BEST: International Journal of Humanities, Arts, Medicine and Sciences (BEST: IJHAMS)
ISSN (P): 2348-0521, ISSN (E): 2454-4728
Vol. 3, Issue 12, Dec 2015, 89- 104

SOCIO-ECONOMIC VALUATION OF INFORMATION FOR CLIMATE CHANGE ADAPTATION AND MITIGATION: A CASE OF FARMERS' RESPONSES IN KAKAMEGA COUNTY

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ABSTRACT

This study investigates the socio-economic value that farmers in Kakamega County place on information on climate change adaptation and mitigation.

The Data used in this study consisted of household data, observed rainfall and temperature data from Kakamega Synoptic Station and PRECIS Model output for rainfall and temperature spanning 2050 over the area of study.

Trend analysis for observed and PRECIS RCM simulated Rainfall and temperature data was done. Methods used in the analysis of cross-sectional data included Descriptive statistical analysis, The OLS, Logit, Probit and Tobit Analysis.

The results show that Rainfall is on a decreasing trend under A1b scenario while temperature is on an increasing trend over the region of study both in the recent past and near future. Results from the OLS/Logit/Probit/Tobit for willingness to pay reveal that for an increase in education period (educ), there is a significant point increase in the predicted value of willingness to pay (WTP) while for a unit increase in income (inc) there is a significant point increase in the predicted value of WTP. The results for age show that there is a reduction in the predicted value of WTP for a unit increase in age of the farmers.

KEYWORDS: Climate Change Adaptation, Climate Change Mitigation, OLS/ Logit/ Tobit, Willingness to Pay

INTRODUCTION

Kakamega, an Agro-Based County in western Kenya is home to Commercial and food crops namely Sugarcane,Tea and Maize among others. Major Ecosyetems are also found in this County including Kakamega Forest National Reserve , situated in the Lake Victoria basin, about 50km north of Kisumu city. Being the only remnant in Kenya of the unique Guineo-Congolian forest ecosystem, the park offers unique wildlife and scenic beauty. For bird and butterfly watchers, this is the place to visit. The forest is home to over 400 species of butterflies, about 300 bird species and 27 species of snakes. The park also supports more than 350 species of trees and 7 primate species including the endangered DeBrazza monkey, black and white colobus monkey and vervet monkey. The Potto (the world's slowest mammal on earth), duikers and Dik diks are also found in Kakamega Forest National Reserve.Farmers in Kakamega County May be attaching less value to or lacking information on climate variability and/or change which would make them deteriorate in agricultural productivity.If agricultural information is availed to them, it may increase food production,future disaster preparedness and boost food security at household level.

Access to, and appreciation of Information on climate change adaptation or mitigation is instrumental in formulating sustainable policies for both Kakamega County and National Government ,much as attracting donors and other stakeholders.

The area of study is characterized by many economic Activities including Commercial and food crop farming, Mining of Minerals,Tourism, Formal and Informal Employment. Rain-based Agriculture is the Main form of agriculture in this region and therefore making the area of study highly sensitive to any change in Climate.

Current agricultural intensification in Kakamega is unsustainable as it leads to soil degradation such as increased soil erosion, declining soil fertility and reduced biodiversity .

Concerns are raised over the long-term sustainability and the environmental consequences of the current intensification of agriculture systems in Kakamega in addition to the frequent food insecurity situations. Hence, there is need to develop agricultural systems that increases food productivity while maintaining or enhancing the resource base quality and environmental services. Rural livelihoods in the agriculture-based economy of Kakamega depend on the success of implementing sustainable agriculture systems. (Nambiro 2007).

To determine the Socio-economic value that farmers in kakamega attach to information on Climate Change adaptation and Mitigation.

Specific objectives

- To determine the trends in observed rainfall and temperature over the region of study during the recent past.
- To determine the trends in simulated rainfall and temperature records over the area of study during the recent past and near future.
- To determine the extent to which farmers are willing to pay for climate change adaptation and mitigation services.

METHODS

Methods used were single mass curve technique for data quality control, temporal distribution analysis using time series analysis, Correlation analysis, Descriptive statistics analysis and the Logit/Probit/Tobit analysis in STATA Statistical Software

Sample size determination

The sample size for this research was determined using the Cochran's formular as shown below

$$\eta_O = \frac{z^2 (p)(q)}{d^2} \quad (1)$$

Where

n_{0}= sample size

p= proportion of the population with the desired characteristics

z= standard normal deviate at 95% confidence level =1.96

q= 1-p (proportion of population that does not have characteristics being measured)

d= degree of precision set at 5%

Since the variability of the population is unknown, we assume p=0.5 (maximum variability). Moreover, the desired level of confidence is at 95% and the degree of precision at ±5% precision.

