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Review Article

Climate Knowledge, Adaptation and Intensity of Adaptation Strategies among Farmers in the Slopes of Mount Kenya

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ABSTRACT

This paper sought to give insights and inform policy on farmers' knowledge on climate change, the adaptation strategies and the intensity of adaptation. The research was carried out in Kirinyaga County in Kenya. Purposive sampling was used to select the county while random sampling was used to select the respondents. Primary data was collected through a structured questionnaire. The probit regression model, the multivariate probit model, and Poisson model were utilized. The findings indicate that farming experience, education, age of the farmer, ownership of livestock and growing of horticulture were key determinants of climate change knowledge. The farmers' adaptation to different strategies was influenced by; land size, age, gender, education, ownership of land title deed, ownership of livestock, growing of maize, location, and ownership of television. The intensity of adaptation was influenced by ownership of livestock, access to credit and access to extension services. The paper concludes that more information on climate change should be aired on radio and TV and farmers should adopt planting of new crops, adjusting of planting time, planting of drought-tolerant crops and practicing of soil and water conservation practices as climate change adaptation strategies.

Keywords: Climate change knowledge; Adaptation strategies; Multivariate probit

INTRODUCTION

Climate change is currently a serious problem worldwide [1]. In Africa, there is evidence of increased temperatures and reduction in rainfall resulting in adverse effects on rain-fed agricultural production [2,3]. Despite this, there is a knowledge deficit among members of the public on climate change [4]. There have been numerous studies on climate change adaptation, but few have concentrated on knowledge [3]. Where there are systems to predict and forecast information on climate change, the process of dissemination of this information is still poor [5]. With the correct knowledge, mitigation and adaptation strategies will be viable [3]. Several efforts by the stakeholders, governments, and NGOs have come up with several policies and programs related to adaptation [6-9]. Despite these efforts, adaptation at the farmer level is still wanting.

More effort is currently being geared towards adaptation to climate change worldwide [10] but the rate of adoption in developing countries is low due to lack of the necessary tools for adoption [6-9,11-14]. In Africa, the majority of farming is rain-fed and farmers have limited resources which slows the adoption process [10]. Climate change has decreased crop yield and increased production cost which is a threat to food security [8,10]. Farmer's decisions to adjust their farming practices as a mitigating measure is affected by several factors among them are limited access to information, individual farmer characteristics and poor infrastructure developments [6]. Some of the adaptation strategies are the use of different crop varieties, tolerant livestock species, irrigation, inter-cropping, crop rotation, mixed cropping and early planting [6-10,11-14].

In Kenya, the majority of the population are poor with the poverty rate being higher than 50% and depend on agriculture as a source of food, employment, income, and livelihood [15].

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Due to this over-reliance on agriculture, adaptation measures are needed to sustain agricultural productivity. Joseph et al. posit that ignorance and lack of awareness were some of the hindering factors to adaptation and recommended for further research on adoption measures on the poorest strata of small-holding African farmers in different agro-ecological contexts [16]. Bryan et al. found out that Mt. Kenya is adversely affected by climate change as indicated by increased snow cover on the mountain and frequent fog, frost, and hail. This background informed the researchers to examine climate knowledge and adaptation strategies among farmers on the slopes of Mount Kenya [15]. The research sought to give insights on farmer's knowledge on climate change, adaptation strategies and the intensity of adaptation with a view of informing policy on the appropriate approach to climate change information dissemination and adaptation strategies.

LITERATURE REVIEW

Agriculture is a key sector in poverty reduction and achievement of the sustainable development goal number one which proposes ending poverty in all forms by 2030 by supporting people harmed by conflict and climate-related disasters among others [17]. Studies indicate that climate change impacts agricultural productivity negatively, specifically the smallholder farmer, due to over-dependence on rain-fed agriculture [18,19]. Climate change as characterized by increased temperatures and variations in rainfall has resulted in floods and droughts [19]. The effects of climate change and rapid population growth can be devastating or catastrophic to a country that is over-dependent on agriculture as the main source of livelihood and as a core driver to economic growth [20].

