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Smallholder Farmers' Perspectives on Climatic Variability and Adaptation Strategies in East Africa: The Case of Mount Kilimanjaro in Tanzania, Taita and Machakos Hills in Kenya

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Abstract

Climate change is expected to have serious economic and social impacts in East Africa, particularly on rural farmers whose livelihoods largely depend on rain-fed agriculture, hence adaptation is required to offset projected drawbacks of climate change on crop productivity. This paper examines farmers' perceptions and understanding of climatic variability, coping strategies adopted and factors that influence the choice of a particular adaptation. The study uses cross section data collected from 510 farmers in three mountain gradients sites, namely; Mount Kilimanjaro of Tanzania, Taita and Machakos Hills of Kenya. Farmers' perceptions were compared to actual trend in meteorological records over the last thirty years (1981-2010). The result revealed that farmers in East Africa were partly aware of climate variability, mainly in temperature and rainfall patterns. Many respondents reported that conditions are drier and rainfall timing is becoming less predictable. The perception of farmers on temperature and rainfall were in line with recorded meteorological data, but contrary with that of recorded rainfall in Machakos which was perceived to be decreasing by the farmers. Farmers perceived changes in rainfall and temperature to have negative effects on the production and management of crops. The common adaptation strategies used by farmers include water harvesting, soil conservation techniques and shifting of planting periods. The most important variables affecting farmers choices in regards to adaptation option were, lack of access to credit, farming experience and household size. As a conclusion, there is a need for these factors to be taken into account in the development and implementation of smallholder farmers' adaptation strategies to climate variability in East Africa. Additionally, dedicated capacity building and extensive outreach initiatives on adaptation through governments, researchers, policy-makers and the farmers groups themselves are needed to achieve large scale success.

Keywords: Adaptation; Climate variability; East Africa; Farmers' perceptions

Introduction

Increasing global average temperature provides evidence on climate change [1-5], and is mainly due to human activities [1,6-8]. Global temperatures are expected to continue to rise regardless of human interventions for at least the next two decades [2,9]. It is projected that the impacts of climate change will be greater in developing countries with predominant small holders and subsistence farmers, whose livelihoods depend on the use of the natural resource base, being most severely affected [10-13]. Countries in East Africa are highly vulnerable to climate change, primarily due to their reliance on rain-fed agriculture [14-16]. Agriculture is of critical importance given its multiple roles for economic development, poverty alleviation, job creation, and food security of East African countries, yet vulnerability to climate risk [17-20]. The annual average temperatures in the region are expected to increase by about 1.3°C - 2.1°C by the year 2050 [21,22]. Higher temperatures mediate faster loss of soil moisture, and with prolonged drought create favourable conditions for pest and diseases to multiply [23]. It is also predicted that rainfall will be more erratic and violent, further disrupting predominantly rain-fed agricultural production systems and impeding livelihoods [13,16,22,24-27]. Furthermore, evidence strongly suggests that increased events of droughts and floods may be exacerbating poverty levels, leaving many rural farmers trapped in a cycle of poverty and vulnerability to diminishing resources [28]. For instance, frequent droughts and floods have caused failure and damage to crop and livestock leading to persistent food shortages [26,29-31]. Smallholder farmers in East Africa are predicted to be more at risk because of their lower capacity to adapt, resulting from various socio-economics, demographic, policy trends and high population density [4,5,32-36]. Meanwhile population growth in East African countries is among the highest in the world, and estimated to double the demand for food, water, and livestock foraging lands within the next 30 years [22,36]. Smallholder farmers are particularly vulnerable to changes in climate that reduce productivity and negatively affect their weather-

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dependent livelihood systems [16,37]. These farmers also face the challenges of land degradation, poor soil fertility management, and continuous cropping [22]. Despite these vulnerabilities of smallholder farmers, their perceptions and concern on climate variability have largely been overlooked and sidelined by both policy and decision making processes, besides perception of local farmers are important because farmers often manage land according to their perceptions and belief [38]. However, a few studies done across the world demonstrate the growing importance of this focus area [39]. For example, studies done by Aemro et al. [1]; Gandure and Alam [40]; Maddison [41]; Bryan et al. [42]; and Hartter et al. [43] show that educated and experienced farmers have more knowledge and information about climate variability and agronomic practices that they can use in response. Deresa et al. [44] also found that educated farmers significantly increased soil conservation and changing planting dates as adaptation methods. A study in Tanzania by O'Brien et al. [45], reports that despite farmers' awareness and willingness to apply numerous adaptation options, the lack of income to purchase the necessary inputs and other associated equipment (such as purchasing seeds, acquiring transportation, hiring temporary workers) is one of the significant constraints to adaptation. They further noted that large households are more willing to implement the adaptation measures, such as soil conservation techniques, chemical treatments, that are labor intensive. However, people working on climate variability do not really know what information the grassroots people need in the short- and medium-term and what information they already have. Many studies show that adaptation measures and actions are being planned and implemented and need to be further supported [16,41,46-48]; nonetheless, these studies focused on the continental, regional or national levels and only few of them captured local adaptation strategies [49,50]. In this context information on smallholder farmers' perceptions on climate variability is a first step to strengthened adaptation strategies. In addition, local-scale analyses also can help highlight the primary constraints to adaptation and the differential nature of vulnerability of particular groups [51]. Presently, such information is, however, still limited in East Africa, particular at a local scale. Therefore, the present study fills this information gap by exploring the indigenous knowledge of local scale farmers on their perception of climate variability, and on the various adaptation strategies adopted. This study also considers factors influencing the choice of a particular adaptation strategy in Mount Kilimanjaro of Tanzania, and Taita and Machakos Hills of Kenya.