Substituting the values of p,z,q and d in equation (7) we get the following value of n_0

$$n_0 = \frac{1.96^2 x0.5x0.5}{0.05^2}$$

$$n_0 = 384 \text{ respondents} \tag{2}$$

Sampling Method

- The sample was defined by identifying the respondents and their accessability. They were categorized in their respective sub counties namely Kakamega central, Navakholo, Malava,matete, Lugari, Likuyani,Shinyalu,khwisero, Ikolomani, Butere, Mumias, and Matungu.
- The research design chosen was a survey. The main Instruments for this research i.e the questionnaires were made ready and permission was sought to collect data at each sub county.
- Lastly, a meeting was convened at ACK Conference centre, Mumias town to train the research assistants on the procedure for administering questionnaires, together with the ethics and rights of the respondents. A brief overview of the subject of climate change was introduced to the research assistants in a language they can understand and terms and conditions of engagement agreed.

Estimation of Missing Data

Missing data values were estimated using the Normal Ratio Method. In this method, the variable P_A at station A is estimated as a function of the normal monthly or annual variable of the station under consideration

$$P_A = \frac{\sum_{i=1}^{n} \frac{NR_A}{NR_i} * P_i}{n} \tag{3}$$

p_i is the variable at surrounding station(s)

NR_A is the normal monthly or seasonal rainfall at point A

NR_i is the normal monthly or seasonal rainfall at point i

n is the number of surrounding stations whose data is used for estimation

Descriptive Statistical Analysis

Descriptive statistics were used simply to describe the sample of concern. They were used in the first instance to get a feel for the data, in the second for use in the statistical tests themselves, and in the third to indicate the error associated with results and graphical output.

Cross-sectional data was analysed for measures of dispersion and other related parameters.

Direct Statistical Method

Ordinary Least Square Method was used as used by Aguilar et al (1995) in their studies. Respondents were asked open ended questions about their WILLINGNESS TO PAY. The willingness to pay bids were regressed on a number of socio-economic and demographic factors. We can specify the following economic model.

WTP_i = f (Educ., Age, Inc). (4)

Where

WTP_i is the Dependent variable which stands for Willingness To Pay (WTP) for climate change adaptation and mitigation information. This variable is expressed in monetary terms as the monthly payment consumers of Climate change adaptation and mitigation' information services are willing to pay, which is a function of independent variables:

Educ. = Level of education(Number of years studied)

Age = Age of the respondents

Inc = Income of the respondents

The Equation to be estimated is

$WTP_i = \beta_0 + \beta_i \text{ Inc} + \beta_2 \text{ Educ.} + \beta_3 \text{ Age} + \omega t.$ (5)

Where ωt is the random error term

Indirect Statistical Methods

This is a widely used model to get respondents' willing to pay. It is usually called dichotomous choice format. The question was whether the respondent is willing to pay or not.

The probability of giving a positive willingness to pay (p_i) is the Dependent variable and thus predicted the likelihood of willingness to pay given a set of household characteristics or attributes. The respondents were asked to answer "yes" (WTP>0) or NO (WTP = 0)

P= 1 (positive Willingness to pay), P= 0 Otherwise.

This was specified as:

$P_i = F(\alpha_0 + \beta_i V_i) + \varepsilon_{t..}$ (6)

P_i is probability of respondents' willingness to pay

F is cumulative distribution function assuming normal distribution

V_i is the vector of independent variables

α_0 is the intercept

β_i are respective variable coefficients

The model to be estimated was specified as :

$$p_i = \alpha_0 + \alpha_1 Inc + \alpha_2 Age + \alpha_3 Edu + \varepsilon_t. \quad (7)$$

The Logit model

The prediction equation can be given by:

$$\log (p/1-p) = \beta 0 + \beta_1 *Age + \beta_2 *Educ + \beta_3 *Income + \varepsilon_{t..} \quad (8)$$

The Probit Model

Probit regression, also called a probit model, is used to model dichotomous or binary outcome variables. In the probit model, the inverse standard normal distribution of the probability is modeled as a linear combination of the predictors.

