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Vulnerability and adaptation strategies to drought and erratic rains as key extreme events: Insights from small scale farming households in mixed crop agro ecosystems of semi-arid eastern Kenya

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Climate variability and change are some of the most pressing environmental challenges in semi-arid Kenya and Sub Saharan Africa (SSA) and are associated with persistent droughts, dry spells and erratic rains. The present study aimed at determining exposure and adaptation mechanisms among selected small-scale farmers cultivating drought tolerant crops in Wote, Makueni County, Eastern Kenya in the period 2003 to 2013. The sampled 120 farmers cultivate sorghum, cow peas and pigeon peas, which are some of the dominant multipurpose crops. Data collection methods included the use of semi-structured questionnaires. Results indicated that household level vulnerability was caused by exposure to extreme events: Drought (100%) and erratic rains (59%). Key drought adaptation means were drought resistant crops, 65%; terracing, 28%; and crop diversification, 13%. A multiple regression model, R^2=0.319, indicated that age, gender and land size influenced adaptation choices significantly ρ<0.05=0.027, 0.043 and 0.011, respectively. The results reveal prevailing exposure to extreme events at household level and further existing influence of responses by household social characteristics. From the results, the study mainly recommends adoption of alternative income activities, including on farm value addition, coupling of indigenous and modern adaptation mechanisms and provision of comprehensive climate information services.

Key words: Climate change and variability, vulnerability, adaptation, smallholder farmers, semi-arid, Kenya.

INTRODUCTION

Climate change, as defined by the IPCC, refers to "statistically significant variation in either the mean state

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of the climate or its variability, persisting for an extended period typically decades or longer" (IPCC, 2001). In addition the World Meteorological Organization (WMO) gives a wider definition of climate variability as "variations in the mean state and other statistics of climate on temporal and spatial scales beyond individual weather events" (WMO, 2015). Smit et al. (2000), in their anatomy of adaptation, relate the two phenomena by explaining the strong relationship between climate change and climate variability such that adaptation to climate change necessarily includes adaptation to variability. Climate variability and change have been identified as major challenges facing communities at local, regional and global levels in an array of ways as they lead to occurrence of droughts and floods (LVBC, 2011). These events have over time lead to sever and frequent calamities that often affect livelihoods of the already poor (Dixon et al., 2003). Key resources, such as water, are becoming scarce in the already stressed regions of sub Saharan Africa with negative implications on social and economic activities in rural and urban areas (Mongare and Chege, 2011). In many instances when there is constrained access to water households tend to spend time searching for the resource rather than engaging in productive activities. A sector that is highly vulnerable to climate variability and change is rain fed agriculture which in Africa is highly dependent on seasonal rainfall (Challinor et al., 2007; Rao et al., 2011). In Africa, such rain fed agriculture covers 97% of the crop land and is mainly practiced by rural small scale farmers who are part of the 62% of Africa's rural population (Calzadilla et al., 2009). Such numbers indicate high vulnerability to climate change impacts a situation that is worsened by non-climatic influences such as high cost of inputs and high population growth rates (Calzadilla et al., 2009; Tubiello and Fischer, 2007). Such vulnerability has been shown to directly lead to food insecurity and poverty, a situation that hampered achievement of Millennium Development Goals, MDGs (Haile, 2005) or even an impediment to the recently drafted Sustainable Development Goals, SDGs (Minang et al., 2015). These global blue prints have been widely adopted at national and subnational levels, even by development-oriented organizations. Therefore, achievement of project objectives and impact will be negatively affected by the inherent difficulty in predicting the severity of extreme events. Indeed effects of extreme events resulting from climate change are becoming a major area of concern and will affect the poor in developing countries in a wide range of ways (Desanker and Justice, 2001) including amplifying poverty levels (Speranza et al., 2010).

Climate change and variability are for example associated with drought spells as one of the key impacts. These dry spells vary in frequency and duration and are brought about by precipitation failure such that there is inadequate water to support crops and other consumptive uses (Oliver, 2005). Dry spells, in particular, occur several consecutive days during the onset of the growing season and when these last for about 40 days they graduate into a drought (Mathugama and Peiris, 2011). Associated instances of rise in temperatures and their frequency are a major limiter of crop growth, yield quantity and quality as well as an array of other crop development processes (Lin, 2011; Rao and Okwach, 2005; Rosenzweig et al., 2001; Semenov and Porter, 1995). Instances of crop failure linked to higher temperatures eventually lead to impacts such as malnutrition and even severe food shortage in extreme cases (Haile, 2005). Crop pests populations and diseases occurrence and/or virulence have also been linked to changes in temperature and humidity (Verchot et al., 2007). This phenomenon indicates that among farming communities, variation in climate will indeed be one of the drivers of crop losses due to direct and indirect impacts perpetuated by instances of variation in climatic events. Climate related events such as droughts are becoming severer and more frequent (Kisaka et al., 2015), implying many households in Semi-arid Kenya dependent on farming are becoming more impacted and their resilience highly affected. The IPCC's fifth assessment does also raise concerns that effects associated with pests, diseases on livestock and crops are likely to be a concern as the climate changes (Niang et al., 2014).