Most countries in Africa have been affected negatively by climate change for lack of adequate capacity to adopt [2]. Previous research studies reported mixed views on the effects of climate change on agriculture. Abraha and Gårn , while studying the effect of climate change and adaptation policy on agricultural production in Eastern Africa, found out that rising temperatures affect agricultural negatively while rising rainfall affected agricultural output positively [21]. Bryan et al. indicated that unpredictability and shortening of the rainy seasons affected the timing of planting and thus reduced yield [2]. The assumption that adaptation increase crop productivity and net income does not hold always and if it improves the farmers' welfare does not have sufficient literature to support [20]. Joseph found out that adaptation increased labor and capital due to the increase in farm activities. In addition, sudden replacement of organic fertilizer with inorganic may reduce yield in the short run and adverse effect on the already poor farmer [16].

Majority of Kenya's population lives in rural areas and rely on agriculture as a source of livelihood [10,20]. Studies have confirmed that climate change, despite its benefits if adopted well, has affected agricultural productivity negatively which has disastrous effects on food security [20,22]. With the growing population, the current agricultural productivity/output will not sustain the population growth and it means that food security will be adversely affected in the future [2,20]. Though the majority of the farmers in Kenya had adopted compared to other African countries, their strategies were short-term in nature [2,15].

Lack of adequate knowledge and information has been reported in previous studies as an obstacle to adaptation and therefore calls for good quality, accurate and accessible information [23]. Knowledge is a critical ingredient and the most important input in the process of adaptation [1]. Before adaptation, knowledge of climate change, as well as its causes and effects, is important so as to trigger the adaptation process [24]. There exist expert knowledge on climate change and adaptation measures which is not understood by the public masses and thus of little importance to addressing the problems and associated risks of climate change [25]. This information can also mislead the public since they are not familiar with it or have no experience associated with the use of such information [25].

Household characteristics such as age, gender, and education are the key determinants of adoption [26]. Abid et al. stated that adaptation was high with those farmers who were educated, and experienced compared to less educated and inexperienced farmers [20]. Their study confirmed that educated and experienced farmers had more access to services such as credit, extension, market information and weather forecast information. Alauddin and Rashid indicated that those farmers who were knowledgeable still had challenges in adoption due to financial constraints [26]. The purchasing power of the recommended crop varieties hampered adoption as well as lack of proper training on the adaptation measures [2]. Poverty scored the highest as the hindering factor to adoption though political factors led to conflicts and insecurity and thus negative effects on adaptation [2].

There are contradicting results on the effect on the household size on climate change adaptation. Abid et al. indicate that large household size was a hindering factor to adoption due to difficulties in allocating the scarce resources to the household demands while Alauddin and Rashid found out that large household size increased adaptation due to the availability of labor [20,24]. In addition, factors affecting farmer adaptation varies according to individual and environmental characteristics thus the need for the more researches [18]. Abid with other researchers, advice for context-specific policies due to different farmer characteristics, different climates and geographical locations [20].

Abid further indicated that the farmers adopted more with the short-term measures as opposed to long-term measures some of which were illicit adaptation strategies that are not in line with the statutory and customary laws and social norms [20,27]. This is so because it is difficult to go back to the original condition of asset base after droughts and floods associated with climate change and may adopt by engaging in illicit activities [27].

Adaptation reduces the adverse effects of climate change and thus improve the lives and livelihoods of farmers [26]. Despite this, there is inadequate information related to climate change [26]. Assisting farmers to adopt the right strategies require increased access to the relevant information provision of insurance services and credit [21]. Studies summarize that farmers could not realize the full benefits of adaptation due to lack of information on improved adaptation options and emphasized the need for human capital investment and institutional investment that provide reliable information and training [2,20]. It's also difficult to rank the adaptation strategies in order of effectiveness and thus difficult to allocate the necessary resources for implementation which leads to low adaptation by farmers [17].

METHODOLOGY

Study area

The study was carried out in Kirinyaga County in Kenya. The country is characterized by 12% of the land that is fit for crop and animal production [2,19]. The study was based on survey data collected in Kirinyaga County. The County sits on the foothills of Mt. Kenya with 1,479.09 square kilometers. It is one of the wettest County with annual temperature ranging between 120c and 260c or an average of 200c and annual precipitation of about 1,250 mm. The County enjoys two rainy seasons, the long rains between March and May and the short rains between October and December. Agriculture is the main economic activity with over 70% of the residents being small-scale farmers practicing coffee, rice, horticulture, dairy, tea, maize, and beans. The county has a population of 528,054 people who are spread out across 30 locations.