For the probit Model;

$$\Pi_i = \Phi(\eta_i) = \Phi(\alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots\ldots + \beta_k X_{ik}). \quad (9)$$

This model can be expressed in terms of odds as follows:

$$\frac{\Pi i}{1 - \Pi i} = e^{(\alpha + \beta_1 X_{i1+\ldots\ldots+} \beta_k X_{ik})}$$

$$= e^{\alpha} (e^{\beta_1})^{X_{i1}} \ldots\ldots (e^{\beta_k})^{X_{ik}} .. \quad (10)$$

Where e^{β_j} is the multiplicative effect on the odds of increasing Xj by 1, holding the other X'S constant

The Tobit Model

This model is also called the censored normal regression model for situations in which y is observed for values greater than 0 but is not observed (censored) for values of zero or less. Tobit regression coefficients are interpreted in the similiar manner to OLS regression coefficients. However, the linear effect is on the uncensored latent variable, not the observed outcome (McDonald 1980)

This model can be specified as:

$$y_i^* = x_i \beta + \varepsilon_{i.}. \quad (11)$$

$y_i = y_i^*$ if $y_i^* > 0$

$y_i = 0$ if $y_i^* \leq 0$

y_i^* is the latent dependent variable

y_i is the observed dependent variable

X_i is the vector of the independent variables

β is the vector of the coefficients

ϵ_i are assumed to be independently normally distributed $\epsilon_i \sim N(0, \delta)$

PRECIS RCM Model Verification and Simulation

Verification of the model outputs was done using graphical display (direct comparisons of model outputs with observed temporal plots). The most recent observed rainfall and temperature data spanning ten years was used.

Simulated data spanning the year 2050 was also used for determining trends.

RESULTS AND DISCUSSIONS

Data Quality Control

The Data had less than 10% of missing records and therefore the missing records were estimated using the Normal Ratio method

The single mass curve homogeinity test was applied to the data. The figures 1(a) show an example of results obtained from the Homogeneity tests.

Figure 1(b) represents the annual rainfall cycle over the area of study. The figure shows that there are two major rainfall seasons occurring between March –April and August-September.

However, it is important to note that the two rainfall seasons are not separated by a dry spell. Instabilities of the Congo Air mass benefit the region of study making it characterized by significant rainfall amounts.

Observed Annual Time Series of Rainfall

It can be seen that kakamega is experiencing increasing rainfall variability over time, a phenomenom that can be attributed to climate Change. The observed reduction in rainfall patterns are mainly due to La- Niña (abnormally cool sea surface temperatures) conditions that prevails over the equatorial eastern Pacific Ocean. In addition, cooler than normal Sea Surface temperatures could also be prevalent over the Indian Ocean during this periods. As a consequence, kakamega could experience depressed rainfall. The congo air mass instabilities may be the major contributor to enhanced rainfall.

Observed Annual Cycle of Temperatures

Figure 1(d) shows the monthly cycles of minimum temperature. High temperatures during the MAM- OND seasons could be attributed to reduced radiative cooling during this periods while low temperatures can be attributed to increased radiative cooling.

Observed Annual Time Series of Minimum Temperature

Figure 1 (e) shows an annual time series of Minimum Temperatures at Kakamega over time. It can be observed that there is increasing minimum temperature variability over time.

Observed Annual Cycle of Maximum Temperature

Figure 1(f) shows the monthly cycles of maximum temperature. High temperatures during the February could also be attributed to reduced radiative cooling during this periods while low temperatures could be attributed to increased radiative cooling.

Observed Annual Time Series of Maximum Temperature

Figure 1(g) shows annual time series of maximum temperature at Kakamega over time. It can be observed that there is increasing maximum temperature variability over time.

Simulated Trends in Rainfall and Temperature

To establish simulated annual cycles in the climatology of rainfall,and temperatures in Kakamega, the annual cycles presented below were used

Model Validation with Rainfall Data

The figure (2a) below shows the model rainfall data behavior in comparison to observed rainfall data for the period between 2002-2012. It can be noted that the model underestimated past Rainfall under A1b Scenario and slightly overestimated it under A2 scenario. There is a tendency of the model to overestimate rainfall amount with increasing years under both scenarios . Generally, model performance under both scenarios was reasonable.

Model Validation with Temperature Data

The figure 2(b) below shows the model temperature data behavior in comparison to the observed Mean annual temperature data for the period between 2002-2012. It can be noted that the model underestimated temperature under A1b Scenario but perfomed relatively well under A2 scenario.

Simulated Trend in Rainfall

The results in the figure 2(c) show significant variability in precipitation levels in the near future.

There is also a possibility of enhanced precipitation with A2 scenario. However, the interannual variability in rainfall around the mean will be less with an A1b scenario. There is a possibility of reduced precipitation with an A1b scenario. The pearsons correlation coefficient (r) gave a value of 0.18

Simulated Trend in Temperature

Figure 2(d) shows simulated annual mean monthly temperatures under A1b and A2 Scenarions. The results show that there is an increasing temperature trend by the year 2050. The pearsons correlation coefficient (r) gave a value of 0.53.