Vigna unguculata (Cowpeas), *Cajanus cajan* (Pigeon peas) and *Sorghum bicolor* (Sorghum) (Referred hereafter as, focus crops) are examples of drought tolerant crops and their varieties are widely cultivated by small scale farmers in the Wote area in lower eastern Kenya (RoK, 2013). These cereals constitute a key food and nutrition source in the semi-arid area and are widely cultivated in mixed crop agroecosystem. The areas climate is generally semi-arid with the southern part being mainly low-lying grassland, which is suitable for ranching. The mean temperature range is between 20.2 and 24.6°C and is characterized by extreme rainfall variability, which affects farming. Hilly areas receive about 800-1200 mm per annum while the rest of the areas receive about 500mm per annum (CSTI and MoAL, 2009). The existing community practices mainly small scale rain fed Agriculture and livestock rearing (CSTI and MoAL, 2009). The dominant soils in the study area are luvisols and cambisols (Driessen et al., 2001). Luvisols have favorable physical properties including granular surface soils that are porous and well aerated. Cambisols are characterized by a loamy or clayey soil texture with good water holding capacity and internal drainage.

Since this location is largely semi-arid, it experiences instances of climate change and variability. The area and most semi-arid eastern Kenya receives inconsistent rainfall coupled with dry spells that affect the suitability of the growing season (Kisaka et al., 2015; Speranza et al., 2010). These events could be becoming more frequent and severer even affecting the growth and development of the largely drought hardy focus crops. Since rainfall

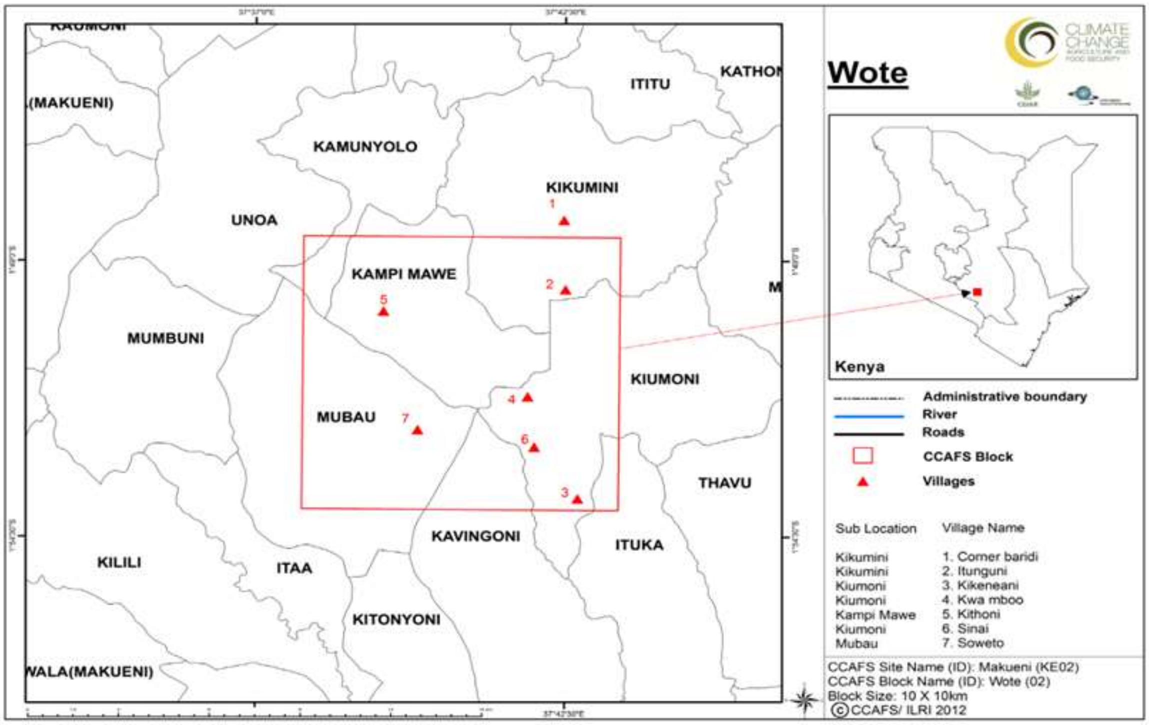

Figure 1. Map showing the study area.
Source: CGIAR-CCAFS (2012).

and agriculture are intimately linked, heavy reliance on rain fed agriculture as the main source of livelihood by small-scale farmers in Wote, negates development by increasing poverty when climate extremes strike. Specifically, small holder farmers in Wote are becoming increasingly vulnerable as their adaptation and resilience efforts and key livelihoods such as drought resistant crops are eroded (RoK, 2013; Speranza et al., 2010) by recurring climate impacts. The focus crops farmers were the entry point of this study since understanding climate based risks posed among these farmers is going to inform appropriate and transferable adaptive capacities. There is evidently little understanding of the vulnerability and adaptation mechanisms of such households. Accordingly, this paper characterizes the nature of vulnerability and adaptation among Wote smallholder farmers to give information on adaptation interventions for buffering against inherent and new combinations of climate extremes and associated impacts.

DATA AND METHODS

The study was part of an ongoing project Climate change agriculture and food security (CCAFS) which cuts across the Consultative Group for International Agricultural Research (CGIAR) (CGIAR-CCAFS, 2012) (Figure 1). The project's study areas in Kenya include a 10 × 10 km^2 block in Wote, Makueni County (CGIAR-CCAFS, 2012). The coordinates of the specific sampling block (Figure 3) are: 37°.378 E, 1°.657 S; 37°.298 E, 1°.702 S; 37°.244 E, 1°.624S; 37°.326E, 1°.581S (Förch et al., 2011). A preceding study selected 200 households based on dominant production systems within the identified block via stratified sampling, with reference to the administrative divisions (sub-locations and villages) aided by village level leaders (Rufino et al., 2013). This study purposively sampled 120 agriculturally active and knowledgeable farmers cultivating the focus crops from the 200 households. The input of agricultural extension officers as well as local leaders such as Chiefs and Village elders came in handy.

