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Household's socio-economic factors influencing the level of adaptation to climate variability in the dry zones of Eastern Kenya

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A B S T R A C T

Climate variability has a negative impact on crop productivity and has had an effect on many small-holder farmers in the arid and semi-arid lands (ASALs). Small-holder farmers in Eastern Kenya are faced with the constraint associated with climate variability and have consequently made effort at local level to utilize adaptation techniques in their quest to adapt to climate variability. However, documentation of the factors that influence the level of adaptation to climate variability in the study area is quite limited. Hence, this study aimed at assessing how the household's socio-economic factors influence the level of adaptation to climate variability. The study sites were Tharaka and Kitui-Central sub-Counties in Tharaka-Nithi and Kitui Counties of Eastern Kenya respectively. The data collected included the household demographic and socio-economic characteristics and farmers' adaptation techniques to cope with climate variability. Triangulation approach research design was used to simultaneously collect both quantitative and qualitative data. Primary data was gathered through a household survey. Both random and purposive sampling strategies were employed. Data analysis was done using descriptive and inferential statistics. Multinomial and Binary logistic regression models were used to predict the influence of socioeconomic characteristics on the level of adaptation to climate variability. This was done using variables derived through a data reduction process that employed Principal Component Analysis (PCA). The study considered five strategies as measures of the level of adaptation to climate variability; crop adjustment; crop management; soil fertility management; water harvesting and crop types; boreholes and crop variety. Several factors were found significant in predicting the level of adaptation to climate variability as being either low or medium relative to high. These were average size of land under maize; farming experience; household size; household members involved in farming; education level; age; main occupation and gender of the household head. Household socio economic factors found significant in explaining the level of adaptation should be considered in any efforts that aim to promote adaptation to climate variability in the agricultural sector amongst smallholder farmers.

1. Introduction

Climate variability has negative effects on agricultural productivity according to Manneh et al. (2007); Rarieya and Fortun (2009), thus the need for small-holder farmers to devise adaptation measures (Omoyo et al., 2015). As was noted by Chang'a et al. (2010) small holder farmers suffer the adverse effects of climate variability. These farmers have characteristically adopted adaptation strategies at local level. In sub-Saharan Africa, adaptation is critical as highlighted in IPCC (2013) not only because of the existing poverty but also because of the large uncertainty on the effects and the magnitude of climate variability.

The ability of small-holder farmers to adapt to the effects of climate variability is influenced by many factors which include socio-economic characteristics, IPCC (2014) of a household such as household size, age, gender, education level and marital status of

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the household head (Opiyo et al., 2015). These factors vary between individuals and within communities, countries and regions (Eriksen et al., 2011). For instance, education of the household head increases the probability of adapting to climate variability Deressa et al. (2009) due to the fact that exposure to education increases farmers' ability to access, process and use information relevant to adaptation to the effects of climate variability (Nkonya et al., 1997). It has also been shown that more educated farmers are more exposed to understand new ideas and concepts related to climate variability (Nkonya et al., 1997). Gender, especially of the household head is also considered to influence the uptake of adaptation strategies (Nhemachena and Hassan, 2007). In respect to gender of the household head, Asfaw and Admassie (2004) asserts that male headed households are more likely to access information on the availability of new technologies than female headed households. In addition to this, having a female heading a household may have negative effects on the adoption of coping strategies to climate variability such as soil and water conservation measures. This is due to the fact that women may have limited access to information, land and other resources due to traditional social barriers Tenge et al. (2004). Conversely, Nhemachena and Hassan (2007) argue that female headed households are more likely to adapt to climate variability by taking up coping strategies because they are responsible for much of the agricultural work thus have greater experience.

Age also appear to be a significant determinant of the level of adaptation to climate variability conditions (Roncoli et al., 2001). This varies with some studies showing a positive relationship between age and the level of adaptation to the effects of climate variability. According to Ziervogel et al. (2008), Ziervogel and Zermoglio (2009), older farmers are perceived to have a high decision making autonomy thus giving them added advantage when it comes to adaptability. However, a study by Shiferaw and Holden (1998) depicted a negative relationship between age and level of adaptation to the effects of climate variability, suggesting that older farmers may be less willing to take the risks associated with new technologies in regard to adaptation. Due to changes in the times, younger farmers also have access to education and exposure thus making them receptive to change (Roncoli et al., 2002 and Vogel and O'Brien, 2006). Household size is also a determinant of the level of adaptation to climate variability by small holder farmers. Tizale (2007) and Yirga (2007) noted that households with large families may be forced to divert part of their labor force to off-farm activities in an effort to earn extra income so as to ease the consumption pressure that is known to be imposed by a large family. On the other hand, large family size is associated with a higher labor endowment which would enable a household to accomplish various agricultural tasks that would serve as coping strategies to climate variability since they have large pool of labor during peak times (Croppenstedt et al., 2003; Dolisca et al., 2006; Anley et al., 2007; Nyangena, 2007).

A better understanding of how small-holder farmers in Eastern Kenya perceive climate variability and the ongoing adaptation measures was found crucial in promoting their successful adaptation since they rely mainly on rain-fed agriculture (Smithers and Smit, 2009). This is so that reliable adaptation options can be appropriately targeted. Small-holder farmers in the study area (farmers who produce relatively small volumes of produce, rely on rain-fed agriculture, are generally less well-resourced and may depend on family labor only) have tried to adapt to such conditions caused by climate variability such as drought and prolonged dry spells through the use of preparedness techniques in combination with conventional approaches. In this context, adaptation focused on maximizing yields by changing farming management practices through the use of various agricultural technologies which are aimed at increasing the growth of agricultural output. This was guided by Doward (2009) where poverty is stated to constrain farmers to move out of agriculture as the scope for stepping out of agriculture requires that farmers should move out of poverty first before moving into other enterprises (off-farm activities).

The technologies used in adapting to climate variability in Kenya includes adjusting the planting dates, crop varieties, crop spacing, and crop types, increasing the use of manure, water harvesting, digging boreholes, agroforestry, crop rotation and post-harvest management (Bryan et al., 2010) and are similar to those identified by Liebenstein and Marrewijk (2000); Mapfumo and Giller (2001); Eriksen et al. (2005); Stringer et al. (2009); Lin (2011); Milgroom and Giller (2013); IPCC (2014); Rurinda et al. (2014) in other countries. However, the factors that influence the use of these strategies as adaptation measures are not adequately documented.