Climate Variability and/or Change

Results show that an overwhelming 80.5 % of the population believe climate is changing. Majority are concerned with non-extreme climate so that they can get better maize crop yields, Sugarcane yields, have good health, attract tourists and lastly for publicity.

Agro-forestry, Afforestation, Mulching, Intercropping, crop rotation, contour farming, Organic farming, Zero tillage agriculture, Planting of cover crops among others are the main conservational agricultural practices over the study area.

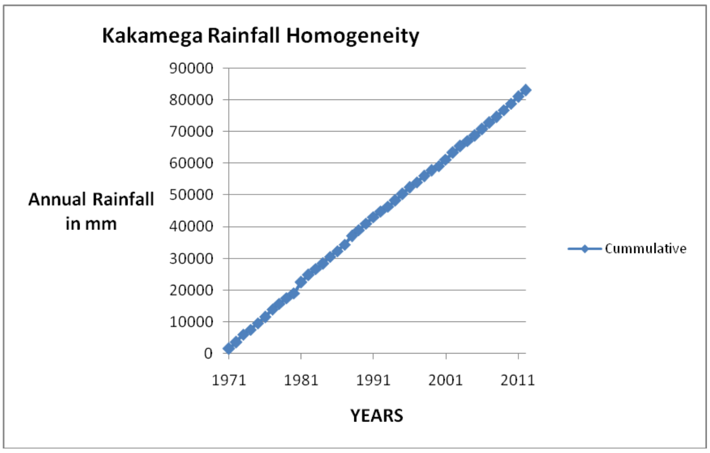

Figure 1(a): Mass Curve To Test The Homogeinity of the Annual Observed Rainfall Records for The Period 1971-2012