Sampling methods and data collection

Purposive sampling method was used to select the county, Kirinyaga, and simple random sampling method was used to select 1 (one) location out of 30 (thirty) locations in Kirinyaga County. The choice of one location was justified by the fact that the 30 locations are relatively homogenous thus information from one location can be generalized. Based on simple random sampling, Ngariama location was selected. Ngariama location has four sublocations with a total population of 18,064 and 5,411 households. Based on the households distribution and sample size determination formula, the proportionate sampling method was used to calculate the sample size for each sub-location (Appendix 1) [28]. With the assistance of sub-chiefs, a list of all households was compiled and simple random sampling utilized to identify individual households in each sub-location. Primary data was collected using a structured questionnaire.

The theoretical and empirical framework

Utilization of climate information and adaptation strategies can be anchored on random utility theory and the characteristic theory of value [29,30]. The utility an individual i obtains from choosing to utilize climate information or not can be specified as;

$U_i = V_i + \varepsilon_i$ (1)

Where U is the utility, V is a vector of observable characteristics and ε captures unobservable characteristics. A farmer will prefer to utilize climate information if and only if he/she derives more utility than not utilizing climate information. The same analogy can be used when a farmer makes the decision of whether or not to undertake a certain adaptation strategy. This behavior can be modeled using probabilistic models [31].

To establish the covariates of access to climate change knowledge, probit regression was utilized. Climate change knowledge was measured as a dummy variable where one (1) denoted that farmer had knowledge of climate change and zero (0) otherwise. The probit regression was specified as;

$CK_i = X_i \beta + \varepsilon_i$ (2)

Where CKi denotes a dummy variable of climate change knowledge, X is a vector of covariates that include household, farm and location characteristics, β's are parameters to be estimated, ε is the stochastic error term and i denotes the respondent.

As a result of climate change, farmers may adopt different strategies in order to cope with the vagaries of climate change. The choice of adaptation strategies could be made simultaneously implying that the error terms of each adaptation equation may be correlated, consequently the multivariate probit model need to be used to account for this correlation. Given the simultaneity nature of the adaptation decisions, this paper utilized multivariate probit model that was specified as;

$AS_{ij}^* = X_i' \pi_j + \varepsilon_{ij}$ (3)

Where ASij* denotes the unobserved preferences associated with jth adaptation strategy for household i, X is a vector of covariates that include household, farm and location characteristics, π's are parameters to be estimated and ε is the stochastic error term. The adaptation strategies considered were; farmers adjusted sowing/planting time, planting of drought-tolerant crops, planting of new crops varieties and use of soil water conservation measures.

Farmers may adopt a number of strategies thereby requiring one to understand what influences the intensity of adaptation to climate change. This paper used the Poisson model to investigate factors that influence the intensity of adaptation to climate change. The Poisson model was specified as;

$y_i = X_i' \gamma + \varepsilon_i$ (4)

Where yi denotes the number of strategies adopted by household i, X is a vector of covariates that include household, farm and location characteristics, γ's are parameters to be estimated and ε is the stochastic error term.

FINDINGS AND DISCUSSIONS

Descriptive statistics

Majority of the respondents indicated that their main source of climate information was radio (28%) and television (27). This could imply that the majority of the farmers owned radio and television and in most cases listens to their vernacular stations where such information on climate could easily be aired. The respondents also indicated religious leaders, print media, friends, family, agricultural extension officers, training, and NGOs workers as the other sources of climate information (Appendix 2).

The respondents gave varied responses to their experience on the changes in climate. The majority had experienced excessive temperatures (40%) and changes in the rainfall pattern (32%). These experiences could be explained by their direct, physical and immediate effect on the crops and thus a negative effect on the yield. The other climate change experienced were frequent drought, excessive cold and frequent flood (Appendix 3).

With regard to climate change adaptation strategies, the farmers had adopted different strategies simultaneously based on their individual characteristics. 34% of the respondents indicated that they adjusted the planting time as their main climate adaptation strategy. This was due to variabilities and thus difficulties in predicting the rainfall patterns. The other strategy was planting of drought-tolerant crops (23%) and use of soil and water conservation measures (23%) due to increased temperatures which resulted in high evapotranspiration rates. 10% of the respondents indicated that they shifted to growing new crops that could thrive well in the new climatic conditions (Appendix 4).

Lastly, the respondents perceived the causes of climate change differently. The majority (48%) indicated deforestation as the main cause of climate change. The study area is adjacent to Mt. Kenya which was characterized by indigenous forest cover. In the recent past, there has been massive deforestation due to increase in population and the need for arable land for food production. The other causes were black smoke of vehicles, industrial effluents, and population growth (Appendix 5).