Consequently, the objective of this study was to assess the influence of household's socio-economic factors on the level of adaptation to climate variability. Studying the factors that influence the level of adaptation to climate variability in the dry zones of Eastern Kenya was necessitated by the fact that small-holder farmers' responses to climate variability are dictated by a host of socio economic factors. Household characteristics for instance are known to influence the day to day farm operations and decision making. Knowledge of key socioeconomic factors influencing farmers' adaptability to climate variability can play a role in policy formulation to mitigate the effects of climate variability on small-holder agriculture (Deressa et al., 2009). Also, knowledge of these socioeconomic factors can play a role in assisting policy makers to strengthen adaptation by investing on them.

2. Material and methods

2.1. Description of the study area

The study was carried out in Tharaka and Kitui Central sub-Counties in Tharaka-Nithi and Kitui Counties respectively, in Eastern Kenya (Fig. 1).

Tharaka Sub-County lies in the Lower Midland 4 and 5 (LM 4 and 5) and Inner Lowland 5 (IL 5) agro-ecological zones (Jaetzold et al., 2006; Smucker and Wisner, 2008). The area experiences a bi-modal pattern of rainfall with mean annual rainfall of 200–800 mm per annum. The area has a mean annual temperature of 11–25.9 °C. During the 2009 Population and Housing Census, Tharaka Sub-County was recorded with a population of 130,098 persons and 27, 393 households (GOK, 2010). The predominant soil type is Ferralsols, highly weathered and leached acid infertile soil (Jaetzold et al., 2006). The major cropping enterprises are; millet (*Pennisetum glaucum*), cowpeas (*Vigna unguiculata*), pigeon peas (*Cajanus cajan*), green grams (*Vigna radiata*), sorghum (*Sorghum bicolor*), cassava (*Manihot esculenta*), maize (*Zea mays*), beans (*Phaseolus vulgaris*), mangoes (*Mangifera indica*), pawpaws (*Asimina triloba*) and bananas (*Musa* spp.).

Kitui-Central Sub-County lies in the Lower Midland 4 and 5 (LM 4 and 5) and Upper Midland 3 and 4 (UM 3 and 4) and Inner Lowland Ranching Zone (IL 6) agro-ecological zones (Jaetzold et al., 2006). The area experiences a bi-modal pattern of rainfall with mean annual rainfall of 500–1050 mm per annum. The area experiences a mean annual temperature of 16 °C–34 °C. It has a population of 447,613 persons with 38,377 households (GOK, 2010). The predominant soil types are Acrisols, Luvisols and Ferralsols (Jaetzold et al., 2006). The major cropping enterprises are; cassava (*M. esculenta*), pigeon peas (*C. cajan*), cow peas (*V. unguiculata*), maize (*Z. mays*), beans (*P. vulgaris*), green grams (*V. radiata*), finger millet (*Eleusine coracana*), cotton (*Gossypium hirsutum*) and mangoes (*M. indica*).

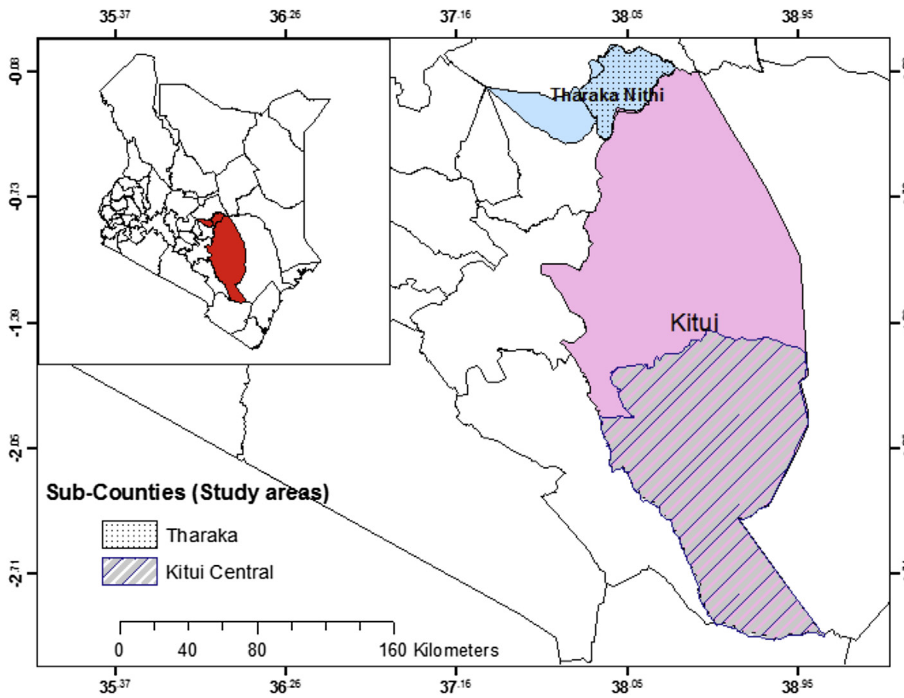

Fig. 1. A map showing the study area where data was collected. Source: Author, 2015.

2.2. Research design, sampling and data management

Triangulation approach (O'Donoghue and Punch, 2003) was adopted in collecting both quantitative and qualitative data. The approach was selected to offer the prospect of enhanced confidence in the ensuing findings. This was achieved by using and cross checking information across both primary and secondary data sources. Primary data was obtained through an exploratory study and a survey (household survey and Focus Group Discussions (FGDs)). Secondary data was obtained by reviewing relevant literature. In particular, the general adaptation strategies employed by small-holder farmers to adapt to climate variability were obtained through literature review while the specific strategies used in the study area were first established through an exploratory study, then pursued through a household survey. This was followed by FGDs whose information played a crucial role in guiding the interpretation of the results from household survey, similar to Bryman (2008).

Random sampling was used to select the specific wards where data was collected upon a purposive sampling of the two Sub-Counties (Tharaka- South and Kitui- Central) due to their high agricultural potential as guided by extension agents in these areas. In Tharaka- Nithi County, Tharaka Sub-County, the wards randomly sampled were; Kithino, Tunyai, Gakurungu, Nkarini and Chiakariga. In Kitui County, Kitui- Central Sub-County, the wards that were sampled were Township, Changwithia West, Tungutu, Mutuni and Mulundi. For household interviews, random sampling of the households (HH) was done. Lists of all household heads were obtained from the Ministry of Agriculture (MoA) offices and random sampling was used to select the required sample size, with the help of the local extension officers. A sample size of 100 households per Sub-County was arrived at using Eq. (1) (CRS, 2007).

$$S = Z^{2*}(p) * (1 - p)/c^2 \quad (1)$$

Where: S is sample size, Z is Z value (e.g. 1.96 for 95% confidence level), P is percentage of picking a choice, expressed as decimal (0.5), C is confidence interval, expressed as a decimal (0.098 = ±9.8%).