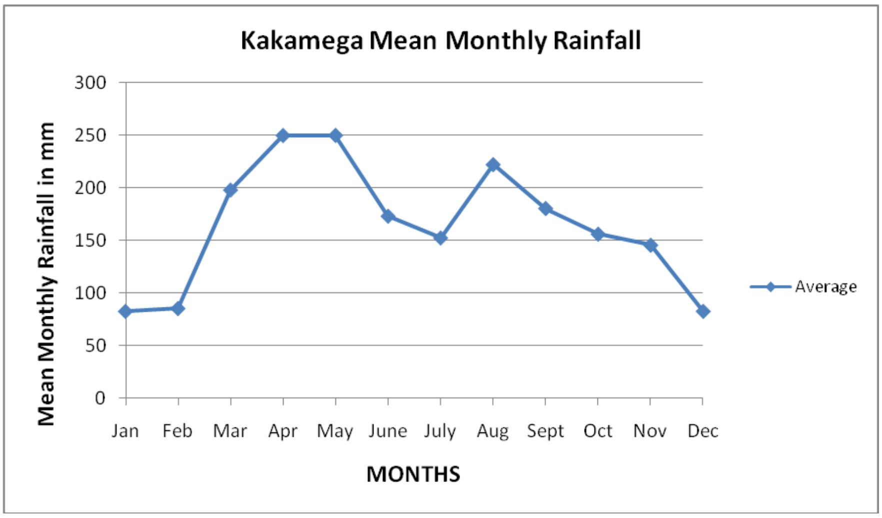

Figure 1(b): Observed Annual Cycle Of Rainfall Over Kakamega

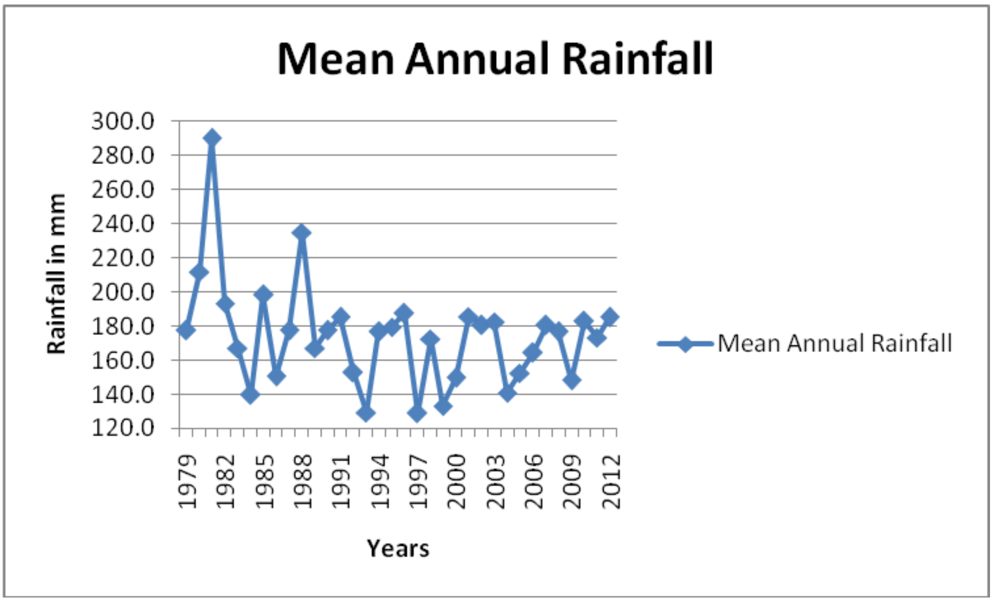

Figure (1c): Observed 1979-2012 Rainfall Time Series Over Kakamega

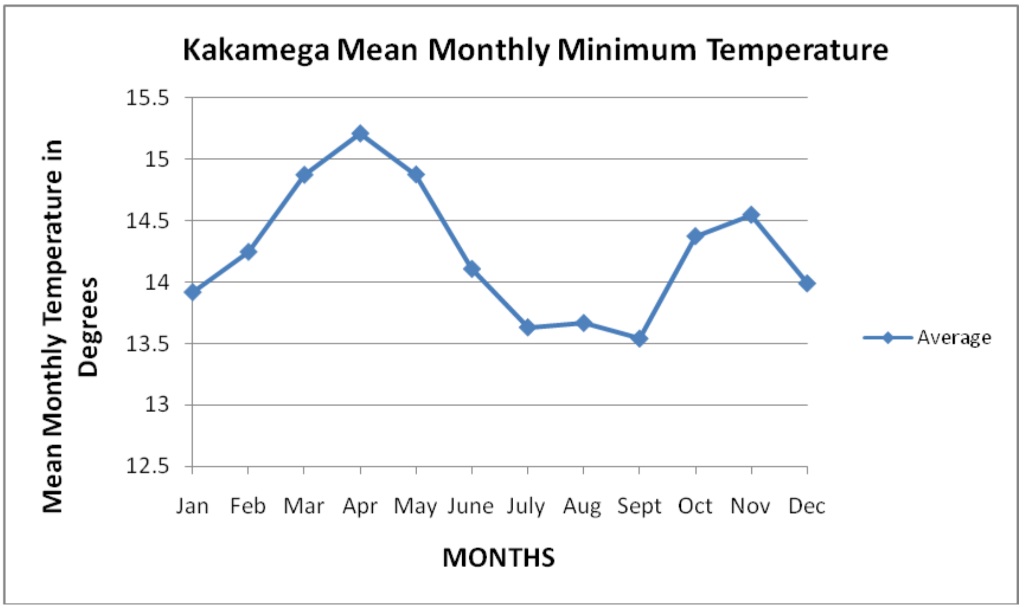

Figure 1(d): Observed Annual Cycle of Minimum Temperature Over Kakamega

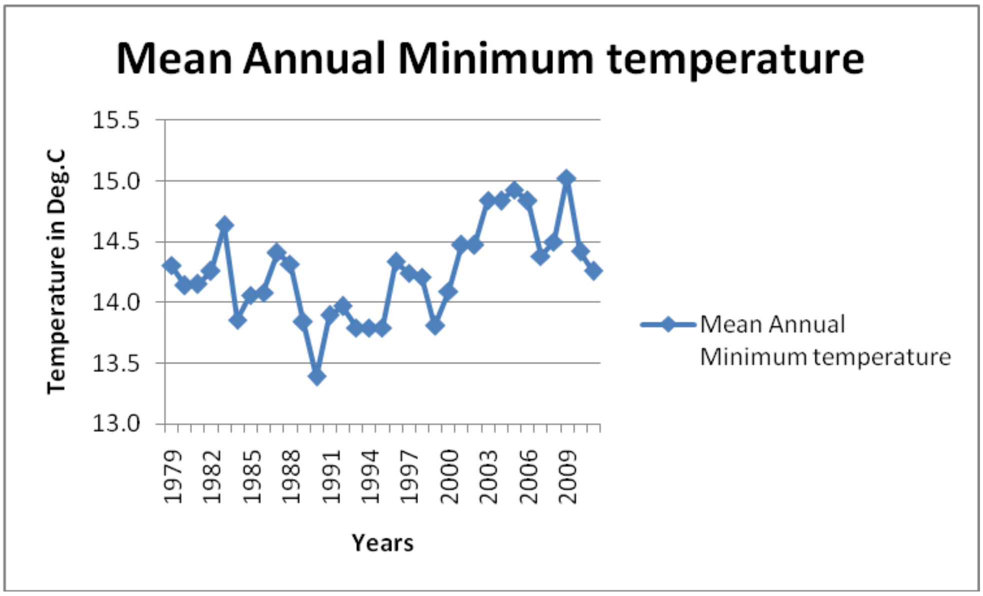