Material and Methods

Study sites

The study areas are located at the Eastern Afromontane Biodiversity Hotspot (EABH) in Kenya and Tanzania. This important biodiversity hotspot is composed of scattered, but biogeographically similar mountain ranges. The EABH have important ecosystem service values arising from the water towers it provides for the low lying areas, food production from major crops such as maize, cabbages and cash crops like coffee and avocado, recreation and eco-tourism, habitats and refugia, and nutrient recycling [52,53]. The high human population density results in resource competition between agriculture, forest and biodiversity conservation, water provision and carbon sequestration. Due to climate and land use changes, exacerbated through high population increase, EABH is at risk of extreme climatic changes, while the goods and services its ecosystems provide are under significant threat [52]. The target areas represent samples of the EABH agriculture-forest mosaics in which all above-mentioned crops can be studied on farms with various scales of agricultural intensity, environmental settings and altitudinal gradients. In Kenya, the target areas are Taita and Machakos Hills. The Taita Hills are situated in the Coast province, at an elevation ranging from 700-2000 meters above sea level (m.a.s.l), between latitude 3°25´ S and longitude 38°20 E. Mean annual rainfall ranges from 500mm to over 1500mm and mean annual temperature ranges from 16.5 to 23.5°C . The location is generally characterized by a bimodal rainfall distribution, where the long rains occur from March to May/June and short rains from September/October to December [53]. The Machakos Hills is situated in Eastern Province in Kenya, and has elevation ranging from 1000 to 2100 m a.s.l, between latitude 1°31´ S and longitude 37°16´ E. Mean annual rainfall varies between 900mm to 1200mm. The long rains occur during March to May and the short rains from October to November. The temperature ranges from a minimum of 9.1 to a maximum of 26.7°C per annum. In Northeast Tanzania, the target area is situated in the Pangani river basin with a focus on the small upper catchment areas on the southeastern slope of Mount Kilimanjaro, at 700-1800 (m.a.s.l), approximately located between latitude 3°4´ S and longitude 37°4´ E. The mean annual temperature ranges from 18 to 23.6°C and mean annual rainfall ranges between 1000mm to 1300mm. The area experiences two distinct rainy seasons: the long rains from March to May and the short rains between October and December [53].

Data collection

Data were collected in 2012 by administering semi-structured questionnaire to a random sample of 510 smallholder farmer households residing in 17 villages. 30 farmers were selected per village, and one respondent was interviewed per household. Data were collected on farmers' perception of climate variability, specifically the changes in rainfall, temperature and other climatic events over the past 10 years and the adaptations option they use. Each farmer was subjected to an interview session for approximately one hour. All interviews took place face-to-face on the farmers homestead. In addition, secondary data on rainfall and temperature over the last thirty years (1981-2010) were collected from Kenya Meteorological Department and Tanzania Meteorological Agency.

Data analysis

Descriptive statistics together with an ordinary least square and multinomial logit model (MNL) were used to characterize farmers' perceptions on climate variability. The qualitative and quantitative information gathered was analyzed using STATA, version 12 (StatCorp Lp, TX, USA). Trends of annual rainfall and temperature over the past 30 years (1981-2010) were calculated using simple linear regression. The main descriptive analyses used were the frequencies; cross tabulations, and Chi-square tests. Further, Principal Component Analysis (PCA) [54] was used to develop farmers' perception score on climate variability such as temperature, rainfall and occurrences of extreme events. A measure of sampling adequacy was carried out using Kaiser-Meyer-Olkin (KMO) to ensure suitability of the use of PCA. The computed value of the KMO measure of sampling adequacy for the set of variables used in this study for the PCA is 0.631, which implies appropriateness of the PCA technique [55]. To determ ine the strength of relationship, we conducted Bartlett's test of Sphericity (BTS) The result of BTS yield a Chi-Square of 854.18, at a level of significance of $p< 0.001$. We then rejected the null hypothesis and concluded that there are correlations in the data set that are appropriate for PCA. Four principal components were extracted with their proportion of variation. The four factors explained 68.59% of the total variation. Using the proportion of variation as a weight of the component score, the Non-

Standardized Index (NSI) score of climate perception was computed, using the formula:

$$NSI = \sum_{i=4}^{n} \frac{pc_i}{Tpc} \times fc_i \qquad (1)$$

where pc_i is the proportion component at i, Tpc is the principal component score at i, and Tpc is the total proportion variation. However, the value of NSI can be positive or negative, making it difficult to interpret. Thus, a Standardized Index (SI) was calculated (Antony and Rao, 2007), using the following formula:

$$SI = \frac{NSI_i - MinNSI}{MaxNSI - MinNSI} \times 100 \qquad (2)$$

where $MaxNSI$ and $MinNSI$ are the maximum and minimum values of the non-standardized index, respectively. The value of SI usually ranges from 0 to 100. The SI of 0 indicates a low perception on Climate change while 100 indicates a high perception.

A standardized index of perception constructed was used in a linear regression to estimate factors influencing farmers' perception. The regression model is specified as:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \beta_{11} x_{11} + \beta_{12} x_{12} + \beta_{13} x_{13} + \beta_{14} x_{14} + \varepsilon \qquad (3)$$

where Y is the farmer's perception on climate change (dependent variable), $x_1,\ldots,x_{14}$ are the independent variables namely age of household head, household size, total land areas the house hold own (land owned), sex of the household head, access to credit, irrigation, farmers practices cropping farming activities, farmers practices livestock farming activities, farmer who plant maize as major crops, farmers practices mixed farming activities, farmer plant beans as major crops, farmers member of agricultural social-network and farmers practices intercropping, respectively; $\beta_0,\ldots,\beta_{14}$ are constant parameters estimates for the independent variable, and ε is an error term.