The actual data collection was preceded by an exploratory study in each of the two Sub-Counties under the guidance of the local extension workers which helped to enhance an understanding of climate variability issues and aid in designing of the data collection instruments. The kind of information collected during the exploratory study included small-holder farmers' perceptions of climate variability, issues and problems affecting farmers in the face of climate variability and the adaptation strategies employed by small-holder farmers.

The household survey was guided by a structured household survey interview schedule administered among 200 households with the help of interviewers who were carefully selected and trained so as to be equipped with knowledge of the subject matter and enable them to portray the survey objectives.

The FGDs (one per sub-County) were guided by FGD check lists containing unstructured probing questions so as to get the maximum amount of information to help in clarifying the information collected through prior methods (Bryman, 2008). Data collected included household demographic and socio-economic characteristics and small-holder farmer's adaptive strategies to climate variability.

The research instruments used were first pre-tested to evaluate their competency and were then revised according to the suggestions made. The respondents who participated in the pre-test exercise were excluded in the actual survey.

Data from household survey was subjected to data reduction using Principal Component Analysis (PCA) with the aim of condensing all the information from the original interdependent variables to a smaller set of independent variables. This was done by statistically grouping ten adaptation strategies popularly used by small-holder farmers in the study area into five factors that represented the major adaptation strategies, similar to Barbier et al. (2009). Prior to PCA, Varimax rotation with Kaiser Normalization procedure was employed, similar to Mairura et al. (2007) to check for appropriateness of the PCA technique (Lattin et al., 2005; Field, 2005). The rotation method was used due to its appropriateness in loading a smaller number of highly correlated variables onto each factor, thus simplifying interpretation (Field, 2005).

The five factors were retained for subsequent analyses. The factors were later subjected to descriptive statistics (frequencies and means) and in order to express the degree of correspondence between two variables, chi square and t-test was used. Binary Logistic Regression model and Multinomial model was used similar to Greene (2003) and Hassan and Nhemachena (2008) with the aim of determining how socio-economic factors influenced the level of adaptation to climate variability at statistical significance of 5% probability level. For estimation of the multinomial logit regression model (MNLR model), one category (the reference/base category) was normalized as being the third category (high adaptation to climate variability) and therefore all results were explained in reference to this category. This was in respect to the level of use of crop adjustment factor, crop management factor, soil fertility management factor and water harvesting & crop types' factor. To conduct these analyses, SPSS version16 (Bryman and Cramer, 1999) was used.

3. Results and discussion

3.1. Farmers' level of adaptation to climate variability

Farmers' level of adaptation was measured by the extent of use of the various adaptation strategies in Tharaka and Kitui Central Sub-Counties. This was based on factor analysis significance level $P = 0.001$ and Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (KMO = 0.76), similar to Bidogeza et al. (2009). The ten adaptation strategies popularly employed by the small-holder farmers to adapt to climate variability were reduced to five factors. The five factors had a total explained variance of 64.3% indicating the percentage of the original data that was explained and had Eigen values that were greater than 1 (Table 1). The factor loadings and communalities for the reduced components are shown in Table 1. The first factor had high positive loadings on the extent of use of crop rotation (0.73) and changing of planting dates (0.70). As a result, the factor was identified as the *crop adjustment factor*. The second factor had high positive loadings on the extent of use of changing crop spacing (0.77) and storing food in stores to be used later (0.71). Consequently, the factor was identified as the *crop management factor* because it was composed of strategies that ensured good management of the crop both in the field and during the post-harvest phase. The third factor had high positive loadings on the extent of use of agro forestry (0.79) and increasing the use of manure/fertilizer (0.64) and was consequently identified as the *soil fertility management factor*. This was because the factor comprised of strategies that minimized soil degradation and enhanced use of manure and fertilizers.

The fourth factor comprised of the extent of use of water harvesting and changing crop types and had high positive loadings on the extent of use of water harvesting (0.81) and a high negative loading on the extent of use of changing crop types (−0.60). The factor was identified as *water harvesting and crop types factor* because the use of the two strategies had a negative correlation in such a way that small-holder farmers who do water harvesting do not change crop types and do not make use of most of the other popular strategies. The fifth factor comprised of extent of use of digging boreholes/water pans and changing crop varieties. This factor had high positive loadings on the extent of use of digging boreholes/water pans (0.74) and a high negative loading on the extent of use of changing crop varieties (−0.64). It was therefore identified as *boreholes and crop variety factor* because the use of the two strategies had a negative correlation in such a way that small-holder farmers who dig boreholes/water pans do not change crop varieties and they do not make use of most of the other popular strategies. The strategies in factor 4 and 5 (with negative correlations) can be collectively referred to as *tactical management strategies* because decisions for their use calls for a foresight and were made based on the expected weather conditions.

The 5 extracted factors explained percentages of variance in the popularly used adaptation strategies by small-holder farmers in the study area as 60% in the extent of use of crop rotation, 54% in changing planting dates, 63% in changing crop spacing, 55% in storing food in stores to be used later, 73% in agro forestry, 64% in increasing the use of manure/fertilizer, 73% in water harvesting, 72% in changing crop types, 73% in digging boreholes/water pans and 53% in changing crop varieties as indicated by their communalities (Table 1).

3.2. The extent of use of crop adjustment factor

Both descriptive statistics and the MNLR revealed that, two socio-economic factors (education level of the household head and average area of land under maize) were significantly associated with the extent of use of *crop adjustment* factor (extent of use of crop rotation and extent of use of changing planting dates)

Table 1
Extent of utilization of climate variability adaptation strategies (indicating level of adaptation) by small-holder farmers on maize crop in the study area.