Figure 1(e): Observed 1979-2012 Minimum Temperature Time Series Over Kakamega

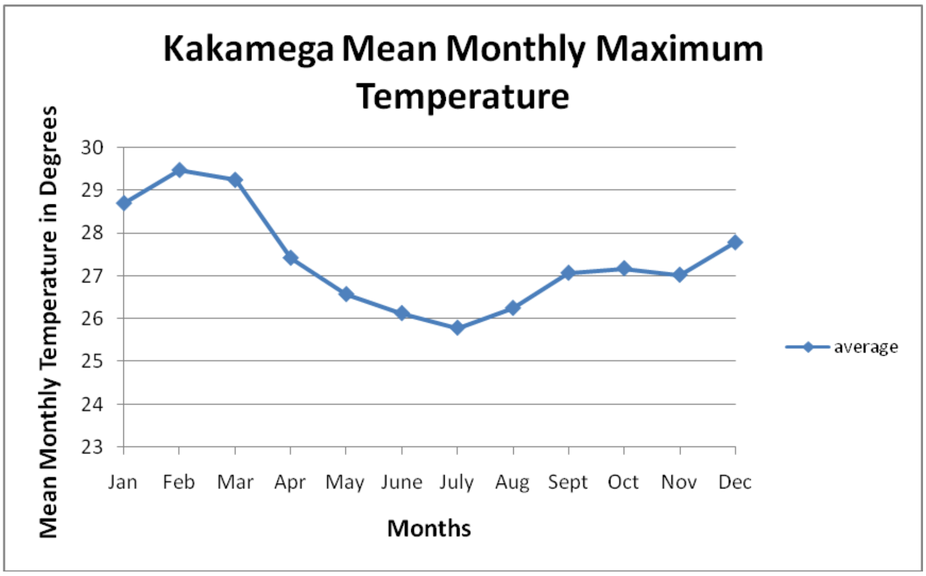

Figure 1(f): Observed Annual Cycle of Maximum Temperature over Kakamega

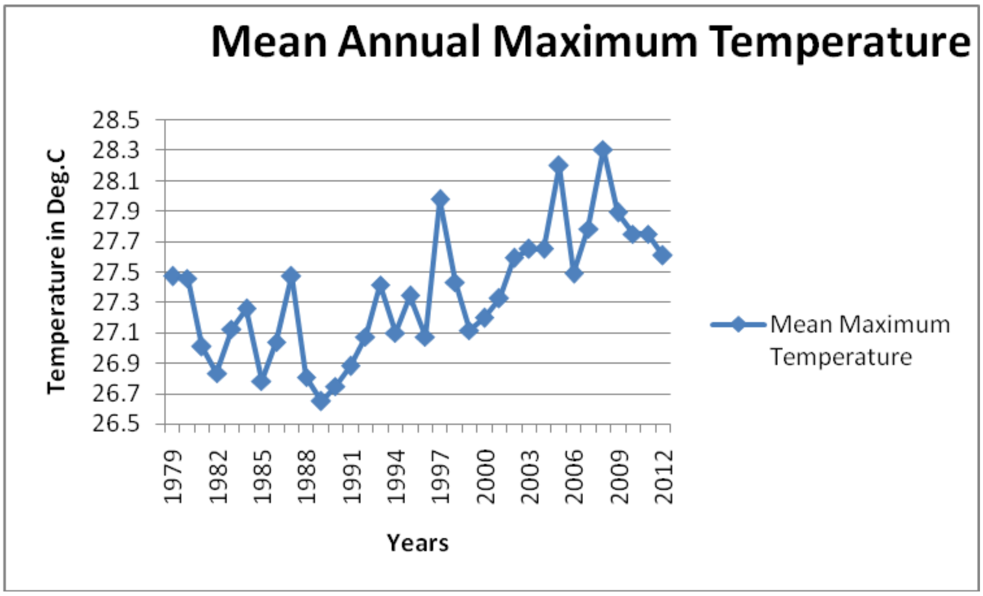

Figure 1(g): Observed 1979-2012 Maximum Temperature Time Series over Kakamega

Figure 2(a): Model Validation Relative to Observed Rainfall under the Two Scenarios Over Kakamega County for the Period 2002-2012