Knowledge of climate change

The results from the probit regression on covariates of climate change knowledge, as depicted in (Table 1) shows that the age of the farmer, the farmer experience, education level, ownership of livestock and growing of horticultural crops were significant determinants of climate change knowledge. This implies that there is a high likelihood that older farmers were more experienced and knowledgeable about climate change as compared to young farmers. Those farmers who practice horticulture were more likely to access climate information due to the sensitivity of horticultural crops to small changes in climate. Farmer's education is also a key determinant of climate change knowledge. This means that the more educated a farmer the more likelihood of being knowledgeable on climate change. Education gives the farmer the ability to read and understand the changes in climate as compared to those farmers without education. This results support that of Abid who stated that adaptation was high with those farmers who were educated and experienced compared to less educated and inexperienced farmers [20].

The results further indicate that those farmers with livestock had a high likelihood to access information on climate change to facilitate their decision making when there are likely occurrences of extreme weather conditions such as droughts.

The probit regression analysis on the determinants of climate change knowledge by farmers confirmed the results of the previous studies. Bryan posits that farmers perceptions and decisions are based on past observation on recent climate occurrences and that these observations modified farmers knowledge on climate change over time [2]. Alauddin and Rashid indicated that household characteristics such as age, gender, and educational characteristics were the key determinants of adoption [26]. Lack of adequate knowledge and information has been reported in previous studies as an obstacle to adaptation [23]. According to Tripathi and Mishra knowledge are a critical ingredient and the most important input in the process of adaptation [1]. Before adaptation, knowledge of climate change, as well as its causes and effects, is important so as to trigger the adaptation process [24].

Table 1: Probit Regression Model for access to climate information; dependent variable: Knowledge of climate change standard errors in parentheses, $^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$.

Variables	Coefficients
Land size in acres	0.0822
	-0.0838
The land has title deed (1=yes, 0 otherwise)	0.3414
	-0.2367
Owned livestock (1=yes, 0 otherwise)	0.4624*
	-0.2641
Access to extension services (1=yes, 0 otherwise)	0.0032
	-0.235
Gender (1=Male, 0 Female)	0.1081
	-0.2477
Age in years	0.1027***
	-0.038
Age squared	-0.0009**
	-0.0004
Marital status (Single)	0.0497
	-0.3564
Marital status (Windowed)	0.822
	-0.5878
Years of education	0.0921**
	-0.0445
Rungeto Sub-location	0.2848
	-0.2786

Kabari Sub-location	0.6444
	-0.7763
Thirikwa Sub-location	0.2365
	-0.3734
Monthly income (in Thousands Kshs)	-0.0007
	-0.0011
Credit access (1=yes, 0 otherwise)	-0.1706
	-0.2604
Owned radio (1=yes, 0 otherwise)	-0.3617
	-0.568
Owned television (1=yes, 0 otherwise)	0.3466
	-0.2284
Grows tea (1=yes, 0 otherwise)	-0.0967
	-0.2382
Grows Maize (1=yes, 0 otherwise)	-0.2891
	-0.2603
Grows Horticulture (1=yes, 0 otherwise)	0.8940***
	-0.2736
Constant	-3.3541***
	-1.2539
LR Chi-Square	44.83**
Observations	323

Climate change adaptation strategies

In examining the relevant covariates of climate change adaptation strategies, the research findings (Table 2) indicate that household characteristics, farm resource, and farm characteristics were significant determinants to climate change adaptation strategies.

Age of the farmer increases the probability of planting drought-tolerant crops while farmers experience reduced the probability of planting drought-tolerant crops and no effect on adjusting planting time, planting new crops and use of soil and water conservation measures. As the farmer gets older, the likelihood of planting drought-tolerant crops reduces by 0.08 percent. This implies that older farmers direct their resources more on consumption other than investing in adapting to new strategies.

Gender of the household head reduces the likelihood of adjusting planting time. The female-headed household has a lower probability of adjusting their planting time. This may be due to their limitation in decision making.

Education of the farmer increases the probability of planting drought-tolerant crops and the probability of planting new crops. This implies that educated farmers could easily access information on the importance of such adaptation strategies.

Land size increases the probability of planting new crops. An increase in land size by one acre increases the probability of planting new crops by 9 percent. This is an indication that farmers with large parcels of land have sufficient land to plant new crops on the alternative parcels.