Extent of use of;	Component (factor)					Communalities (%)
	1	2	3	4	5	
Crop rotation	0.73					60
Changing planting dates	0.70					54
Changing crop spacing		0.77				63
Storing food in stores to be used later		0.71				55
Agro forestry			0.79			74
Increasing the use of manure/fertilizer			0.64			65
Water harvesting				0.81		74
Changing crop types				−0.60		72
Digging boreholes/water pans					0.80	74
Changing crop varieties					−0.64	53
Eigen values	**1.5**	**1.3**	**1.3**	**1.2**	**1.1**	
%Explained variance	**15.3**	**13.3**	**13.2**	**11.7**	**10.8**	
% Cumulative variance	**15.3**	**28.6**	**41.8**	**53.5**	**64.3**	

Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; Kaiser-Meyer-Olkin Measure of Sampling Adequacy (0.76, Chi-square = 107.5, Sig = 0.001); Cut point for loadings and communalities = 0.5.

(Table 2).

Multinomial Logistic Regression model revealed that education level of the household head was a significant positive predictor of the adaptation level of the farmer as being low as related to high (Table 3).

This implies that, less educated farmers are more likely to have low adaptation relative to high adaptation to climate variability in regard to the extent of use of crop adjustment factor. This corroborates Deressa et al. (2009) that education level of the household influenced the probability of adapting to climate variability, such that the lower the educational attainment, the lower the level of adaptation to climate variability. Likewise, household heads with a higher level of education are likely to have a better level of planning, access and understanding of information for effective climate variability adaptation (Opiyo et al., 2015).

Average size of land under maize was a significant positive predictor of the adaptation level of the farmer as being low as related to being high (Table 3). This implies that having low level of adaptation relative to high adaptation level is associated with large farm sizes of land under maize crop which is the main crop in the study area. Farmers attributed this to the fact that, large area of land under maize can become overwhelming in terms of the extent of use of the adaptation strategies in the crop adjustment factor.

Education level of the household head also had a strong negative influence on the probability of having a medium relative to high adaptation to climate variability (Table 3). This implies that medium level of adaptation relative to high level of adaptation is associated with low level of education and agrees with Nkonya et al. (1997) in that less educated farmers are not adequately exposed to understanding new ideas and concepts related to climate variability, which in this context refers to new ideas related to the adaptation strategies in the crop adjustment factor.

3.3. *The extent of use of crop management factor*

Univariate results revealed the socio-economic factors which had a significant association with the extent of use of strategies in the *crop management factor* (management of the crop while in the field and out of the field). The strategies were extent of use of changing crop spacing and extent of use of storing food in stores to be used later. The factors were household size, gender of the household head and average area of land that is normally put under maize crop (Table 4).

The MNLR model revealed that three predictor variables: gender of the household head, household size and average size of land under maize were significant in explaining whether the farmer's adaptation level was low relative to high level of adaptation in regard to the use of adaptation strategies in the crop management factor.

Gender of the household head was a significant negative predictor of the adaptation level of the farmer as being low relative to being highly adapted (Table 5) in regard to the use of crop management factor.

This implies that, the male headed households from the study area were more likely to have low level of adaptation in relation to being highly adapted in regard to the use of the strategies in the crop management factor. This is similar to Nhemachena and Hassan (2007) who argued that male-headed households were less likely to take up climate variability adaptation methods and attributed this to the fact that men are not responsible for much of the agricultural work in line with the adaptation strategies in the crop management factor therefore have less experience in regard to the use of the strategies in adaptation to climate variability. In tandem with this, Opiyo et al. (2015) noted that female headed households were more likely to take up climate adaptation since they are responsible for most of the household welfare activities and have better experience on various farm-based production practices.

Household size was a significant negative predictor of whether the adaptation level of the farmer was low relative to high level of adaptation to climate variability (Table 5) in regard to the use of strategies in the crop management factor. This implies that smaller household sizes are related to low use of the crop management factor as related to the high use of the factor in adaptation, in line with Nyangena (2007). Small-holder farmers attributed this to the fact that smaller household sizes do not require a lot of food thus such households do not lay emphasis on storage of food. This was in regard to storing food to be used during the lean periods as a strategy in the crop management factor. Likewise, Silvestri et al.

Table 2
Univariate analysis of the socio-economic factors influencing the extent of use of *crop adjustment* factor in Tharaka and Kitui Central Sub- Counties.

Independent variables	Adaptation level			χ^2 P value
	Low	Medium	High	
HHH gender				
Male	14 (9.5)	69 (46.6)	65 (43.9)	NS
Female	5 (9.6)	26 (50.0)	21 (40.4)	
HHH marital status				
Single	2 (15.4)	6 (46.2)	5 (38.5)	NS
Married	14 (9.7)	67 (46.5)	63 (43.8)	
Divorced/Separated & Widowed	3 (7)	22 (51.1)	18 (41.9)	
HHH education level				
None	1 (2.3)	22 (51.2)	20 (46.5)	0.012
Primary	15 (13.2)	52 (45.6)	47 (41.2)	
Post-Primary	3 (7)	21 (48.8)	19 (44.2)	
HHH main occupation				
Full-time farmer	14 (8.2)	84 (49.4)	72 (42.4)	NS
Part-time farmer	5 (16.7)	11 (36.7)	14 (46.7)	
	Mean	**Mean**	**Mean**	**t-test**
Age	48.89	52.89	54.78	NS
HH size	5.79	6.35	7.01	NS
HH members in farming	3.42	3.66	3.47	NS
Farming experience	22.95	25.57	25.73	NS
Total land size owned	3.3	7.2	8.3	NS
Average land under maize	1.4	1.5	1.6	0.036

N = 200, association significant at $\alpha = 0.05$; Values in parenthesis are in percentage.
HH = HouseHold; HHH = HouseHold Head.

Table 3
Multinomial analysis of the socio-economic factors influencing the extent of use of *crop adjustment* factor in Tharaka and Kitui-Central Sub-Counties.