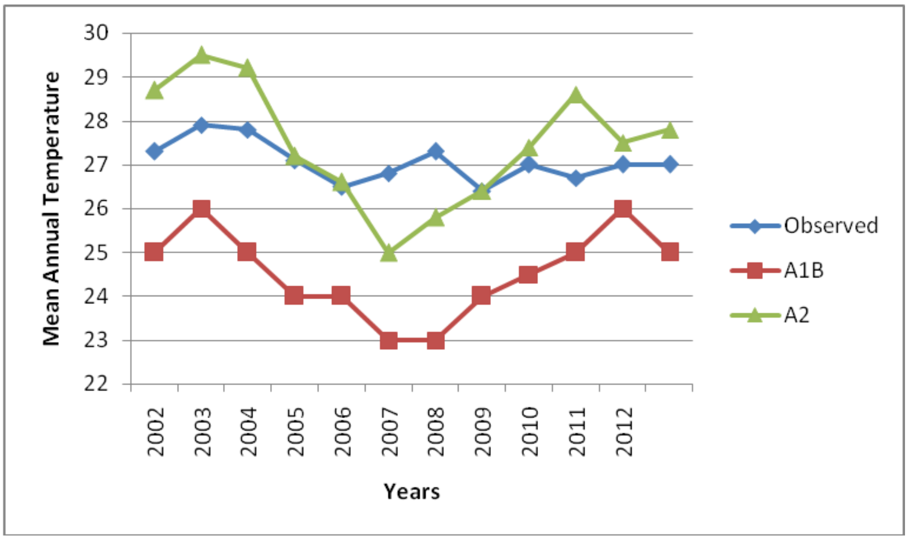

Figure 2(b): Model Validation Relative to Observed Temperature under the Two Scenarios Over County for the Period 2002-2012

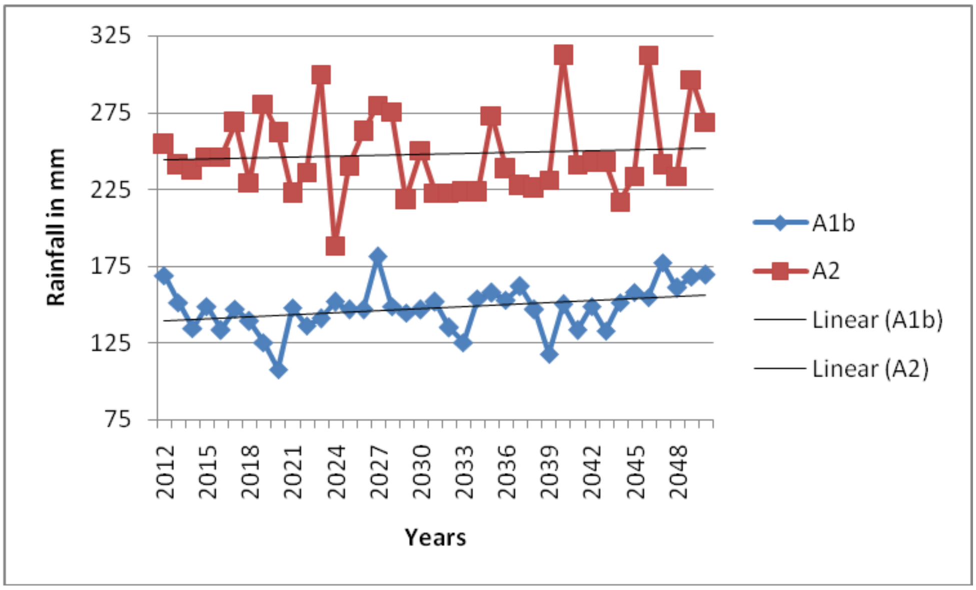

Figure 2(c): Simulated Annual Trend of Mean Monthly Rainfall over Kakamega for the Period 2012-2050 under A1b and A2 Scenarios