Land ownership as evidenced by a title deed increased the probability of adjusting planting time significantly by 43 percent. This implies that the farmer with a title deed had no fear of time-lapse as to the lease period.

Ownership of livestock increases the chances of adjusting planting time and planting drought-tolerant crops. A one unit increase in ownership of livestock increases the probability of adjusting planting time by 0.6 and planting drought-tolerant crops by 0.5.

Monthly income reduces the probability of planting drought-tolerant crops with no effect on adjusting planting time, planting new crops or practicing soil water conservation measures. This implies that one can easily buy the product from the market instead of laboring with planting.

Farmers who owned television were more likely to adjust their planting time. This is so because they received regular and updated information on climate change and the appropriate adoption strategies.

Credit access increases the probability of adopting soil water conservation measures. This is an indication that the farmer has the financial resource to invest in these technologies.

Farmers with access to extension services where more likely to adjust planting time as a strategy to climate change. This implies that farmers could easily access extension services due to the devolved governments and thus devolved services. It could also be due to the majority of them owning television and radios and thus extension information could be tailored in their local language via these channels.

The location also played a critical role in determining the adaptation strategy. Being a resident of Range to sub-location reduces the likelihood of planting new crops 42 percent. Being a resident of Kabari sub-location increases the probability of planting drought-tolerant crops by 69 percent. While being a resident of Thirikwa sub-location increases the likelihood of planting drought-tolerant crops by 86 percent and reduces the probability of planting new crops by 55 percent. This implies that different geographical locations call for different strategies due to climatic and weather variations.

Practicing other agricultural practices also significantly determined adaptations strategies. Those farmers who grow maize had a high likelihood of planting new crops whole those who grow horticulture had a high likelihood of practicing soil water conservation.

The results were in agreement with the previous studies. These studies indicated that some of the adaptation strategies were the use of different crop varieties, tolerant livestock species, irrigation, inter-cropping, crop rotation, mixed cropping and early planting [6-14]. Another study indicated that unpredictability and shortening of the rainy seasons affected the timing of planting and thus reduced yield [2].

Table 2: Multivariate regression model for climate adaptation strategies; Wald Chi-square=176.85***, Likelihood ratio test of rho21=rho31=rho41=rho32=rho42=rho43=0: chi2(6)=66.6442 Prob>chi^2=0.0000, Standard errors in parentheses, ***p<0.01, **p<0.05, *p<0.1.

Variables	Adjusted Sowing/ Planting time	Planted Drought Tolerant Crops	Planted New Crops	Soil water conservation measures
	-0.012	0.0266	0.0973**	-0.0278
Land size in acres	-0.0479	-0.0463	-0.0479	-0.0484
	0.4303**	0.1199	-0.0202	-0.274
Land has title deed (1=yes, 0 otherwise)	-0.1893	-0.1782	-0.1987	-0.1804
	0.5637***	0.4563**	0.2743	0.3068
Owned livestock (1=yes, 0 otherwise)	-0.2138	-0.2063	-0.2407	-0.2093
	0.4120**	0.2478	0.1816	0.1396
Access to extension services (1=yes, 0 otherwise)	-0.1771	-0.1676	-0.1911	-0.1671
	-0.7140***	-0.1891	-0.1742	0.1731
Gender (1=Male, 0 Female)	-0.2148	-0.1858	-0.2062	-0.182
	0.0201	0.0639*	0.0778	0.0403
Age in years	-0.0372	-0.0368	-0.0491	-0.0349
	-0.0003	-0.0008*	-0.0008	-0.0005
Age squared	-0.0004	-0.0004	-0.0005	-0.0004
	-0.399	-0.1705	-0.0261	-0.1327
Marital status (Single)	-0.2911	-0.2739	-0.3039	-0.2866
	-0.1807	0.2063	-0.0864	0.405
Marital status (Windowed)	-0.3334	-0.2804	-0.344	-0.2774
	0.0336	0.0877**	0.0644*	-0.0376
Years of education	-0.0362	-0.0344	-0.0378	-0.034
	0.1597	-0.2126	-0.4207*	0.7871***
Rungeto Sub-location	-0.2059	-0.1925	-0.2178	-0.1958
	0.5803	0.6994*	-3.7635	0.5132
Kabari Sub-location	-0.443	-0.3629	-68.1888	-0.3263
Thirikwa Sub-location	0.1925	0.8693***	-0.5507*	0.2776