Low adaptation level						Medium adaptation level				
Independent variables	Β	S.E.	Wald	Sig.	Exp(β)	β	S.E.	Wald	Sig.	Exp(β)
Intercept	3.013	2.656	1.287	0.257	_	1.396	1.482	0.886	0.346	_
HHH Gender	−0.577	0.687	0.705	0.401	0.562	−0.053	0.449	0.014	0.906	0.949
HHH Marital status	−0.470	0.562	0.699	0.403	0.625	0.038	0.381	0.010	0.920	1.039
HHH Education level	0.560*	0.530	1.117	0.029	0.571	−0.162*	0.259	0.147	0.050	1.105
HHH Main occupation	0.742	0.727	1.044	0.307	2.101	−0.522	0.480	1.184	0.277	0.593
HHH Age	−0.028	0.028	0.976	0.323	0.972	−0.017	0.015	1.164	0.281	0.984
HH size	−0.137	0.137	1.006	0.316	0.872	0.099	0.074	4.789	0.701	0.850
HH members in farming	0.141	0.174	0.651	0.420	1.151	0.192	0.098	3.834	0.150	1.211
Farming experience	0.023	0.033	0.491	0.484	1.023	0.018	0.016	1.250	0.264	1.019
Total land size owned	−0.632	0.232	7.403	0.237	0.532	−0.010	0.023	0.207	0.649	0.990
Average land under maize	0.057*	0.391	7.310	0.007	2.877	−0.015	0.104	0.021	0.885	0.985

Reference category is High adaptation level.
HH = HouseHold; HHH= HouseHold Head.

Table 4
Univariate analysis of the socio-economic factors influencing the extent of use of *crop management* factor.

Independent variables	Adaptation level			χ^2 P value
	Low	Medium	High	
HHH Gender				
Male	23 (15.5)	76 (51.4)	49 (33.1)	0.016
Female	5 (9.6)	24 (46.2)	23 (44.2)	
HHH marital status				
Single	2 (15.4)	6 (46.2)	5 (38.5)	NS
Married	23 (16)	74 (51.4)	47 (32.6)	
Divorced/Separated & Widowed	3 (7)	20 (46.5)	20 (46.5)	
HHH education level				
None	8 (18.6)	23 (53.5)	12 (27.9)	NS
Primary	16 (14.0)	54 (47.4)	44 (38.6)	
Post-primary	4 (9.3)	23 (53.5)	16 (37.2)	
HHH main occupation				
Full-time farmer	24 (14.1)	88 (51.8)	58 (34.1)	NS
Part-time farmer	4 (13.3)	12 (40.0)	14 (46.7)	
	Mean	**Mean**	**Mean**	**t-test**
Age	54.71	53.45	52.61	NS
HH size	7.50	6.23	6.71	0.003
HH members in farming	3.93	3.34	3.71	NS
Farming experience	27.11	24.57	25.86	NS
Total land size owned	9.4	7.9	5.7	NS
Average land under maize	2.0	1.6	1.1	0.021

N = 200, association significant at $\alpha = 0.05$; Values in parenthesis are in percentage.
HH = HouseHold; HHH = HouseHold Head.

Table 5
Multinomial analysis of the socio-economic factors influencing the extent of use of *crop management* factor.

Low adaptation level						Medium adaptation level				
Independent variables	Β	S.E.	Wald	Sig.	Exp(β)	Β	S.E.	Wald	Sig.	Exp(β)
Intercept	2.975	2.278	1.705	0.192	_	2.561	1.529	2.807	0.094	_
HHH Gender	−0.571*	0.661	0.746	0.038	0.565	−0.359	0.456	0.620	0.431	0.699
HHH Marital status	−0.734	0.552	1.769	0.184	0.480	−0.115	0.389	0.088	0.767	0.891
HHH Education level	−0.822	0.434	3.576	0.604	0.440	−0.243	0.277	0.772	0.380	0.784
HHH Main occupation	−0.074	0.687	0.012	0.914	0.928	−0.662	0.478	1.915	0.166	0.516
HHH age	0.000	0.025	0.000	0.990	1.000	0.016	0.016	0.916	0.339	1.016
HH size	−0.052*	0.100	0.268	0.005	1.053	−0.080	0.078	1.034	0.309	0.923
HH members in farming	−0.107	0.141	0.584	0.445	0.898	−0.115	0.102	1.272	0.259	0.891
Farming experience	−0.013	0.026	0.235	0.628	0.987	−0.024	0.018	1.838	0.175	0.976
Total land size owned	0.021	0.036	0.339	0.560	1.021	0.031	0.028	1.237	0.266	1.031
Average land under maize	0.222	0.179	1.538	0.245	1.249	0.170*	0.147	1.351	0.021	1.186

Reference category is High adaptation level.
HH = HouseHold; HHH = HouseHold Head.

(2012) asserts that larger households are associated with higher labor endowments, which would enable the household to accomplish various production tasks, such as in this context packaging the surplus produce in storage bags for use during the lean periods.

Average land under maize was found to be a significant positive predictor of the adaptation level of the farmer being medium in relation to high (Table 5). This implies that farmers who have smaller sizes of land under maize crop are more likely to have medium relative to high level of adaptation to climate variability in regard to the extent of use of the adaptation strategies in the crop management factor, thus agreeing with Deressa et al. (2009).

3.4. The extent of use of soil fertility management factor

Results from the univariate analysis indicated that gender, education level and main occupation of the household head were the factors that had a significant association with the extent of use of soil fertility management factor (agro-forestry and use of manure/fertilizer) adaptation strategies (Table 6).

The MNLR model showed that two predictor variables: gender and main occupation of the household head, were significant in explaining whether the farmer's adaptation level was low relative to high in regard to the use of adaptation strategies in the soil and water conservation factor.

Gender of the household head was found to be a significant negative predictor of whether the adaptation level of the farmer was low relative to high (Table 7) in regard to the use of soil fertility management factor. This meant that the male headed households from the study area were more likely to have low level of adaptation relative to high level of adaptation in regard to the use of the strategies in the soil fertility management factor. This concurs with Bayard et al. (2007) and Opiyo et al. (2015) that households headed by female farmers are more likely to take up adaptation strategies in regard to climate variability. Similar results were observed by Kangai et al. (2002) where female-headed households in Chuka, Kenya showed a high probability of adopting fertility improvement options such as agro forestry and use of manure/fertilizer.

The main occupation of the household head was a significant negative predictor of whether the adaptation level of the farmer was low relative to high (Table 7) regarding the use of strategies in the soil fertility management factor. This implies that farmers who were not fully into farming were more likely to have a low adaptation to climate variability in relation to high adaptation in regard to the use of the strategies in soil fertility management factor. This could be attributed to the fact that part time farmers have other things to attend to and might end up over-looking the need to use strategies in the soil fertility management factor thus end up having a low adaptation relative to high adaptation to climate variability in regard to the use of this factor. This is also in tandem with Tenge et al. (2004) in that households where the heads were not fully involved in farming but engaged in off-farm activities are less interested in measures involving soil and water conservation. The study attributed this to competition in labor between soil water conservation measures and off-farm activities, similar to what Hella (2002) found out in Central Tanzania.