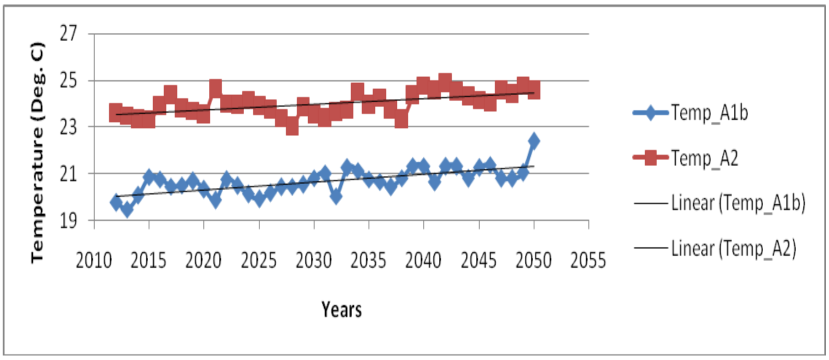

Figure 2 (d): Simulated Annual Trend of Mean Monthly Temperature over Kakamega for the Period 2012-2050 under A1b and A2 Scenarios

Table 1: Ordinary Least Square Regression Results

SOURCE	SS	df	ms	Number of obs = 384
				F (3, 380) =10.47 Prod > F =0.0000 R-Squared =0.0764 Root MSE =5613
MODEL	989659536	3	329886512	
RESIDUAL	1.1972e+10	380	31505975.9	
TOTAL	1.2962e+10	383	33843160.3	
WTP(KSHS)	Coef. Std. Err.	t P>t	[95% Conf. Interval]	
EDUC	117.9246 73.19411	1.61	0.108	-25.99156 261.8408
AGE	10.75218 23.50115	0.46	0.648	-35.45641 56.96077
INCOME	2196.413 438.2424	5.01	0.000	1334.729 3058.097

Table 2: Logistic Regression Results

Logistic Regression Log likelihood =-230.5858				Number of observations = 384		
				LR Chi 2 (3) =29.05		
				Prob > Chi 2 =0.0000		
				Pseudo R2 =0.0593		
WTP	Coef.	Std.error	z	P>|z|	[95% Conf.	
age	-.0125745	.0089488	-1.41	0.160	-.0301138	.0049648
educ	.0871788	.030017	2.90	0.004	.0283465	.146011
income	.6372177	.1829168	3.48	0.000	.2787074	.9957279
_cons	-.8843179	.5545705	-1.59	0.111	-1.971256	.2026203

Table 3: Probit Regression Results

Probit Regression Log likelihood =-230.70639				Number of observations = 384		
				LR Chi 2 (3) =28.80		
				Prob > Chi 2 =0.0000		
				Pseudo R2 =0.0588		
wtp	Coef.	Std.error	z	P>|z|	[95% Conf.	
educ	.0515019	.017835	2.89	0.004	.0165461	.0864578
income	.3795295	.1086882	3.49	0.000	.1665046	.5925544
age	-.007788	.0054789	-1.42	0.155	-.0185264	.0029504
_cons	-.5026649	.3332482	-1.51	0.131	-1.155819	.1504895

Table 4: Tobit Regression Results

Tobit Regression Log likelihood =-379.29042				Number of observations = 384		
				LR Chi 2 (3) =28.34		
				Prob > Chi 2 =0.0000		
				Pseudo R2 =0.0360		
wtp	Coef.	Std.error	t	P>|t|	[95% Conf.	
educ	.0255718	.0088343	2.89	0.004	.0082018	.0429419
income	.188916	.531859	3.55	0.000	.843413	.2934908
age	-.0045267	.0029532	-1.53	0.126	-.0103334	.0012799
_cons	-.801659	.1742352	0.46	0.646	-.2624172	.4227489
Sigma	.6566896	.0324276			.5929301	.7204491
Obs. Summary 129 left censored observations at wtp <= 0 255 Uncensored observations 0 Right censored observations						

CONCLUSIONS

The study reveals that farmers in kakamega value information on climate change adaptation and mitigation.Trend analysis in observed rainfall and temperature over the region of study during the recent past show that the mean annual rainfall is on a decreasing trend while temperatures are on an increasing trend both in the recent past and near future.The study showed a moderate level of awareness that climate is changing over the region of study and that the respondents are willing to pay for the information on climate change adaptation and mitigation. The actual WTP value was generally low among the respondents reflecting their low incomes. Information obtained in this study can be vital in formulation of sustainable policies at county level.

ACKNOWLEDGEMENTS

Profuse thanks to God for his guidance and help. We thank ACK church, mumias town for hosting us during training of the research assistants. Finally, I acknowledge the support of Mr. Harrison B. Atitwa, Ms. William M. Orembo, Mr. Alexander Ayoti Chikombe, Mr. Enos Mukolwe, Ms. Dablin Ong'ayo who were field assistants in this study.

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