	-0.2939	-0.285	-0.3296	-0.2699
	-0.0009	-0.0028*	-0.0002	0.0001
Monthly income (in Thousands Kshs)	-0.001	-0.0014	-0.001	-0.001
	0.301	0.1866	0.1834	0.3314*
Credit access (1=yes, 0 otherwise)	-0.1935	-0.187	-0.2074	-0.1906
	-0.7186	-0.1873	-0.2078	-0.31
Owned radio (1=yes, 0 otherwise)	-0.4772	-0.3916	-0.3989	-0.3993
	0.3152*	0.2506	-0.286	0.2157
Owned television (1=yes, 0 otherwise)	-0.1758	-0.1583	-0.1797	-0.1565
	-0.2659	-0.1058	-0.2391	-0.1
Grows tea (1=yes, 0 otherwise)	-0.1824	-0.167	-0.1891	-0.1687
	-0.2982	-0.1896	0.8003***	0.1913
Grows Maize (1=yes, 0 otherwise)	-0.1899	-0.1709	-0.2019	-0.1729
	0.0402	-0.1016	-0.0101	0.4826***
Grows Horticulture (1=yes, 0 otherwise)	-0.2041	-0.1788	-0.2097	-0.1788
	0.0324	-2.6417***	-3.6609***	-1.408
Constant	-1.1102	-1.0217	-1.3748	-1.0065
Observations	321	321	321	321

The intensity of adaptation to climate change

The Poisson regression results showed that ownership of livestock, access to extension services and access to credit influences intensity of adoption to climate change. Ownership of livestock increases the likelihood of adopting several adaptation strategies. Livestock is an asset that can easily be liquidated and the proceeds invested in the adoption of new strategies. Access to extension services also increases the chances of adopting several strategies.

Table 3: Poisson regression model of intensity of adaptation to climate change; LR Chi-square=37.78***, Standard errors in parentheses, ***p<0.01, **p<0.05, *p<0.1.

Variables	Coefficients
	0.017
Land size in acres	-0.0256
	0.0317
The land has title deed (1=yes, 0 otherwise)	-0.0997
	0.2915**
Owned livestock (1=yes, 0 otherwise)	-0.1217
	0.1747*
Access to extension services (1=yes, 0 otherwise)	-0.0945
	-0.1443
Gender (1=Male, 0 Female)	-0.0994
	0.0293
Age in years	-0.0208
	-0.0003
Age squared	-0.0002
	-0.1579
Marital status (Single)	-0.1564
Marital status (Windowed)	0.0456

	-0.1437
	0.0248
Years of education	-0.0192
	0.0721
Rungeto Sub-location	-0.1064
	0.1642
Kabari Sub-location	-0.1719
	0.1091
Thirikwa Sub-location	-0.1431
	-0.0007
Monthly income (in Thousands Kshs)	-0.0007
	0.2165**
Credit access (1=yes, 0 otherwise)	-0.1094
	-0.2159
Owned radio (1=yes, 0 otherwise)	-0.211
	0.0919
Owned television (1= yes, 0 otherwise)	-0.0856
	-0.1157
Grows tea (1= yes, 0 otherwise)	-0.0924
	0.0659
Grows Maize (1=yes, 0 otherwise)	-0.0945
	0.1036
Grows Horticulture (1=yes, 0 otherwise)	-0.0955
	-0.6136
Constant	-0.586
Observations	323

This implies that farmers who accessed extension services received regular updates on the appropriate strategies. Credit access increases the cash resource to invest in several strategies and thus increases the likelihood of adopting several strategies. Abid et al. stated that adaptation was high with those farmers who were educated and experienced compared to less educated and inexperienced farmers [20]. However, the research findings indicate that these variables (education and experience) were not statistically significant and thus had no effects on the intensity of adaptation (Table 3).

CONCLUSION

Climate change is currently a serious problem with evidence of increased temperatures and reduction in rainfall resulting in adverse effects on rain-fed agricultural production. Despite this, there is still a knowledge deficit among members of the public on climate change thus negatively affecting the adaptation measures.

The research paper sought to give insights on farmer knowledge on climate change, adaptation strategies and the intensity of adaptation with a view of informing policy on the appropriate approach to climate change information dissemination and adaptation strategies. The research paper on the determinants of climate change knowledge by farmers concludes that more information on climate change should be aired on radio and TV since the majority of the respondents indicated radio and TV as the main source of climate information. Further, the research concludes that farming experience, education, and age in years were also key determinants to access of climate information and thus more effort should be put on education since age and experienced were determined by time, which we have limited control over.