To establish factors that govern choices of a particular adaptation technique a multinomial logit model (MNL) was used. This study utilizes a MNL model to analyze the determinants of farmer's decisions because it is widely used in adoption decision studies involving multiple choices, easier to compute than its alternative, and also since households employ different adaptation strategies, which are not mutually exclusive [16,38,56]. Further, the advantage of using MNL model is its computational simplicity in calculating the choice probabilities that are expressible in analytical form [1]. The parameters of the MNL model provide only the direction of the effect of the independent variables on the dependent variable; they do not represent the actual magnitude of change of probability. Thus, the marginal effects of the explanatory variables were computed. The marginal effects are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean. The MNL was structured by closely grouping related choices together in the same category to produce significant estimates of adaptation. The likelihood ratio statistics as indicated by the chi-square statistics was found to be highly significant. Multi-collinearity among the independent variables was checked using Variance Inflation Factor (VIF), which for all variables was less than 10, indicating that multi-collinearity is not a serious problem in model estimation. Finally, the model was tested for validity of the Independence of Irrelevant Alternatives (IIA) assumptions by Using Hausman's Test. The choice set in the restricted MNL model included six adaptation options; (a) soil, water and conservation management (such as tree planting, mulching, rainwater harvesting and irrigation; (b) change of crop varieties; (c) change in planting and harvesting dates (change in time of planting and harvesting); (d) crop diversification; (e) other adaptation (such as diversifying from farm to non-farm activities; and no adaptation. The empirical Model is defined as:

$$Y_i = f\left(z_1, z_2, \ldots, z_7\right) \qquad (4)$$

where Y_i is the dependent variable and $z_1,\ldots,z_7$ are independent variables namely; sex, age, education level, household size, access to credit, access to climatic information and farmer experience, respectively.

Results

Socio-economic characteristics

The results indicate that males accounted for 52.75% of the respondents while females 47.25%. The average age for farmers was 53 years ranging from 21 to 95 years of age, indicating that most farmers are within the productive and economically active age group and assumed to have a better knowledge and information on change in climatic conditions. The average household size was 5.19 (±2.63) in the study sites. About 8.63% of the respondents had no formal education, 63.73% had attended primary and other education after primary school (tertiary education), and 26.47% reached secondary level, had either completed secondary school ("O" Level or "A" Level in the English schooling system) . This later proportion had discontinued their secondary education before finishing, either at Form one or Form two or reached tertiary institution after secondary and other training. However, only 1.17% of the respondents had received University degree. Taita Hills had the highest percentage of respondents without any formal education, followed by Machakos and Mount Kilimanjaro. Highest level with primary school was found in Mount Kilimanjaro with 74.44% followed by Taita (57.77%). Agriculture is the main economic activity in the areas with 79.41% of farmers practicing mixed farming. In single farming practice the respondents are engaged in cropping (16.27%), livestock keeping (2.16%), apiculture (0.39%) and aquaculture farming (0.2%). However, apiculture and aquaculture activities were reported only in the Taita Hills. This is probably due to the difference in the level of urbanization in these three sites. Analysis indicated that maize and beans are the major crops grown in all the three sites. Apart from these two major crops recorded across all the three study areas, potatoes, banana and cowpeas occupied the third place in Taita Hills, Mount Kilimanjaro and Machakos respectively. About 85.6% of maize production in study areas is used for home consumption, and the remaining percentages are sold at the local markets for other needs of the households.

Farmers' perception towards changes in temperature and rainfall

The respondents identified three characteristics associated with the changes in rainfall and how this affected their livelihoods. Firstly, rainfall variability was described in terms of annual and seasonal variation. They perceived that the rainfall was likely to be irregular from one year or season to the next. The duration of the respective seasons were calculated from the stated onset (March/April and September/October and offset months (June and December) for long rain and short rain, respectively. The results indicate that the mean duration of the long rain and short rain seasons is distinct in each site (Table 1).

Almost all the farmers interviewed (97%) believe there had been

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changes in the overall rainy seasons. The results show that there was no significant relationship between the year of change in seasons and the study sites (χ^2 = 4.0026, p = 0.135). However, there was considerable variation concerning the time this change had begun to be evident, and 72.58% of the farmers identified the change of climate to have started less than 15 years ago; while 27.42% had noticed that rainfall changes started more than 15 year ago (Table 2). Secondly, majority of the surveyed farmers (99%) believed that rainfall had declined in terms of frequency and amount (Figure 1a), and there was no difference between study sites. The trend analysis of rainfall data showed that annual rainfall decreased from year 1981 to 2010 in the Taita Hills and Mount Kilimanjaro (Figure 2b and d), indicating that farmer's perception are in accordance with the statistical records in the these two study areas. However, the result was contrary to the view of farmer's perception in Machakos (Figure 2f). The third factor associated with the variations in rainfall was the change in the time the first rains generally occurred, 95% of the farmers have observed that rains were now coming very late for the last 10 years (Figure 1a). In the case of temperature, majority of interviewed farmers perceived changes in temperature patterns in all three study sites. The results showed that 95.51%, 77.65% and 91.33% of the farmers perceived that temperature became warmer in Mount Kilimanjaro, Taita and Machakos Hills, respectively (Figure 1b). Some farmers thought this was due to the changes in seasons, while others were not sure about the causes. The farmer's perceptions on temperature are similar with the trend for annual mean temperature analysis over a period of 30 years from the meteorological stations (Figures 2a, c and e), which showed an increasing of temperature in all study sites. With respect to the prevalence of drought, flood and storms, a large percentage of farmers reported that there have been many changes in drought for the three sites (Figure 1c); less than 25% of farmers reckoned changes with flooding and storms incidence in all the three study areas for the past 10 years (Figure 1c). However, there was considerable variation among study areas concerning believes of the extreme events, and 43% of farmers in Machakos, have observed extreme events compared to Mount Kilimanjaro (31%) and Taita Hills (29%) who believed that this is a normal phenomenon. As to the causes of perceived changes, the majority (91%) of the farmers attributed it to cultural and religious factors. There is a general feeling that as much as science provides evidence on climate variability, there is now a deliberate effort to ignore cultural and religious dimensions that have been central in climate prediction and analysis. There was a significant association (χ^2 =10.675, P = 0.016) with the levels of education and perception of causes of climate variability. Farmers with higher level of education constituted majority (92.77%) of those citing environmental factors that identified deforestation, overpopulation, environmental destruction and corruption as critical factors causing climate variability while those with less education cited mainly (25%) socio-cultural and religious factors, referred to the Bible, arguing that disobedience of humankind to God's principles and/or lack of respect to ancestral spirits and other customs.

