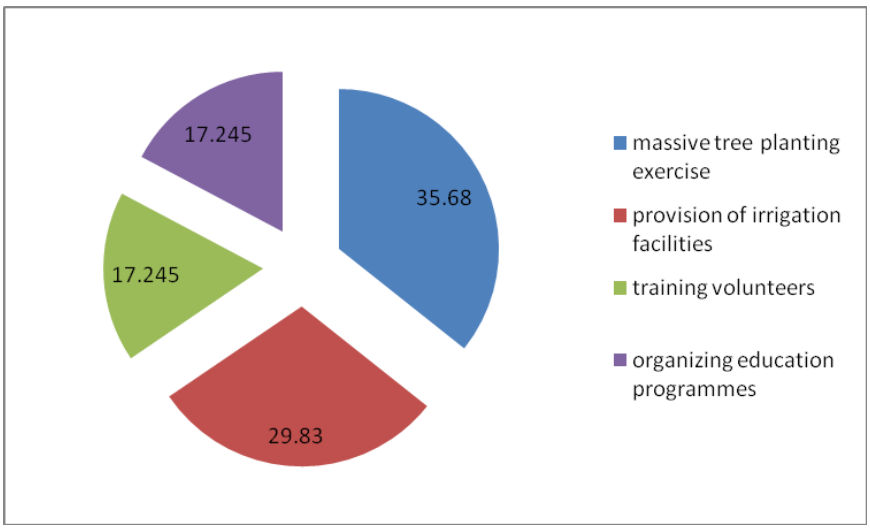
Graph 5 shows the distribution of the farmers' willingness to pay for these climates mitigation policies. From the graph, it is obvious that farmers willingness to pay for tree planting exercise was high (35.68%); followed by provision of irrigation facilities to farmers constituting about 30% of the farmers. About 17% of the farmers interviewed were willing to pay for training of volunteers whilst about 17% were willing to pay for climate change education programmes.

Table 1 shows the summary statistics of the willingness to pay responses of farmers. The mean and median were GH¢ 12.3519, GH¢9.00 respectively. The median was lower than the mean, indicating that majority of the farmers were willing to pay less than the mean willingness to pay, and that the response distribution was skewed by a limited number of high bidders.

Model Estimation Results of the Probit Regression Analysis

A probit regression analysis was employed to analyze the socio-economic factors that influence farmer's willingness to pay for climate change mitigation policies. The Akaike Information Criteria (Akaike, 1973), provided the basis for selecting the model that provided the best fit to the willingness to pay data. The model specification with willingness to pay for climate change mitigation policies as the dependent variable and gender, age, household size, years of education, years of farming experience, own farm land and other income generating activity as the covariates provided the best fit with AIC of 114.65.

The model estimation result reveals a negative relationship between willingness to pay for climate change mitigation policies and the regression covariates (i.e. gender, household size, years of farming experience and other income generating activity). A positive relationship exists between willingness to pay for climate change mitigation policies and the regression covariates (i.e. Age, years of education and Ownership of farm land).



Source: Field data, 2011.

Graph 5: Distribution of Farmers Willingness-To-Pay for Climate Change Mitigation Policies (In Percentage).

N=54	
Mean	12.3519
Median	9.00000
Std. Deviation	9.60573
Skewness	1.840 (std. error 0.325)
kurtosis	2.915 (std. error 0.639)

Source: Field data, 2011

Table 1: The Statistics of Willingness-To-Pay (WTP).

Variables	Estimates	Std. Error	z value	Pr (>I z I)
Intercept	-1.290	0.840	-1.536	0.124
GEN	-1.309	0.413	-3.169	0.001**
AGE	0.081	0.032	2.542	0.011 *
HHS	-0.029	0.082	-0.362	0.717
EDU	0.108	0.046	2.343	0.019*
EXP	-0.127	0.040	-3.114	0.001**
OFL	0.738	0.368	2.002	0.045*
OINC	-0.001	0.0001	-2.517	0.011*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Note: GEN= Gender, AGE= Age of respondent, HHS= Household size, EDU= Years of education of respondent, EXP= Farming Experience, OFL= Own farm land OINC= Other Income Activity.

Source: Field data, 2011.

Table 2: Parameter estimates of the Probit Model.

Evidence from the probit regression analysis finds the age, gender, years of education, years of farming experience, own farm land and other income generating activity as significant predictors of the willingness to pay for climate change mitigation policies. The parameters of gender and years of farming experience were negative and significant at 1% level while other income activity was also negative and significant at 5%. While the parameters of age, years of education and own farm land were positive and significant at 5% level. It should be emphasized that a negative sign of a parameter indicates that high values of the variables tends to decrease the probability of the willingness to pay for climate change mitigation policies. A positive sign implies that high values of the variables will increase the probability of the willingness to pay for climate change mitigation policies. In effect the probability of willingness to pay for climate change mitigation policies increases with age, years of education and ownership of farm land.

Conclusion

Farmer adaptation to climate change is crucial to combating food insecurity and related problems. Against this background, this paper assesses farmer's perception and adaptation to climate change. Specifically, the study investigated farmer perception of changes in temperature and precipitation, choice of adaptation methods, barriers to adaptation and socio-economic determinants of willingness to pay for climate mitigation policies.

Results from the descriptive analysis of farmers interviewed revealed that the farmers were characterized by active labour force, small farm sizes, low income distribution, high farming experience, large household size, and low level of formal education. With regards to farmers' perception and methods of adaptation, majority of the farmers perceived increase in temperature and decrease in rainfall pattern. Farmers' level of adaptation was found to be relatively high with majority of the farmers using changing planting dates, different crop varieties, soil conservation and water harvesting as the major adaptation measures to climate change impacts. However, access to water, high cost of adaptation, lack of information on climate change adaptation options, lack of knowledge on adaptation, insecure property rights, lack of credits and insufficient access to inputs were identified as the major barriers to adaptation.

Results revealed high level of willingness to pay for mitigation policies among the farmers. However, majority of the farmers supported massive tree planting exercise. The probit regression estimation results indicated that the probability of willingness to pay for climate change mitigation policies increases with age, years of education and ownership of farm land. Implications for policy will be to implement a public education program on climate change adaptation strategies. There is the need for government to embark on massive implementation of mitigation policies since most farmers are willing to pay for these policies.

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