Data collection tools included semi-structured questionnaires administered in person at household level and was conducted in August 2013. The questionnaires were developed with reference to expert knowledge and related literature and were initially pre tested. Two key household members (Main respondent and correspondent) were chosen as respondents with the aim of identifying and involving key members of the respective households. These participants were later incentivized at an acceptable rate of 1 kg of sugar at the end of the interview session. The main respondent represents the main provider of household income with the correspondent being a spouse or an elder son. The involvement of two household members is important because each contributes to the household's income, well-being and decision-making. A similar approach has been used in related studies such as Notenbaert et al. (2013a) in their work in Mozambique. In this study, responses from the main respondents and correspondents are only analyzed separately for selected variables including education and main occupation. Other variables represent the respective household responses. Collected data was entered, using CsPro and later exported to Microsoft Excel and further to SPSS. Analysis of qualitative and quantitative data was run using SPSS functions such as coding, multiple responses, descriptive statistics and multiple regression (Tabachnick and Fidell, 2001).

Table 1. Summary of selected Wote household characteristics.

Parameter	Mean	SD(σ)	Minimum	Maximum
Household size	6.08	2.38	2	17
Main respondent age	49.87	18.06	21	95
Correspondent age	42.63	16.09	17	95
Farm size	7.09	6.97	1	40

n=120.

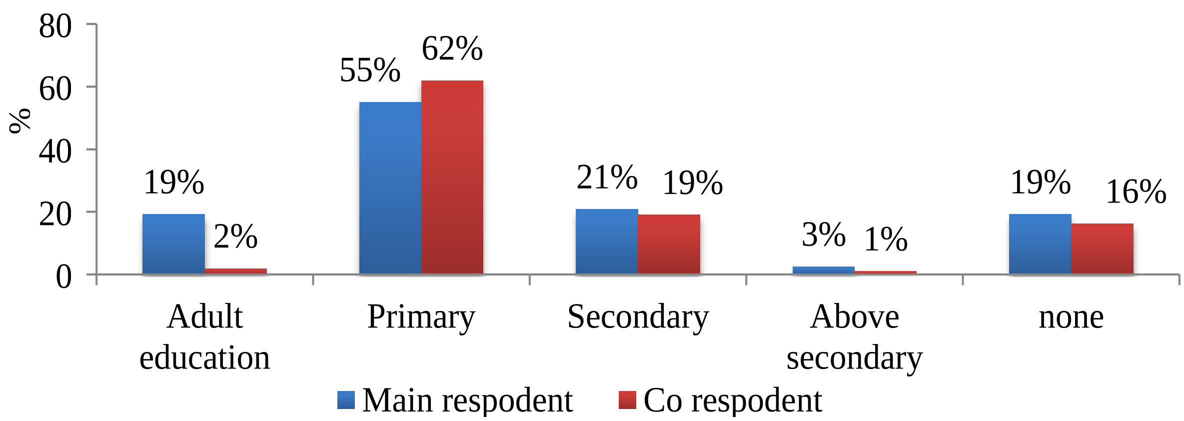

Figure 2. Education levels of key respondents in Wote n=120.

RESULTS

Socio economic characteristics

On average the households had six members which does not differ from the Kenyan national average of 5 UNFPA (2009). Further, the average land size was 7 acres with the largest recorded acreage being 40 acres, Table 1. The average age for the main respondents, regarded as household head was 49 years while that of the correspondent; usually the spouse was 42 years. Figure 2 indicates both main respondents and correspondents were mostly educated to primary level at 55% and 62% respectively.

Key extreme events affecting households in the last ten years

Apart from climate related extremes, other effects such as crop pests and diseases play a significant role in affecting farming households in Wote over the last ten years (2003-2013) (Figure 4). It is apparent that all the households, 100%, had experienced drought. An almost equal number of households had experienced crop pests, 93% and crop diseases following at 83%. It is notable that events such as floods affect few of the households, 4.2%, and frost at 2%, indicate that the study area does indeed experience heavy rainfall related impacts. This paper pays attention to drought as the major calamity experienced by households and in the next section explore the associated impacts and instituted responses at household level.

To further bring extreme events to perspective, households were asked to rank the three major extreme events experienced with the order where a value of one represents the key calamity. The households ranking of these events were further analyzed ,using the Kendall's coefficient of concordance (Kendall's W) which is used on ordinal data and is a non-parametric statistic similar to spearman correlation (Kraska-Miller, 2013). The results shown in Table 2 indicate the ranking of key extreme events; Drought, erratic rains, pests and diseases are statistically significant (ρ<0.05=0.000) at 95% confidence interval with (χ=32.788, Df=3). Analysis of precipitation parameters over the last 35 years by the Kenya Agricultural Productivity program (KAPP), indicates high variability and inconsistency (KAPP, 2017). Figure 5 shows instances of years with extremely high rainfall in the larger Makueni County. This represents instances of extreme rainfall that could be contributing to crop and asset losses. Most importantly, Figure 6 reveals several years with total dry spells above 40 days. This is an indicator of the inter-annual occurrence of dry conditions as extreme climate events and perhaps inherent difficulties in prediction. Such spells pose as a risk to