Study sites	Long Rains (months)	Short Rains(months)	T-value
Mount Kilimanjaro	3.09	1.88	11.671***
Taita Hills	2.68	2.21	4.48***
Machakos Hills	2.39	1.73	4.60***

Table 1: Perception of changes in the mean durations of seasons in months. *** is the significant at 1%.

	Overall	Mount Kilimanjaro	Taita Hills	Machakos Hills
Recent past (<15 years)	72.58	73.89	76.27	66.67
Long time ago (>15 years)	27.42	26.11	23.73	33.33

Table 2: Perception of farmers' realization of change in the seasons (%).

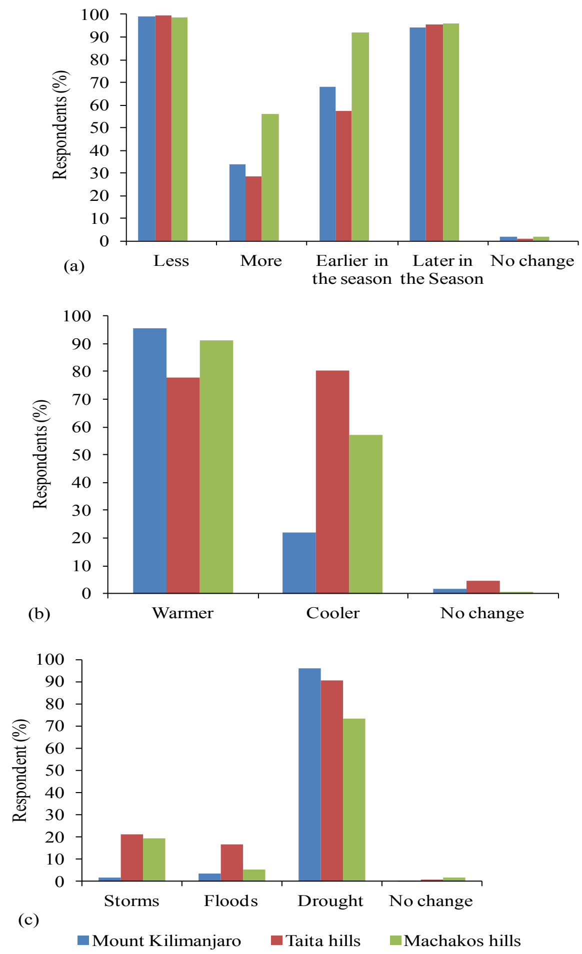

Figure 1: Farmers perception towards changes in rainfall (a), temperature (b), and extreme climatic events (c) for the past 10 years across the Mount Kilimanjaro (*blue*), Taita Hills (*red*) and Machakos Hills (*green*) sites of East Africa.

Factor explaining farmers' perception

The results showed that farmers practicing intercropping, maize production and livestock keeping in their farms have a higher climate variability perception score as compared to farmers engaged in other farming activities such as cropping, mixed farming, aquaculture and apiculture (Table 3). Farmers who do not have access to credit and farmers cultivating beans have a lower perception score towards climate variability (Table 3). There is no evidence that age, household size, irrigation, land owned, mixed farming, apiculture, aquaculture and access to any information shape farmers perception on climate variability (Table 3).

Current adaptation strategies at farmers' level to climate variability

In response to the impacts associated with climate variability, farmers in the study areas reported to have taken different adaptation

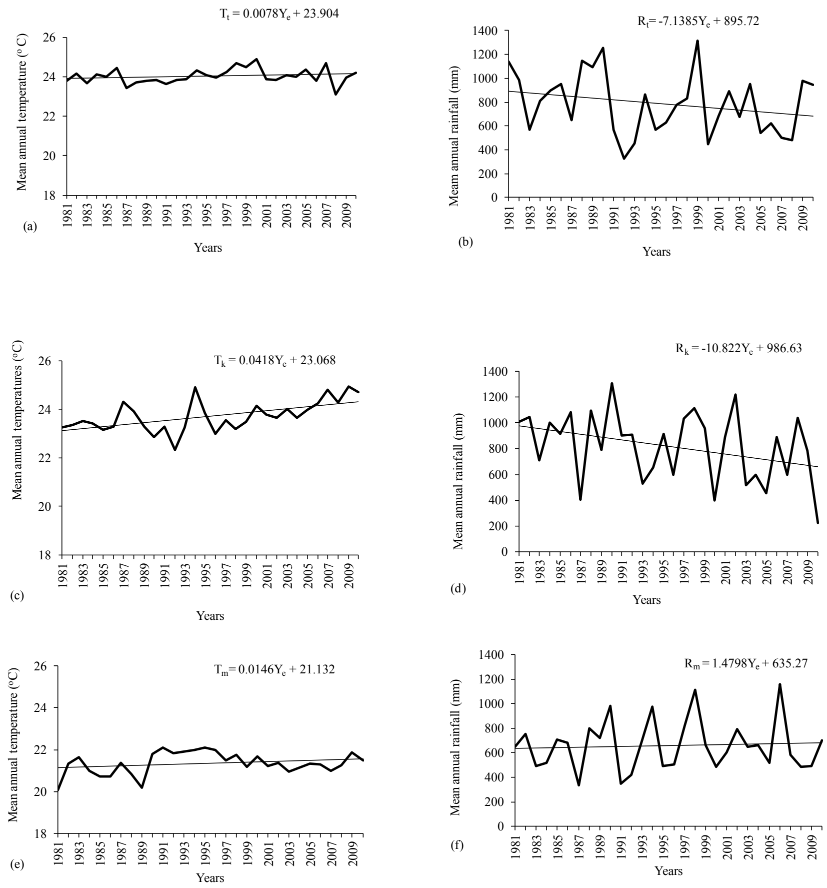

Figure 2: Annual variability and trend (line) of the development of annual mean temperature (left hand graphs) and rainfall (right hand graphs) during the past 30 years in three study areas; (a) and (b) along Taita Hills; (c) and (d) along Mount Kilimanjaro; and (e) and (f) along Machakos Hills.