On examining the relevant covariates of climate change adaptation strategies used by farmers, the research paper concludes that the farmers should adopt planting of new crops, adjusting of planting time, planting of drought-tolerant crops and practicing of soil and water conservation practices as mitigation strategies to climate change.

Lastly, the research findings indicate that ownership of livestock, credit access and access to extension services were key determinants to the intensity of adaptation. Previous research stated that adaptation was high with those farmers who were educated and experienced compared to less educated and inexperienced farmers. However, the research findings indicate that these variables (education and experience) were not statistically significant and thus had no effects on the intensity of adaptation. In conclusion, therefore, the researchers recommended further research on the intensity of adaptation. The study also recommends that similar research should be conducted in different counties since the sample size was small and may not provide conclusive results.

REFERENCES

1. Tripathi A, Mishra AK. Knowledge and passive adaptation to climate change: An example from Indian farmers. Climate Risk Management. 2017;16:195-207.
2. Bryana E, Ringlera C, Okobab B, Roncolic C, Silvestrid S, Herrero M. Adapting agriculture to climate change in Kenya: Household strategies and determinants. J Environ Mgmt. 2013;114:26-35.
3. Epule TE, Ford JD, Lwasa S, Lepage L. Climate change adaptation in the Sahel. Environmental Science and Policy. 2017;75:121-137.
4. Stoutenborough J W, Vedlitz A. The effect of perceived and assessed knowledge of climate change on public policy concerns: An empirical comparison. Environmental Science and Policy. 2014;37:23-33.