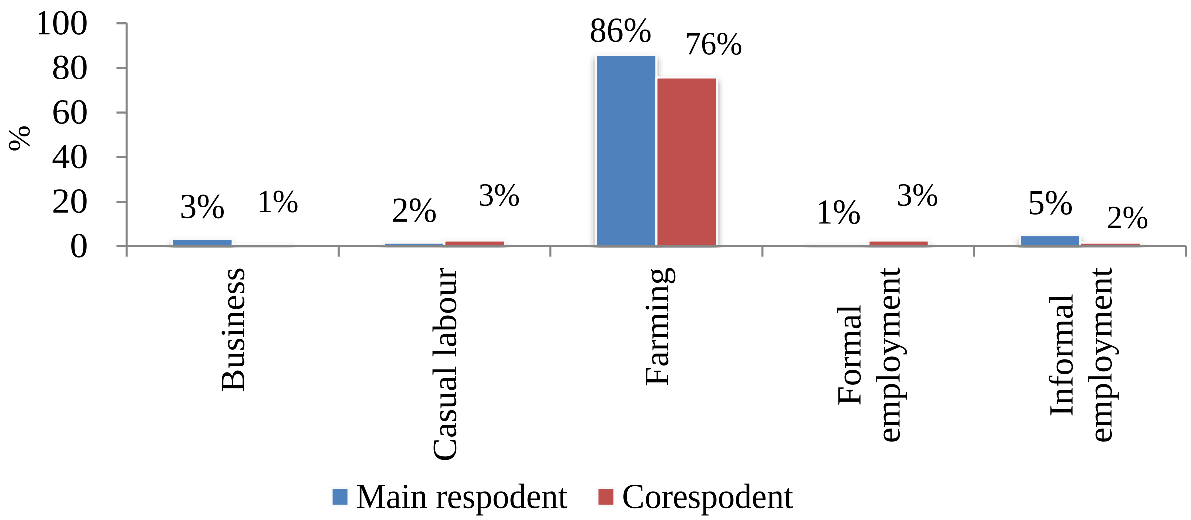

Figure 3. Main occupation of Respondents in Wote n=120.

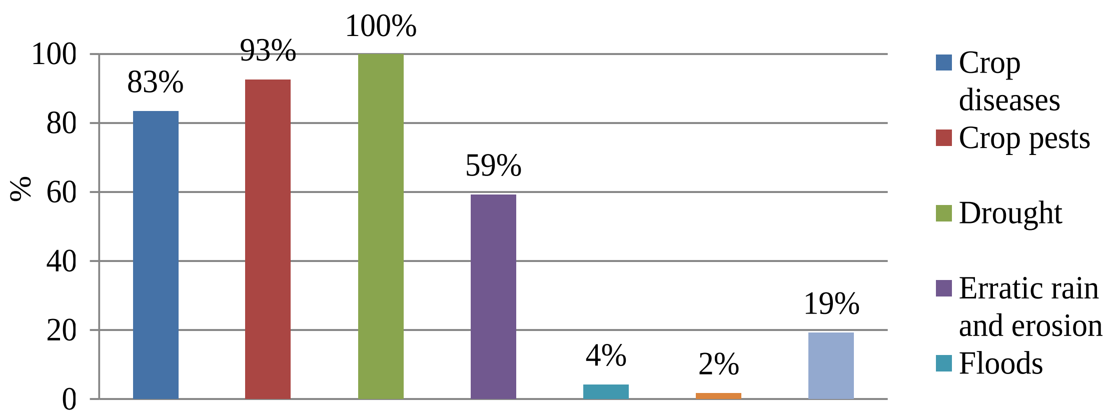

Figure 4. Major extreme events affecting households in Wote in the last ten years n=120.

Table 2. Kendall's coefficient of concordance (Kendall's W) for key extreme events as ranked by households in Wote.

Statistic	Value
Kendall's W	*0.643*
Chi-Square	*32.788*
Df	*3*
Asymp. Sig.	*0.000*
Drought ranking	1.06
Erratic rain ranking	2.53
Crop disease ranking	2.94
Crop pest ranking	3.47

farming as they contribute to massive crop failure and may cause exceeding the threshold of drought hardy

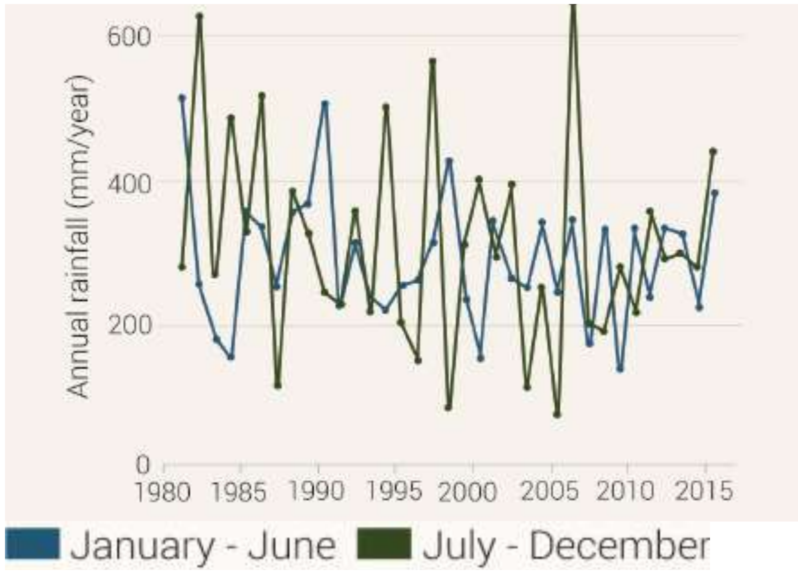

Figure 5. Historical annual precipitation in Makueni county.
Source: KAPP (2017).