measures (Table 4). The main adapting mechanism that was consciously acknowledged as a direct result of the change in climate was increased use of rain water harvesting and soil conversation techniques, which were used by about 60% of farmers. Another common response to climate variability was the shifting of planting periods. There were two main ways to change their planting techniques. The first option was earlier planting, technique used by about 28.0% of the farmers (Table 4); however, farmers noted that this was vulnerable to the possibility that the rain would not come, and their investment would be lost; coupled with this shift, farmers were also spreading the risk by planting twice and only when it rains. The other option was to wait until the rains actually started and to carry out late planting used by about 28.2%; however, farmers reported that waiting for the rains coupled with a shorter rains season, resulted in a rushed season which affected yields. Furthermore, it was noted that farmer have wide advantages of different varieties on crop, drought-tolerant varieties and also practice mixed cropping among the major adaptation strategies identified in the study sites (Table 4). Additionally, about (87.43%) of respondents mentioned that government-based weather information, both daily and for future seasons, reach most of the farmers. The presence of television and radio in village households is becoming increasingly widespread in both the three study areas, and farmers recalled hearing this information either from television or on the radio. However, there were very mixed views on the importance of this information. A greater proportion (67.58%) of the farmers did not trust the information, and 25.11% of them complained of having followed a government prediction only to have the rains fail or fall unexpectedly. Although, those farmers who accessed and used this information noted that, it is delivered in a way to farmers that is hard to understand, and further it was noted that there is a lack of understanding of how to apply recommendations practically.

Determinant of farmer's choice of adaptation

The analysis of barriers to adaptation to climate change in the study areas indicate that there were three major constraints against adoption of adaptation methods; these include household size, access to credit and farming experience (Table 5). The results revealed that farmers with more experience and access to credit have higher chance of choosing change of planting date, soil and water conservation management as an adaptation measure (Table 5). This result supports the important role of increased institutional support in promoting the use of adaptation options to reduce the negative impact of climate variability.

Discussion

In this study, farmers' perceptions of climate variability and adaptation strategies as well factors affecting the adoption of a specific strategy were assessed. Across the three study sites farmers were

Perceptions~e	β	Std. Err.	t	P>|t|	[95% Conf. Interval]	
Cropping	46453.1	44089.3	1.05	0.293	-40176.9	133083.2
Livestock	207508.1	74361.7	2.79	0.005	61396.4	353619.8
Mixed	51215.4	39174.3	1.31	0.192	-25757.2	128188.0
Maize	76469.3	42622.7	1.79	0.073	-7279.1	160217.7
Beans	-56215.6	63163.9	-2.43	0.016	-101729.9	-10701.3
Sex of the household head	22146.5	17244.8	1.28	0.200	-11737.4	56030.5
Age	851.9	526.7	1.62	0.106	-182.9	1886.9
Household size	1512.72	3797.3	0.40	0.691	-5948.5	8973.9
Landowned	654.468	2232.2	0.29	0.769	-3731.5	5040.5
Intercropping	70340.6	27685.5	2.54	0.011	15941.9	124739.3
Irrigation	-25755	31694.7	-0.81	0.417	-88031.4	36520.9
Access to credit	-60133	19515.9	-3.08	0.002	-98479.8	-21786.8
Apiculture	-8613.7	57395.4	-0.15	0.881	121388.6	104161.2
Aquaculture	-15452.5	55287.7	-0.28	0.780	-124086.1	93181.1
Infopro	-26702.5	18230.5	-1.46	0.144	-62523.3	9118.3
Grame	8836.3	21258.5	0.42	0.678	-32934.1	50606.7

Table 3: Factor explaining farmers' perception. Infropro is the access to any information related to maize cropping,and Grame is the agricultural social network.

Strategy applied	Mount Kilimanjaro	Taita Hills	Machakos Hills	Overall
Different varieties of one crop	2.9	52.9	2.0	20.2
New variety of one crop	17.9	34.4	2.7	19.2
Stopped planting a crop forever	0.0	16.1	0.0	5.7
Shift to other crops (stopped to grow one crop and plants another instead)	0.0	3.9	0.0	1.4
Use of drought-tolerant varieties	0.6	50.6	2.0	18.6
Use of pest-resistant varieties	0.0	27.9	0.0	9.8
Use of short-maturing varieties	2.9	32.2	14.7	16.7
Increased use of insecticide	0.6	6.7	4.0	3.7
Earlier planting and harvesting dates	30.6	29.4	23.3	28.0
Late planting and harvesting dates	30.0	30.0	24.0	28.2
Increased use of irrigation	0.0	1.1	2.0	0.9
Crop diversification	0.6	8.9	1.3	3.7
Increased use of water and soil conversation techniques	27.8	74.4	67.3	55.9
Diversification from non-farm activities	0.0	18.9	14.0	10.8
Change in cultivated area	10.0	0.0	14.0	7.7

Table 4: Current measures adopted (%) by farmers in response to climate variability in Mount Kilimanjaro, Taita, and Machakos Hills of East Africa.