For the medium level of adaptation in relation to high level of adaptation to climate variability in regard to the extent of use of the adaptation strategies in the soil fertility management factor, education level of the household head was found to be significant in determining the adaptation level. Education level of the household head was found to be a significant positive predictor of adaptation level of the farmer being medium relative to high (Table 7) in regard to the use of soil fertility management factor. This is in line with Pali et al. (2002) who observed a positive influence of education on the use of soil water conservation measures. This implies that farmers who have low level of education are more likely to have a medium level of adaptation to climate variability relative to the high level of adaptation, considering the extent of use of soil and water conservation factor. This corroborates Tenge et al. (2004) that in the Tanzanian highland, 60% of household heads with over primary education adopted soil and water conservation measures. This means that less educated farmers are not adequately exposed to understand new ideas and concepts related to climate variability thus ending up being less adapted in relation to more educated farmers who in most cases are more exposed to understand new ideas and concepts related to climate variability thus being highly adapted (Nkonya et al., 1997). In addition, Mignouna (2011) stresses similar results by stating that education level of a farmer increases his ability to obtain, process and use a technology that is expected to yield better results.

3.5. The extent of use of water harvesting and crop types factor

The socio-economic factors that had a significant association

Table 6
Univariate analysis of the factors influencing the extent of use of *soil fertility management* factor.

Independent variables	Adaptation level			χ^2 P value
	Low	Medium	High	
HHH gender				
Male	42 (28.4)	74 (50.0)	32 (21.6)	0.029
Female	21 (40.4)	22 (42.3)	9 (17.3)	
HHH Marital Status				
Single	3 (23.1)	6 (46.2)	4 (30.8)	NS
Married	41 (28.5)	73 (50.7)	30 (20.8)	
Divorced/Separated & Widowed	19 (44.2)	17 (39.5)	7 (16.3)	
HHH Education Level				
None	18 (41.9)	20 (46.5)	5 (11.6)	0.044
Primary	38 (33.3)	53 (46.5)	23 (20.2)	
Post-Primary	7 (16.3)	23 (53.5)	13 (30.2)	
HHH Main Occupation				
Full-time farmer	53 (31.2)	84 (49.4)	33 (19.4)	0.038
Part-time farmer	10 (33.3)	12 (40.0)	8 (26.7)	
	Mean	**Mean**	**Mean**	**t-test**
Age	54.51	54.22	49.41	NS
HH size	7.0	6.59	5.9	NS
HH members in farming	3.92	3.37	3.41	NS
Farming experience	29.05	24.90	20.94	NS
Total land size owned	7.5	8.4	4.5	NS
Average land under maize	1.3	1.7	1.3	NS

N = 200, association significant at $\alpha = 0.05$; Values in parenthesis are in percentage.
HH = HouseHold; HHH = HouseHold Head.

Table 7
Multinomial analysis of the socio-economic factors influencing the extent of use of *soil fertility management* factor.

Low adaptation level						Medium adaptation level				
Independent variables	Β	S.E.	Wald	Sig.	Exp(β)	β	S.E.	Wald	Sig.	Exp(β)
Intercept	−0.735	2.005	0.135	0.714	_	−0.394	1.801	0.048	0.827	_
HHH gender	−0.616*	0.593	1.079	0.035	1.851	0.414	0.526	0.620	0.431	1.513
HHH marital status	0.248	0.496	0.249	0.618	1.281	0.062	0.435	0.020	0.887	1.064
HHH education level	−0.140	0.372	2.312	0.226	0.568	0.060*	0.315	0.036	0.024	0.942
HHH main occupation	−0.498*	0.591	0.709	0.040	1.645	−0.354	0.554	0.409	0.523	0.702
HHH age	−0.040	0.023	3.063	0.180	0.961	0.008	0.018	0.199	0.655	1.008
HH size	0.101	0.107	0.887	0.346	1.107	0.090	0.100	0.820	0.365	1.094
HH members in farming	0.025	0.134	0.035	0.852	1.025	−0.167	0.128	1.695	0.193	0.846
Farming experience	0.053	0.025	4.469	0.299	1.054	0.004	0.021	0.036	0.849	1.004
Total land size owned	0.189	0.063	4.949	0.128	1.150	0.138	0.061	5.094	0.624	1.148
Average land under maize	−0.268	0.203	1.743	0.187	0.765	−0.118	0.183	0.420	0.517	0.888

Reference category is High adaptation level.
HH = HouseHold; HHH = HouseHold Head.

with the extent of use of water harvesting and extent of use of changing crop types were average size of land under maize, farming experience, age and main occupation of the household head (Table 8).

The MNLR had two predictor variables: main occupation of the household head and farming experience being significant in explaining farmer's adaptation level as low in relation to high level of adaptation in regard to the use of adaptation strategies in the water harvesting and crop type factor. The rest of the variables were not significant in determining if the level of adaptation to climate variability is low in relation to high in regard to the use of the adaptation strategies in this factor (Table 9).

Main occupation of the household head was a negative predictor of adaptation level of the farmer being low relative to high (Table 9) in regard to the use of water harvesting and crop type factor. This implies that households where the heads are partly involved in farming are more likely to have a low adaptation to climate variability in relation to high level of adaptation in regard to the extent of use of water harvesting and crop type factor. Farmers in the area attributed this to the fact that part time farmers are involved in other activities thus may not be in a position to realize every other requirement in the farm in regard to the use of water harvesting and crop type factor.

Farming experience was found to be negatively significant in predicting adaptation level of the farmer as low in relation to high (Table 9) in regard to the use of water harvesting and crop type factor. The implication of this is that farmers who have not been involved in farming for long are more likely to have a low adaptation in relation to high adaptation to climate variability regarding the extent of use water harvesting and crop type factor. This is supported by Maddison (2006) in that less experienced farmers are expected to have less knowledge and information about climate variability and the adaptation strategies that could be used.

In reference to medium level of adaptation in relation to high level of adaptation to climate variability in regard to the extent of use of the adaptation strategies in the water harvesting and crop type factor, age of the household head and average size of land under maize were found to be significant in determining the adaptation level.

Age of the household head was found to be a significant positive predictor of adaptation level of the farmer as medium relative to high (Table 9) in regard to the use of water harvesting and crop type

Table 8
Univariate analysis of the social-economic factors influencing the extent of use of *water harvesting and change of crop types'* factor.