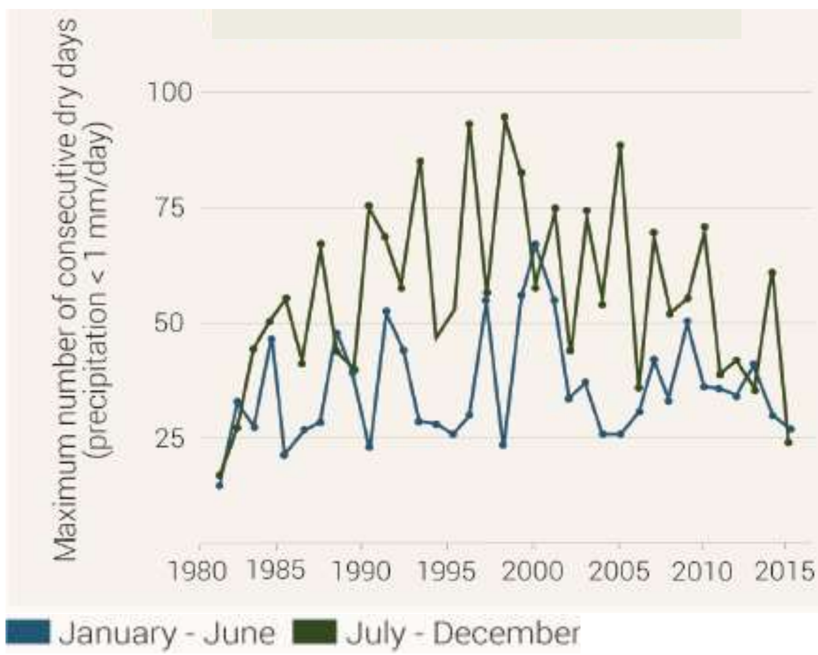

Figure 6. Historical distribution of dry spells in Makueni county.
Source: KAPP (2017).

cereals discussed in the next section.

Impacts associated with drought as a key extreme event

Almost half of the households, 46%, reported that they have experienced crop failure as a result of occurrence of drought indicating risks associated with this event in the largely agriculture dependent households, Figure 7. An almost equal number, 44%, indicated that they had experienced extreme hunger in the area because of drought with an almost equal number, 43%, indicating they had experienced water shortage. These numbers

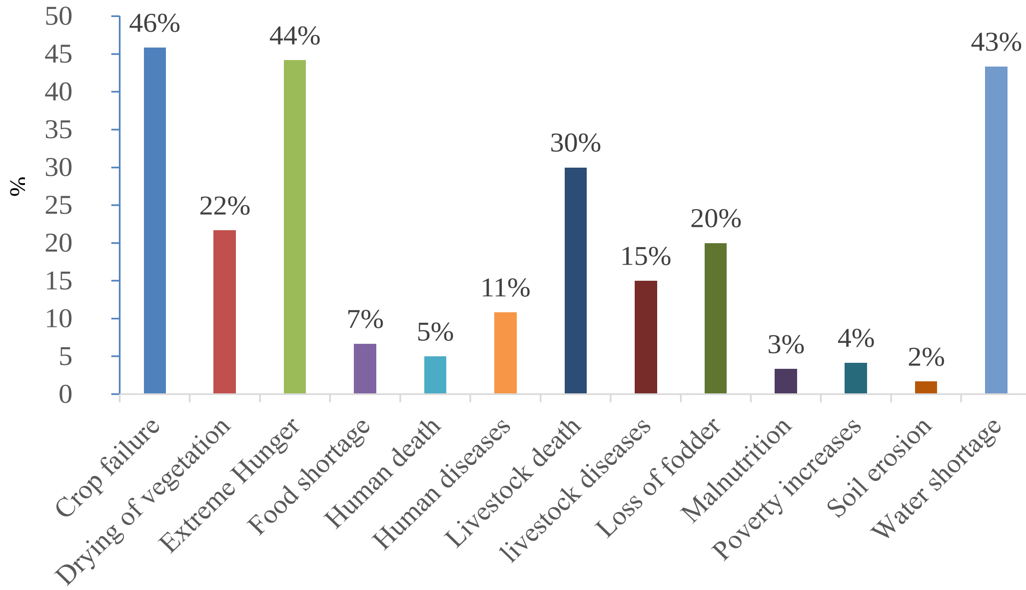

Figure 7. Impacts associated with drought among Wote households n=120.

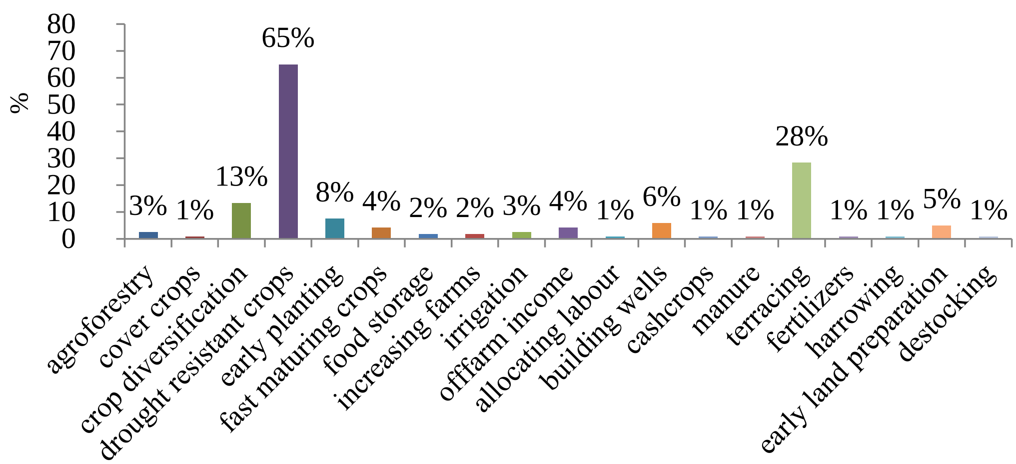

Figure 8. Adaptation mechanisms against drought by Wote households.

indicate that households are indeed experiencing severe effects including severe food shortage denoted as extreme hunger because of instances of drought and probable occurrence of intervening dry spells. This scenario could not only be associated with insufficiency of food but also access and variety and could be contributing to nutrition insecurity and/or malnutrition. This would largely influence growing children more who require a diet with multiple essential nutrients. Resulting to water shortage, this further worsens this situation as the deterioration of the quantity and quality of this essential commodity directly contributes to a myriad of human and livestock impacts, including health and survival. The impacts of drought, as the results show, do not only affects crops but also natural vegetation, perhaps limiting growth and distribution.