aware of climate variability and perceived changes in temperatures and rainfall regimes, and its impacts on their livelihoods. However, their perceptions on climate variability differed from one farmer to another and were largely dependent on the characteristics of the study sites and education. Similar results were reported by Maddison [41] whereby a significant number of farmers in eleven countries believed that temperature had increased and that rainfall had declined as a result of climate change. Also our results are consistent with studies reported by farmers in western Uganda, who cited changes in weather patterns, including increasing temperatures and decreasing rainfall as causes of decreased crop yields [43]. Furthermore, according to IPCC [19], an increase in average temperature will adversely affect crops, especially in semi-arid regions, where already heat is a limiting factor for production. Interestingly, this observation was in line with the meteorological records trend analysis on the temperature and rainfall. However, rainfall observations were contrary to the trend analysis in the Machakos study site. This difference could be as a result of erratic rainfall in the past 10 years because farmer put more weight on recent information. A similar discrepancy between farmer's perception and recorded weather data was reported by Zampligre et al. [57] from different agro-ecological zones in Burkina Faso. Further, perception of climate variability may vary based on the number of years spent as a farmer, level of education, wealth, gender, and age [38,41,58]. However, it is important to be aware of these perceptions since farmers frequently act on their perceptions, change their behavior, and develop coping strategies based on their dynamic and evolving knowledge, whether or not they are consistent with meteorological data [59,60]. The results indicate that farmers, who practice intercropping, keep livestock, have access to credit, grow maize, and beans are more likely to perceive climate variability. This is due to the fact that farmers who practice

Explanatory variables	Soil and water Conservation	Change of crop varieties	Change of planting dates	Crop diversification	Other adaptation	No adaptation
Gender	0.243	0.959	0.972	1.000	1.000	0.345
Age	0.961	0.678	0.419	1.000	1.000	0.730
Household size	0.984	0.279	0.460	1.000	1.000	0.083*
Literacy	0.551	0.598	0.564	1.000	1.000	0.988
Access to credit	0.000**	0.176	0.000**	1.000	1.000	0.986
Experience (Years)	0.016**	0.193	0.015**	1.000	1.000	0.959
Weather Information	0.131	0.341	0.533	1.000	1.000	0.197

Table 5: The marginal effects of the determinants of household adaptation decision. **Significant at 5%, *Significant at 10%.

those activities observed a decline in crop yield which had resulted into food insecurity [43]. Farmers' adaptation to climate variability was innovative and self-reliant. Respondents used several coping strategies to reduce the adverse impacts of climate change, these include; water harvesting and soil conversation techniques, shifting of planting periods and multi-cropping systems. It was rare to find farmers who did not grow at least two types of crops or more. Moreover, according to farmers', a combination of strategies to adapt, such as proper timing of agricultural operations, crop diversification, use of different crop varieties, changing planting dates, and diversifying from farm to non-farm activities were their main adaptation options. This result is in line with findings by Below et al. [37] who stipulated that variation in crops and improved crop varieties, change in timing of cropping and cropping patterns, water conservation techniques and implementation of irrigation schemes irrigations are common adaptation strategies used by small-scale farmers in Africa. Deressa et al. [56] concluded that the most common adaptation strategies by agriculturalists were tree planting, soil conservation, planting different crop varieties, being flexible with the planting time, and irrigation schemes. Farmers indeed possess the capacity and desire required for successful adaptation to climate variability at households levels, but need to be further supported and strengthened. Such measures might play an important role in maintaining or increasing the countries productivity and therefore help farmers to cope with food security and the negative impacts of climate change [46]. With regards to the choice of a given adaptation strategy, the results indicate that experienced farming households and those with access to credit have an increase likelihood of choosing coping and adaptation strategies such as change in planting date, planting different crops and planting different varieties. Experience has taught most of the farmers on the various farm management practices and techniques that can be used in the face of anticipated climate change. Access to credit of the households surveyed has a positive and significant effect on using coping strategies such as improved crop varieties, soil and water conservation and crop diversification techniques. These results confirm the findings of Nhemachena [61] and Gbetibouo [38]. Furthermore, the results are consistent with many studies which also point out the significant role of socioeconomic factors such as the individual decision maker's experience, education, wealth status and availability of resource such as land, credit and water storage facilities as important factor influencing adaptation and coping strategies [41,56,62]. Deressa et al. [56] concluded that ecological zones also affect choice of adaptation strategies. A similar study by Ajibade [63] and Salick and Byg [64] hypothesized that local adaptation strategies are based on coping experience acquired over time, which is transmitted from generation to generation. This implies the important role of increased institutional support in promoting the use of adaptation options to reduce the negative impacts of climate variability.

Conclusion

This study demonstrated the importance of the local context, and the role of existing practices and farmers' perceptions in the investigation of possible adaptation strategies to climate change. The study shows that farmers in the three study areas have already adopted some creative strategies to secure their livelihoods in view of perceived and actually occurring climate variability; these can be further adjusted to the challenge of climate change by incorporating lessons learned from other regions of the world as well as through the findings of innovative science. However, current policy trends in the three study sites indicate less government support for interventions in the solution of specific agricultural sector problems. Thus in developing effective adaptive management strategies in the three case studies, there is a need for increase collaboration between small-scale farmers, researchers, policy-makers, the private sector and the local government. Finally, quantifying local people's perception to climate variability and their adaptation options is fundamental to addressing the dual challenge of food insecurity and poverty alleviation in densely population in East Africa.

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References

1. Aemro T, Jemma H, Mengistu K (2012) Climate Change Adaptation Strategies of Smallholder Farmers: The Case of Babilie District, East Harerghe Zone of Oromia Regional State of Ethiopia. J Econ and Sust Devel. Vol.3, No.14.
2. Intergovernmental Panel on Climate Change (IPCC) (2013) Summary for Policymakers. In: Climate Change 2013: The physical Science Basic. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
3. Ravi Shankar K, Nagasree K, Maruthi Sankar GR, Prasad MS, Raju BMK, et al. (2013) Farmers Perceptions and Adaptation Measures towards Changing Climate in South India and Role of Extension in Adaptation and Mitigation to Changing Climate. Extension Bulletin No. 03/2013. Central Research Institute for Dryland Agriculture, Hyderabad. 28p.
4. Schellnhuber HJ, Hare W, Serdeczny O, Schaeffer M, Adams S, et al. (2013) Turn down the heat: Climate extremes, regional impacts and the case for resilience. Full report World Bank, Washington, D.C, pp 1-255.
5. Milano M (2013) Current state of Mediterranean water resources and future trends under climatic and anthropogenic changes. J Hydrol Sci 58: 498-518.
6. Malla G (2008) Climate change and its impact on Nepalese Agriculture. J Agricult and Environ 9: 62-71.
7. Maraseni TN, Mushtaq S, Maroulis J (2009) Greenhouse gas emissions from rice farming inputs: a cross-country assessment. J Agricult Sci 147: 117-126.
8. Vose JM, Peterson, DL, Patel-Weynand T (2012) Effects of climatic variability and change on forest ecosystems: a comprehensive science synthesis for

the U.S. forest sector. Gen. Tech. Rep. PNW-GTR-870. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 265p.