5. Seebauer S. Validation of a social media quiz game as a measurement instrument for climate change knowledge. Entertainment Computing. 2014:5:425-437.
6. Comoe H, Siegrist M. Relevant drivers of farmers' decision behavior regarding their adaptation to climate change: A case study of two regions in Côte d'Ivoire. Mitigation and Adaptation Strategies for Global Change. 2013;20:179-199.
7. Piya L, Maharjan KL, Joshi NP. Determinants of adaptation practices to climate change by Chepang households in the rural Mid-Hills of Nepal. Regional Environmental Change. 2013:13:437-447.
8. Seinn Seinn MU, Ahmad MM, Thapa GB, Shrestha RP. Farmers' adaptation to rainfall variability and salinity through agronomic practices in lower Ayeyarwady Delta, Myanmar. J Earth Sci Clim Change. 2015;6:1-12.
9. Kibue GW, Liu X, Zheng J, Zhang X, Pan G, Li L et al. Farmers' perceptions of climate variability and factors influencing adaptation: evidence from Anhui and Jiangsu, China. Environ Manage. 2016;57:976-986.
10. Thoai TQ, Rañola RF, Camacho LD, Simelton E. Determinants of farmers' adaptation to climate change in agricultural production in the central region of Vietnam. Land Use Policy. 2018;70: 224-231.
11. Hendrix CS. The streetlight effect in climate change research on Africa', Global Environmental Change. 2017;43:137-147.
12. Biggs EM, Gupta N, Saikia SD, Duncan JMA. The tea landscape of Assam: Multi-stakeholder insights into sustainable livelihoods under a changing climate. Environ Sci Policy. 2018;82:9-18.
13. Gunathilaka RPD, Smart JCR, Fleming CM. Adaptation to climate change in perennial cropping systems: Options, barriers and policy implications. Environmental Science and Policy. 2018;82:108-116.
14. Azhoni A, Jude S, Holman I. Adapting to climate change by water management organizations: Enablers and barriers. J Hydrol. 2018;559:736-748.
15. Bryan, E., Deressa, T.T., Gbetibouo, G.A. and Ringler, C. Adaptation to climate change in Ethiopia and South Africa: options and constraints. Environmental Science and Policy. 2009;12(4):413-426.
16. Joseph C, Chemarum AK, Vedelda PO, Petursson JG. Old wine , new bottles? Investigating the differential adoption of "climate-smart" agricultural practices in western Kenya. Journal of Rural Studies. 2017;56:114-123.
17. Shikuku KM, Winowiecki L, Twyman J, Eitzinger A, Perez JG, Mwongera C, et al. Climate risk management smallholder farmers' attitudes and determinants of adaptation to climate risks in East Africa. Climate Risk Management. 2017;16: 234-245.
18. Mugi-ngenga EW, Mucheru-Muna MW, Mugwe JN, Ngetich FK, Mairura FS, Mugendi DN. Household's socio-economic factors influencing the level of adaptation to climate variability in the dry zones of Eastern Kenya. Journal of Rural Studies. 2016;43:49-60.
19. Kabubo-Mariara J, Karanja FK. The economic impact of climate change on Kenyan crop agriculture: A Ricardian approach. Global and Planetary Change. 2007;57:319-330.
20. Abid M, Schneider UA, Scheffran J. Adaptation to climate change and its impacts on food productivity and crop income: Perspectives of farmers in rural Pakistan. J Rural Stud. 2016;47:254-266.
21. Kahsay Abraha G, Garn L. The effect of climate change and adaptation policy on agricultural production in Eastern Africa. Ecological Economics. 2016;121:54-64.
22. Abid, M., Scheffran, J., Schneider, U.A., Ashfaq, M., (2015) Farmers' perceptions of and adaptation strategies to climate change and their determinants: the case of Punjab Province, Pakistan. Earth Syst Dyn. 6:225e243.
23. Pandey R, Kumar P, Archie KM, Gupta AK, Joshi PK, Valenteet D, et al. Climate change adaptation in the western-Himalayas: Household level perspectives on impacts and barriers. Ecological Indicators. 2017;84:27-37.
24. Niles MT, Mueller ND. Farmer perceptions of climate change: Associations with observed temperature and precipitation trends, irrigation, and climate beliefs. Global Environmental Change. 2016;39:133-142.
25. Olazabal M, Chiabai A, Foudi S, Neumann MB. The emergence of new knowledge for climate change adaptation. Environmental Science and Policy. 2018;83:46-53.
26. Alauddin M, Rashid A. Climate change and farm-level adaptation decisions and strategies in drought-prone and groundwater-depleted areas of Bangladesh: An empirical investigation. Ecol Econ. 2014;106:204-213.
27. Mosberg M, Eriksen SH. Responding to climate variability and change in dryland Kenya: The role of illicit coping strategies in the politics of adaptation. Global Environmental Change. 2015;35:545-557.
28. Yamane T. Elementary sampling theory. USA: Prentice-Hall, University of Michigan. 1967.
29. Lancaster KJ. A new approach to consumer theory. Journal of Political Economy. 1966;74:132-157.
30. Manski CF. The structure of random utility models. Theory and Decision. 1977;8:229-254.
31. Greene H. Econometric analysis (7th Ed.). Upper Saddle River, N. J Prentice Hall. 2012.

Appendices

Appendix 1: Target Population and Sample Size.

Sub-location	Population	Number of Households	Sample Size
Rungeto	5,050	1,507	104
Kabari	4,305	1,282	88
Thirikwa	3,611	1,125	77
Nyangeni	5,098	1,497	103
Total	18,064	5,411	372

Appendix 2: Sources of Climate Information.

Source of Climate Information	Frequency	Percentage
Newspapers/magazines	97	9.58
Television	279	27.54
Radio	285	28.13
NGOs workers	7	0.69
Agricultural Extension Officers	56	5.53
Family members/relatives	66	6.52
Preachers/Pastors/Imams	100	9.87
Friends	80	7.9
Personal involvement in Training	43	4.24
Total	1013	100

Appendix 3: Type of Climate Change Experienced.

Type of climate change experienced	Frequency	Percentage
Excessive temperature	294	40.44
Excessive cold	26	3.58
Change of pattern of rainfall	238	32.74
Frequent flood	5	0.69
Frequent drought	154	21.18
Don't know/don't understand	10	1.38
Total	727	100

Appendix 4: Climate Change Adaptation Strategies.

Climate Change Adaptation Strategies	Frequency	Percentage
Adjusted sowing/planting time	242	34.42
Started planting drought tolerant crops	168	23.9
Shifted/started growing new crops	74	10.53
Used soil water conservation measures (e.g mulching, terracing)	168	23.9
I did nothing	51	7.25
Total	703	100

Appendix 5: Perceived Causes of Climate Change.

Perceived Causes of climate change	Frequency	Percentage
Deforestation	334	48.55
Industrial effluents	123	17.88
Population growth	97	14.1
Black smoke of vehicles	134	19.48
Total	688	100