Independent variables	Adaptation level			χ^2 P value
	Low	Medium	High	
HHH Gender				
Male	61 (41.2)	61 (41.2)	26 (17.6)	NS
Female	19 (36.5)	28 (53.8)	5 (9.6)	
HHH Marital Status				
Single	3 (23.1)	8 (61.5)	2 (15.4)	NS
Married	59 (41)	61 (42.4)	24 (16.6)	
Divorced/Separated & Widowed	18 (41.9)	20 (46.5)	5 (11.6)	
HHH Education Level				
None	23 (53.5)	17 (39.5)	3 (7.0)	NS
Primary	42 (36.8)	52 (45.6)	20 (17.5)	
Post-Primary	15 (34.9)	20 (46.5)	8 (18.6)	
HHH Main Occupation				
Full-time farmer	70 (41.2)	74 (43.5)	26 (15.3)	0.032
Part-time farmer	10 (33.3)	15 (50.0)	5 (16.7)	
	Mean	**Mean**	**Mean**	**t-test**
Age	55.14	52.5	51.1	0.029
HH size	6.8	6.4	6.87	NS
HH members in farming	3.7	3.4	3.7	NS
Farming experience	26.1	24.74	25.1	0.041
Total land size owned	8.1	6.5	7.6	NS
Average land under maize	1.4	1.3	2.3	0.013

N = 200, association significant at $\alpha = 0.05$; Values in parenthesis are in percentage.
HH= HouseHold; HHH= HouseHold Head.

Table 9
Multinomial analysis of the socio-economic factors influencing the extent of use of water harvesting and crop type factor.

Low adaptation level						Medium adaptation level				
Independent variables	Β	S.E.	Wald	Sig.	Exp(β)	β	S.E.	Wald	Sig.	Exp(β)
Intercept	−0.068	2.137	0.001	0.974	_	0.098	2.080	0.002	0.963	_
HHH gender	0.368	0.751	0.240	0.624	1.445	1.122	0.701	2.563	0.109	3.070
HHH marital status	0.085	0.654	0.017	0.896	1.089	−0.429	0.602	0.508	0.476	0.651
HHH education level	−0.174	0.359	0.236	0.627	0.840	−0.054	0.356	0.023	0.879	0.947
HHH main occupation	−0.056*	0.645	0.003	0.035	0.965	0.241	0.620	0.152	0.697	1.273
HHH age	0.028	0.024	1.385	0.239	1.029	0.024*	0.024	0.952	0.032	1.024
HH size	−0.012	0.101	0.015	0.901	0.988	−0.027	0.101	0.071	0.790	0.973
HH members in farming	0.027	0.134	0.041	0.839	1.028	−0.025	0.134	0.036	0.849	0.975
Farming experience	−0.033*	0.026	0.978	0.026	0.975	−0.018	0.026	0.459	0.498	0.983
Total land size owned	0.061	0.045	1.792	0.181	1.063	0.048	0.046	1.114	0.291	1.049
Average land under maize	−0.297	0.149	3.960	0.324	0.743	−0.324*	0.163	3.959	0.047	0.723

Reference category is High adaptation level.
HH = HouseHold; HHH = HouseHold Head.

factor in adaptation. This implies that farmers who are much older are more likely to have a medium in relation to high level of adaptation to climate variability. This concurs with Shiferaw and Holden (1998) in that older farmers may be less willing to take the risks associated with new technologies in regard to adaptation to climate adaptation. In addition, older farmers are said to still hold to traditional practices and therefore have a lesser likelihood of willingness to access information on new adaptation strategies. Similarly, Alexander and Van Mellor (2005) asserts that younger farmers were more likely to take up genetically modified maize as they are in the process of increasing their stock of human capital unlike their older counterparts who are closer to retirement.

Average land size under maize was found to be a significant negatively predictor of adaptation level of the farmer as medium relative to high adaptation level (Table 9) in regard to the use of water harvesting and crop type factor. This implies that farmers who have smaller sizes of land allocated to maize which is the staple crop in the study area are more likely to have a medium level relative to high level of adaptation to climate variability considering the extent of use of water harvesting and crop type factor. Farmers in the area attributed this to the fact that having a smaller area of land under maize crop is not a satisfactory incentive to using the adaptation strategies in the water harvesting and crop type factor at a higher level as related to having a larger area allocated to the staple crop which would consequently call for higher extent of use of the strategies in the factor. This also means that farmers with large farm size are likely to try a strategy like introduction of new crops and construction of water harvesting structures such as water pans, and conquers with Uaiene et al. (2009) in that farmers with large farm size are likely to take up a new technology as they can afford to devote part of their land to try a new technology unlike those with small farms. This is also in line with Anley et al. (2007) that in Haiti, farmers with larger farms were found to have more land for constructing such things as water harvesting structures as related to those who had smaller land sizes.

3.6. *The extent of use of boreholes and crop variety factor*

Results of the Univariate analysis of socio-economic variables showed that three variables were significant in explaining the adaptation level in regard to the use of boreholes and crop variety factor as an adaptation strategy. These were the number household members involved in farming, gender and age of the household head (Table 10).

Binary Logistic Regression model was significant at $p < 0.05$ and correctly predicted 93% of the small holder farmers with high and low levels of adaptation to climate variability in regard to the use of boreholes and crop variety factor (Table 11). Three variables (gender, age of the household head and number of household members involved in farming) were found to be significant in explaining the adaptation level in regard to the use of boreholes/water pans and crop variety factor.

Age of the household head was found to be significant in influencing the level of adaptation to climate variability in regard to the use of boreholes/water pans and crop varieties factor. This implies that households headed by more elderly people were more likely to have a high level of adaptation to climate variability in regard to the extent of use of boreholes/water pans and changing crop varieties factor. This is supported by Ziervogel et al. (2008) and Ziervogel and Zermoglio (2009), in that older farmers are perceived to have more knowledge especially on indigenous methods of climate forecasting and high decision making autonomy thus giving them added advantage when it comes to adaptability. In addition, Pali et al. (2002) noted that older farmers in Tororo, Uganda are likely to take up new technologies due to their social status in the community. This also corroborates Mignouna (2011) and Kariyasa and Dewi (2011) that older farmers are assumed to have

Table 10
Univariate analysis of the socio-economic factors influencing the extent of use of *boreholes/water pans and changing crop varieties* factor.