9. Intergovernmental Panel on Climate Change (IPCC) (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects.Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York,NY, USA, pp 1132.

10. Thornton PK, Jones PG, Alagarsway G, Adressen J, Herrero M (2009) Adapting climate change agricultural system and household impacts in East Africa. Agricult. Syst 103: 73-82.

11. Ito T, Kurosaki T (2009) Weather risk wages in kind and the off-farm labor supply of agricultural households in a developing country. Americ J Agricult Econom 91: 697-710.

12. Roudier P, Sultan B, Quirion P, Berg A (2011) The impact of future climate change on West African crop yields: What does the recent literature say? Glob Environ Change 21: 1073-1083.

13. Zewdie A (2012) Impacts of Climate Change on Food Security: A Literature Review in Sub Saharan Africa. J Earth Sci Clim Change 5: 225.

14. World Wide Fund (WWF) for Nature (2006) Climate Change Impacts on East Africa. A Review of the Scientific Literature.

15. Fussel H (2007) Vulnerability: A generally applicable conceptual framework for climate change research. Glob Environ Change 17: 155-167.

16. Hisali E, Birungi P, Buyinza F (2011) Adaptation to climate change in Uganda: Evidence from micro level data. Glob Environ Change 21: 1245-1261.

17. Funk C, Senay G, Asfaw A, Verdin J, Rowland J, et al. (2005) Recent drought tendencies in Ethiopia and equatorial-subtropical eastern Africa. Washington, D.C, FEWS-NET.

18. Kandji ST, Verchot L, Mackensen J (2006) Climate change and variability in the Sahel region: Impact and adaptation strategies in the agricultural sector. UNEP/ICRAF, Nairobi, Kenya.

19. Christy JR, Norris WB, McNider RT (2009) Surface Temperature Variations in East Africa and Possible Causes. J. Climate 22: 3342-3356.

20. Ringler C, Zhu T, Cai X, Koo J, Wang D (2010) Climate change impacts on food security in sub-Saharan Africa: insights from comprehensive climate change scenarios. IFPRI discussion paper 01042, Environment and Production Technology Division, Inter- national Food Policy Research Institute (IFPRI), Washington, D.C.

21. James R, Washington R (2012) Changes in African temperature and precipitation associated with degrees of global warming. Clim Change 117: 859-872.

22. Waithaka M, Nelson GC, Thomas ST, Miriam K (2013) East African and Climate change: A comprehensive Analysis.

23. Hoffmann L (2009) Livestock and climate change.

24. Plisnier PD, Serneels S, Lambin EF (2000) Impact of ENSO on East African ecosystems: a multivariate analysis based on climate and remote sensing data. Glob Ecol Biogeogr 9: 481-497.

25. Rowe DP (2001) Teleconnections between the tropical Pacific and the Sahel. Quart J Royal Meteorol Soc 127: 1683-1706.

26. Pachauri RK, Reisinger A (2007) Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the IPCC, Geneva, Switzerland. 104 p.

27. Naylor RL, Battisti DS, Vimont DJ, Falcon WP, Burke MB (2007) Assessing risks of climate variability and climate change for Indonesian rice agriculture. P Natl Acad Sci USA 104: 7752-7757.

28. Phiri MG, Saka I, Alex R (2005) The Impact of Changing Environmental Conditionson Vulnerable Communities of the Shire Valley, Southern Malawi. Lilongwe, Malawi.

29. Kangalawe RYM, Liwenga ET (2005) Livelihoods in the Wetlands of Kilombero Valley in Tanzania: Opportunities and challenges to integrated Water Resource. Managem Phys Chem Earth 30: 968-975.

30. Liwenga ET, Kangalawe RYM, Lyimo JG, Majule AE, Ngana JO (2007) Research Protocols for Assessing the Impact of Climate change and variability in Rural Tanzania: Water, Food system, Vulnerability and Adaptation. START/PACOM, Africa Global Change Research.

31. Knox J, Hess T, Daccache A, Wheeler T (2012) Climate change impacts on crop productivity in Africa and South Asia. Environ Res Lett 7: 034032.

32. Downing C, Preston F, Parusheva D, Horrocks L, Edberg O, et al. (2008) Final Report - Appendices, Kenya: Climate Screening and Information Exchange. AEA Technology plc. UK.

33. Lloyd SJ, Kovats RS, Chalabi Z (2011) Climate Change, Crop Yields, and Under nutrition: Development of a Modelto Quantify the Impact of Climate Scenarios on Child Under nutrition. Environ Health Perspect 119: 1817-1823.

34. Hinkel J, Brown S, Exner L, Nicholls RJ, Vafeidis AT, et al. (2011) Sea-level rise impacts on Africa and the effects of mitigation and adaptation: an application of DIVA. Regional Environ Change 12: 207-224.

35. Sarah AO, Christian RV, Josef E, Michael H (2012) Local Perceptions and Responses to Climate Change and Variability: The Case of Laikipia District, Kenya. Susta 4: 3302-3325.

36. United Nations (UN) Department of Economic and Social Affairs. Population Division 2013 World Population Prospects: The 2012 Revision, Highlight and abundance Tables. ESA/P/WP.228.