Adaptation mechanisms

Adaptation mechanisms against drought

Households engaged in an array of mechanisms to adjust to the frequent occurrences of drought with most of the key mechanisms revolving around farming (Figure 8). Most of the households, 65%, have engaged in cultivation of drought resistant crops and varieties, 13% practicing crop diversification and 28% setting up terraces all largely

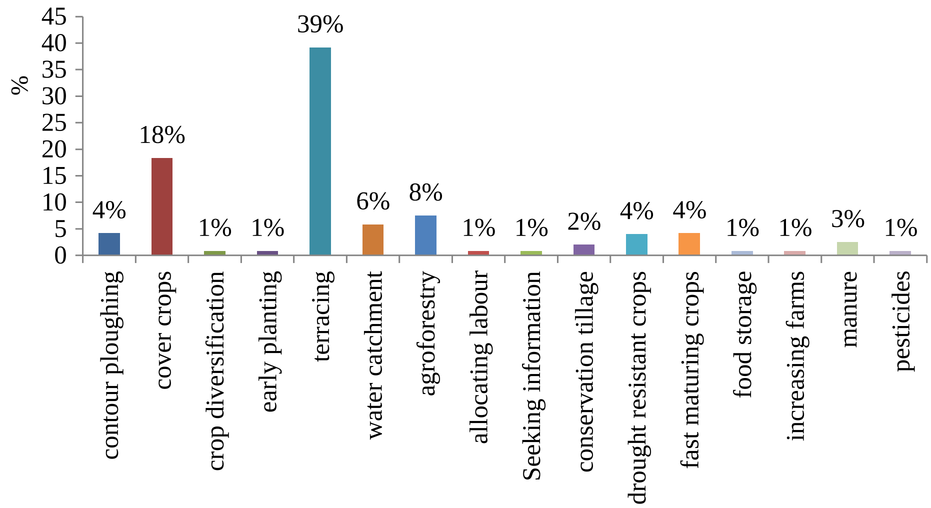

Figure 9. Adaptation mechanisms against erratic rains by Wote households n=120.

Table 3. Selected adaptation mechanisms by Wote households.

Selected adaptation mechanism	No.	%*
Sale of household assets	81	68
Extension services	55	46
CBOs and farmer associations	43	36
Post-harvest processing and value addition	19	16
Credit and loans for farming	1	1

n=120, *Percentages sum exceed 100% because these are multiple responses.

adjustments aiming at enhancing efficiency in water use.

Adaptations against erratic rains

Households in Wote have made efforts to adjust to erratic rains through several response strategies. From Figure 9, most of the households, 39%, established terraces with 18% cultivating cover crops. A few households employed related mechanisms such as contour ploughing, 4%; agro forestry, 8%; and setting up of water catchment, 6%. Mechanisms of adapting to erratic rains include terracing, 39%; agroforestry, 8%; and water catchment 6%. These are principally approaches aimed at enhancing the utilization of scarce water resources.

Other notable response strategies

Selected mechanisms presented in Table 3 include selected initiatives and key individual household efforts to adapt to climate extremes as well as institutional backing to enhance adaptive capacity against climate change and variability. Most of the households (68%) as Table 3 indicates, are involved in selling of household assets such as livestock. Almost half of the households (46%) accessed extension services, which aids in decisions around adaptive capacity and more so improved and new farming practices. Furthermore, 36% of the households in Wote indicated being members of Community Based Organizations (CBOs) and farmer associations. A few of the households (16%) indicated involving in post-harvest processing and value addition. This involves applying technologies that aim at improving harvests or developing multiple products from harvests or on farm produce.

Relating adaptation mechanisms to socio economic characteristics

To understand socio economic factors influencing adaptation a multiple regression model was developed, a similar approach applied by Adebisi-Adelani and Oyesola (2013). Multiple regressions explain the overall fit of the model or rather prediction of the value of one variable from others and the relative unique contribution of each explanatory variable to the model (Tabachnick and Fidell, 2001).

Table 4. Descriptive Statistics of Adaptation responses against calamities by Wote Households.

Mean	4.69
Median	5.00
Mode	4
Std. Deviation	1.527
Minimum	0
Maximum	8

Freund et al. (2006) as well as Tabachnick and Fidell (2001) state that a multiple regression model is denoted as an extension of the linear or bivariate regression as shown in Equation 1:

$$y = A+\beta_1 x_1+\beta_2 x_2+.....................+\beta_k x_{k+}E,................ \quad (1)$$

Where y is the dependent, target or response variable.
A is the y intercept, the value of which is zero when all X values are zero.
X =1, 2,........., k, represent m different independent, explanatory or control variables;
β_0 is the intercept value when all predictors are 0, also denoted as α in other cases;
β =1, 2,.................,m, denote the respective k regression coefficients;
E is the random error or disturbance term, usually assumed to be normally distributed with mean zero and variance. Also denoted as μ in other cases.