Independent variables	Adaptation level		χ^2 P value
	Low	High	
HHH Gender			
Male	11 (0.7)	137(7.4)	0.004
Female	3 (0.0)	49 (5.8)	
HHH Marital status			
Single	2 (0.0)	11(15.4)	NS
Married	10 (0.7)	134 (6.9)	
Divorced/Separated/Widowed	2 (0.0)	41(4.7)	
HHH Education Level			
None	3 (7.0)	40 (93)	NS
Primary	5 (4.4)	109 (95.6)	
Post-Primary	6 (14)	37(86)	
HHH Main Occupation			
Full-time farmer	11 (6.5)	159 (93.5)	NS
Part-time farmer	3 (10)	27 (90)	
	Mean	**Mean**	**T-test**
Age	33.0	53.43	0.013
HH size	6	6.58	NS
HH members in farming	2	3.56	0.013
Farming experience	13	15	NS
Total land size	5	7.3	NS
Average land under maize	0.85	1.49	NS

N = 200, association significant at $\alpha = 0.05$. Values in parenthesis are in percentage.
HH = HouseHold; HHH = HouseHold Head.

Table 11
Multinomial analysis of the socio-economic factors influencing the extent of use of *boreholes and crop variety* factor.

Independent variables	B	S.E.	Wald	Sig.	Exp(β)
HHH gender	0.098*	0.760	0.001	0.019	0.981
HHH marital status	−0.285	0.606	0.222	0.638	0.752
HHH education level	0.224	0.446	0.251	0.116	1.251
HHH main occupation	0.118	0.747	0.025	0.874	1.126
HHH age	0.026*	0.033	0.651	0.050	0.974
HH size	0.165	0.122	1.825	0.177	1.180
HH members in farming	0.069*	0.171	0.064	0.014	0.933
Farming experience	−0.011	0.036	0.091	0.762	0.989
Total land size owned	−0.044	0.065	0.464	0.496	0.957
Average land under maize	0.106	0.188	0.320	0.572	1.112

N = 200, *Significant at 5% probability level.
HH = HouseHold; HHH = HouseHold Head.

knowledge and experience over time and are in a better position to evaluate a new technology than their younger counterparts.

Gender of the household head was found to be significant in influencing the level of adaptation to climate variability in regard to the use of boreholes/water pans and crop varieties factor. This implies that male headed households were more likely to have a high level of adaptation to climate variability in regard to the extent of use of boreholes/water pans and changing crop varieties factor. The results concur with Asfaw and Admassie (2004) that male headed households were more likely to access information on the availability of new technologies than female headed households. This is due to the fact that women may have limited access to information, land and other resources due to traditional social barriers, Tenge et al. (2004), while men have more access to and control over resources that are considered vital in agricultural production due to socio-cultural values and norms, (Mignouna, 2011).

The number of household members who were involved in farming was found to be significant in influencing the adaptation level of the small-holder to climate variability in regard to the use of boreholes/water pans and changing crop varieties factor (Table 11). This implies that households with a large number of members involved in farming are more likely to have a high level of adaptation to climate variability in regard to the extent of use of boreholes/water pans and changing crop varieties factor. This was explained in regard to labor availability in that households with more members being involved in farming activities are associated with a higher labor endowment. This corroborates Dolisca et al. (2006), Anley et al. (2007) and Nyangena (2007) in that larger family size is expected to enable farmers to take up labor intensive adaptation measure. This would in turn help a household in accomplishing various tasks associated with the strategies in the boreholes/water pans and changing crop varieties factor since the strategies calls for adequate labor availability. This is also supported by Croppenstedt et al. (2003) and Mignouna (2011) that households with a larger pool of labor are more likely to adopt agricultural technology and use it more intensively because they have more labor at peak.

4. Conclusions and policy implications

Results showed that in regard to the extent of use of the adaptation strategies in the five factors (crop management factor; soil fertility management factor; water harvesting and crop types' factor; boreholes and crop variety factor), several significant household socio economic factors were likely to influence the adaptation level to climate variability. These were education level, age, gender and main occupation of the household head, average size of land allocated to maize crop, household size, farming experience and household members who are actively involved in farming.

In the crop adjustment factor, the socio-economic factors that were significant in predicting the use of the strategies were education level of the household and average size of land under maize.

In the crop management factor, the socio-economic factors that were significant in predicting the use of the strategies were gender of the household head, household size and average land under maize.

In the soil fertility management factor, the socio-economic factors that were significant in predicting the use of the strategies were gender, main occupation and education level of the household head.

In the water harvesting and crop types factor, the socio-economic factors that were significant in predicting the use of the strategies were average area of land under maize, farming experience, age and main occupation of the household head.

In the boreholes and crop variety factor, the socio-economic factors that were significant in predicting the use of the strategies were the number of household members who were involved in farming, gender and age of the household head.

Since the study has underlined that small-holder farmers' responses to climate variability are dictated by a host of socio economic factors, studying these factors becomes inevitable. It is also evident that knowledge of these socioeconomic factors can play a role in policy making to strengthen small-holder farmers' adaptation to climate variability. Therefore, researchers, regional planners and policy makers can build on this work by utilizing a more interdisciplinary approach to climate adaptation by involving farmers and rural communities to assess the most suitable adaptation strategies for a given area and farm system as well as their ability to take up the strategies. This is because household types are highly heterogeneous, with some households having better capacity for using different strategies to adapt to climate variability, thus adaptation needs to be tailored to farmers with different biophysical and socio-economic circumstances.

For instance, in the factors that had education level of the household head and farming experience being significant in influencing the use of strategies, (crop adjustment, soil fertility management and water harvesting & crop types factors), non-formal education programmes should be encouraged through extension services manned by competent and qualified extension agents, to enlighten and sensitize farmers on how to efficiently utilize the available resources to curb the effects of climate variability. In this case, since extension is expected to play an important role in educating farmers, there is therefore need to strengthen the existing extension service provision and also bring the private sector on board due to the well-known truism that extension acts as a link between researchers and farmers.

In the factors that had household size, household members involved in farming, age and gender of household head being significant, (crop management, soil fertility management, water harvesting & crop types and boreholes & crop varieties factors), labor availability was seen as an important consideration and since the adaptation strategies in these factors are labor intensive, there is need for research and development to come up with labor saving technologies, which will increase the likelihood of adaptation to climate variability by vulnerable farmers such as women and the elderly farmers. Also, if different culture would give women an equal access to resources and information, they would make better contribution to agriculture owing to the fact that they are responsible for much of the agricultural work.

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