37. Below T, Artner A, Siebert R, Sieber S (2010) Micro-level practices to adapt to climate change for African small scale farmers: a review of selected literature. IFPRI Discussion Paper 00953.

38. Gbetibouo, GA (2009) Understanding farmer perceptions and adaptations to climate change and variability: The case of the Limpopo Basin, South Africa. IFPRI Discussion Paper No. 00849. Cited 3 May.

39. Tucker CM, Eakin H, Castellanos EJ (2010) Perceptions of risk and adaptation: coffee producers, market shocks, and extreme weather in Central America and Mexico. Glob Environ Change 20: 23-32.

40. Gandure S, Alam K (2006) Climate Change and Smallholder Farmers in Malawi: Understanding Poor People's Experiences in Climate Change Adaptation. A report by Action-Aid, Action-Aid International.

41. Maddison D (2006) The Perception of and adaptation to Climate Change in Africa. CEEPA. Discussion Paper No. 10. Centre for Environ. Economic and Policy in Africa. University of Pretoria, South Africa.

42. Bryan BA, Kandulu J, Deere DA, White M, Frizenschaf J, et al. (2009) Adaptive management for mitigating Cryptosporidium risk in source water: A case study in an agricultural catchment in South Australia. J Environ Manage 90: 3122-3134.

43. Hartter J, Stampone MD, Ryan SJ, Kirner K, Chapman CA, et al. (2012) Patterns and Perceptions of Climate Change in a Biodiversity ConservationHotspot. PLoS ONE 7: e32408.

44. Deressa TD, Hassan DRM, Ringler C (2011) Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. J Agric Sci 149: 23-31.

45. O'Brien KL, Sygna L, Næss L, Kingamkono R, Hochobeb B (2000) Is Information Enough? User Responses to Seasonal Climate Forecasts in Southern Africa. Report No. 2000-03. CICERO. University of Oslo, Norway.

46. Boko M, Niang I, Nyong A, Vogel C, Githeko A, et al. (2007) Africa. In: Climate change (2007) Impacts, Adaptation and Vulnerability: In Proceedings of the Working Group II Report. Cambridge University Press, Cambridge, UK, pp. 433-467.

47. Benhin JKA (2006) Climate change and South African agriculture: Impact and adaptation options. CEEPA discussion paper no. 21. Centre for Environmental Economics and Policy in Africa, University of Pretoria.

48. Gwambene B (2007) Climate Change and Variability Adaptation Strategies and its Implications for Land Resource. In Rungwe District, Tanzania. M.Sc. Dissertation, IRA, University of Dar es Salaam, Tanzania.

49. Kaiser HM, Riha SJ, Wilks, DS, Sampath, R (1993) Adaptation to global climate change at the farm level. In: Kaiser HM, Drennen TE (eds.), Agricultural Dimensions of Global Climate Change St. Lucie Press, Delray Beach, Florida pp. 136-152.

50. Mary AL, Majule AE (2009) Impact of climate change, variability and adaptation strategies on agriculture in semi arid areas of Tanzania: The case of Manyoni District in Singida Region,Tanzania. Afr J Environ sci and Tech 3: 206-218.

51. Wehbe MB, Eakin H (2005) Social vulnerability to climate variability and change: case studies in Argentina and Mexico. Final Report. AIACC project LA-29.

52. CEPF (Critical Ecosystem Partnerships Fund) (2012) Ecosystem Profile: Eastern Arc Mountains and Coastal Forests of Tanzania and Kenya Biodiversity Hotspot.

53. Mwalusepo S, Tonnang HEZ, Massawe ES, Okuku GO, Khadioli N, et al. (2015) Predicting the Impact of Temperature Change on the Future Distribution of Maize Stem Borers and Their Natural Enemies along East African Mountain Gradients Using Phenology Models. PLoS ONE 0: e0130427.

54. Krishnan V (2010) Early child development: A conceptual model. Presented at the Early Childhood Courcil Annual Conference 2010, Christchurch, New Zealand, 7 may, 2010.

55. Antony GM, Rao KV (2007) A composite index to explain variation in poverty, health, nutritional status and standard of living: use of multivariate statistical methods. Public Health 121: 578-587.

56. Deressa TD, Hassan DRM, Ringler C (2009) Determinants of farmers' choice of adaptation methods to climate change in Nile Basin of Ethiopia. Glob Environ change 19: 248-255.

57. Zampligre N, Dossa LH, Schlecht E (2014) Climate change and variability: perception and adaptation strategies of Pastoralists and agro-pastoralists across different zones of Burkina Faso. Reg Environ change 14: 769-783.

58. Zahran S, Brody SD, Grover H, Vedlitz A (2006) Climate change vulnerability and policy support. Soc Natur Resour 19: 771-789.

59. Gearheard S, Pocernich M, Steward R, Sanguya J, Huntington HP (2010) Linking Inuit knowledge and meteorological station observations to understand changing wind patterns at Clyde River, Nunavut. Clim Change 100: 267-294.

60. Speranza CI, Kiteme B, Ambenje P, Wiesmann U, Makali S (2010) Indigenous knowledge related to climate variability and change: insights from droughts in semi-arid areas of former Makueni District, Kenya. Clim Change 100: 295-315.

61. Hassan R, Nhemachena C (2008) Adaptation to climate change in Africa: multinomial choice analysis of determinants of farm strategies. African J Agric Resour Econ 2: 83-104.

62. Norris E, Batie S (1987) Virginia farmers soil conservation decisions: and application of tobit analysis. Southern J Agricult Econ 19: 89-97.

63. Ajibade LT (2007) Indigenous Knowledge system of water management in Nigeria. Indian J Tradit knowl 6: 642-647.

64. Salick J, Byg A (2009) Local perspectives on a global phenomenon - climate change in Eastern Tibetan villages. Glob Environ Change 19: 156-166.

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