Multiple regression models require an array of assumption tests which include tests for independence of errors (residuals), linear relationship, multicollinearity, outliers and normal distribution of errors (Lund-research, 2013; Pallant, 2013). These statistical measures were used in the present study to warrant the validity of the model as well as act as a data reduction approach aiming at selection of the best predictors. In the present paper, some of the assumption tests were presented, including collinearity tests and tests for independence of errors in Table 5. Multicolinearity is examined through inspection of correlation coefficients and the tolerance or variance inflation factors (VIF) among predictors (Crown, 1998; Lund-research, 2013).A tolerance value less than 0.10 indicates high correlation with other predictors and similarly a VIF above 10 (Reciprocal of 0.1) indicates collinearity in the model (Lund-research, 2013; Pallant, 2013). From Table 5, the highest tolerance value is 0.339 (VIF=2.950) indicating the data does not exhibit multicollinearity. An important statistic as reported by Ho (2006) is the Durbin Watson statistic that ranges from 0 to 4 with a value close to zero showing strong positive correlation. The statistic is a test of the serial correlation of error values and is used to indicate non independence of error values when significant (Ho, 2006; Pallant, 2013; Tabachnick and Fidell, 2001). Ideally, the statistic should be approximately equal to two to warrant the non-assumption of the requirement. Table 5 shows there was independence of residuals, as noted by the Durbin Watson statistic of 1.684 hence the assumption was not violated. In this analysis, some continuous predictors were transformed to improve their contribution in the linear model as well as reduce collinearity.

As applied in related studies such as Adebisi-Adelani and Oyesola (2013) and Harvey et al. (2014) the Wote household's adaptation strategies were aggregated such that the total numbers of adaptations for each calamity per household were identified to form a dependent variable. The adaptation statistics are presented in Table 4. The results shown in Table 5 indicated that gender of the main respondent, in most cases the household head, significantly influences adaptation (ρ<0.050=0.040). Similarly the age of the key household members, the respondent and correspondent, affected the level of adaptation strategies significantly (ρ<0.05, =0.023=0.006) respectively. Land size as a key resource affects adaptation level significantly (ρ<0.05, =0.014) and more so positively (β=0.345).

The relationship between adaptation and food insufficiency

Since food insufficiency computed on monthly basis was a key indicator of vulnerability, the relationship with the number of adaptations was further explored. This is because it is highly likely food shortage informed adaptation whether in terms of number or variety. Initially the two variables were transformed into nominal variables and the Chi-Square test used to find the relationship. The Chi-Square tests that there is a significant relationship between two categorical variables with a threshold value/significance level/ρ-value of 0. 05 (Huizingh, 2007). Since the Chi-Square does not specify the strength of the relationship between two variables, additional statistics were computed and in this case Cramer's V which denotes the strength of the correlation between two nominal variables(David and Sutton, 2004; Huizingh, 2007). Results in Table 6 indicate that there is a significant relationship between food shortage and adaptation strategies, $\chi^2(1)$=17.623, ρ=0.04. A Cramer's

Table 5. Summary of multiple linear regression model showing the relationship between certain household characteristics and number of adaptation responses.

R^2=32.3% Durbin-Watson=1.684	Standardized coefficients	t	Sig.	Collinearity statistics	
	Beta			Tolerance	VIF
(Constant)		4.895	0.000		
Respondent gender	-0.401	-2.108	0.**040**	0.584	1.712
Correspondent gender	-0.323	-1.631	0.109	0.367	2.723
Respondent education	-0.218	-1.448	0.154	0.445	2.245
Correspondent education	-0.317	-1.835	0.072	0.339	2.950
Income sources number	0.083	0.684	0.497	0.894	1.119
Household number sqrt*	0.185	1.529	0.132	0.716	1.398
Respondent age sqrt*	-0.377	-2.345	**0.023**	0.514	1.947
Correspondent age sqrt*	-0.441	-2.850	**0.006**	0.554	1.803
Acreage sqrt[1]	0.345	2.532	**0.014**	0.904	1.106

* Variables transformed using the square root

Table 6. Monthly food insufficiency statistics among Wote Households.

Mean	3.75
Mode	3
Std. Deviation	1.49
Range	7
Minimum	1
Maximum	8

V value of 0.227 further demonstrates this relationship as being small as per Cohen (1988).

Vulnerability context

Food in security and /or insufficiency is a key variable in this research as a measure of vulnerability notably because the entry point of the research was drought tolerant crops cultivating farmers highly dependent on farming. This measure has indeed been applied in other vulnerability assessments for example Gabrielsson et al. (2013). In this assessment, food insufficiency was measured by the number of months that the household was experiencing difficulty in feeding themselves or rather instances of severe food shortage within a year. The statistics were present in Table 6 showing the distribution of monthly food shortage among households.

DISCUSSION

Socio economic characteristics

Since the study aimed at identifying exposure and adaptation to climate change, the larger number of experienced farmers as Table 1 shows, would be better at" distinguishing climate change and inter-annual variation" (Maddison, 2007) as well as exhibiting farming experience (Deressa et al., 2009). The results further show that most of the household heads had made an effort in acquiring basic education notably to the primary level. However, such minimal education is likely to reduce the capacity to adapt to extreme events and more so advancement of their livelihoods. This is because education has indeed been identified as a key avenue for gaining employment and subsequent alternative income for providing resources in rural households and is hence a key endowment to enable households deal with poverty (Christiaensen et al., 2002; Verma, 2001). The mean household size does not vary from the national average. Nevertheless, the reported average household size could play a role in determining the level of vulnerability among the households. For example, large households will benefit from distribution of on farm labour a number that can however be influenced by the age of the household members. Higher number of dependants has additionally been shown to contribute to shifting of a household from low to high vulnerability to climate change effects in other related studies since there are more mouths to feed than pair of hands to work (Leary, 2008; Nkondze et al., 2013).

The results also indicate that most of the households are largely dependent on farming as a livelihood source or are highly reliant on farm produce. However, extreme climate events effects on rain fed farming would indeed bring about significant impacts on agriculture and livestock as other studies such as Dixon et al. (2003) report. Nevertheless, a few households are engaged in alternative income generating activities such as formal and informal employment. These could act as safety nets in case of poor harvests or widespread crop failure. Such alternatives enhance access to alternative income that cushions against the effects of poverty and by extension reduces multiple risks posed by exposure to climate extremes and amplified by non-climatic influences (Adger, 1999).

Extreme events experienced

In this study, climate change indicators reveal extreme events that households have experienced in the study area presently and over the last 30 years. These elements are also key indicators of exposure to climate change and variability against which impacts are associated (IPCC, 2001). Household ranking of all extreme events shown in Table 3 further indicates the Kendall's coefficient (W=0.643) which is close to 1 showing strong agreement or similar standards in ranking (Kraska-Miller, 2013).This can be interpreted that the households are in agreement or consensus of their rankings of key climate and related calamities risks affecting them. Drought as noted by all households has indeed been shown in related studies as a key concern. A similar observation was made by Mwang`ombe et al. (2011) in their study on rural farmers in Kenyan dry lands. Drought cases in Wote area can also be associated with the fact that the area is classified as an arid area in the category of 85-100% arid and semi-arid, with total arid and semi-arid land at 25% (RoK, 2004).
Results demonstrate that households in Wote have been affected by multiple risks as evidenced by reports of crop pests and diseases in a large number of the households. These further impact on crop health and only add to the risks posed by extreme climate events. Occurrence of such crop pests and diseases could be natural prevalence but also to certain extent interrelated and even associated with extreme climatic events. For example, Reynolds (2010) states that the relationship between pests, diseases and the environment form a 'diseases triangle' that determines the outcome of a particular crop disease. Such crop diseases and pests are likely to reduce crop yields and performance and as Reynolds (2010) adds; they are to a great extent affected by environmental factors.

Erratic rains as mentioned by more than half of the households are associated with unpredictable rainfall spells in some instances late onset of rainfall and insufficiency in the amount of rainfall and do contribute to drought and or intermittent dry spells (Vanlauwe, 2002). Such occurrence could be a great risk to hydrous stress sensitive crops such as maize particularly when such event occurs during the initial growth stages as well as development stages (Ingram et al., 2002; Kambire et al., 2010; Parry et al., 1999). This insufficiency could be due to fewer rainy days, leading to a lower volume of rainfall. In other cases, rainfall occurs in torrents such that most of the runoff is difficult to harvest and ends up as floods.

Impacts associated with drought as a major extreme event

A non-universal description of drought, as discussed by Oliver (2005) and Paron et al. (2013), states the event as a ,natural reduction in the volume of precipitation or available freshwater for an ecosystem, over an extended length of time specifically a season or longer and such droughts differ in intensity, duration and spatial coverage. Drought is associated with certain weather timings such as season of occurrence, delays in start of the rainy season, rain versus crop growth stage as well as rainfall effectiveness (Oliver, 2005). With extreme hunger, crop failure, malnutrition and water shortage identified as key impacts associated with drought, it is likely there lay a strong relationship between occurrences of these impacts. This is because each of the effects, as some authors have noted, leads to another: severe food shortage results from crop failure, Haile (2005) while water scarcity due to rainfall failure is a key contributor in occurrence of crop failure (Dilley, 2005). These impacts are likely to have secondary effects among households in the study area. Water shortage for example, influenced by levels of precipitation and evapo-transpiration, determines the quality of available water and such water quality affects human health (Müller, 2009). Such health impacts and prevalence of malnutrition are likely to affect children and the elderly more severely (Holmberg, 2008) since they are more vulnerable when extreme events strike (Mirza, 2003).

Adaptation strategies

The large number of households engaging in cultivation of drought resistant crops is evidence of the importance of and confidence in and reliance on crop based response strategies among households in the study area. Similar mechanisms in the face of drought have also been noted in several studies around sub Saharan Africa. These include growing of drought tolerant crops and varieties, Mwang`ombe et al. (2011); Mahu et al. (2011); Rufino et al. (2013), crop diversification, Woodfine (2009) and terracing to conserve elusive soil moisture, Mwang`ombe et al. (2011). Drought and heat tolerance cops have indeed been noted as a practical option for adaptation with appropriate implementation (Ngigi and Denning, 2009).

It is likely that households in Wote involve in crop diversification to reduce the risk of extreme events where all crops fail. This is in line with Woodfine (2009) who indicates that one of the key reasons for crop diversification other than monoculture is avoiding the risk of extremes such as droughts such that some crops are likely to survive. Agro forestry as mentioned involves growing of certain multipurpose trees and shrubs on farm to provide an array of products and services including shade, fruits, fodder, wood, carbon sequestration and wind control (Jama and Zeila, 2005; Woodfine, 2009). Among the households, this presents a useful means of accruing multiple benefits and at the same time diversifying income in the face of multiple and concurrent climate and non-climatic risks.

Erratic rains are associated with delayed onset and shorter duration or rather fewer rainy days which could be characterized by intense downpour (Simelton et al., 2011). Such erratic rains are ultimately a concern in arid and semi-arid environments since they negatively affect farming activities particularly making prediction of the start of rains or season onset difficult for farmers. Terraces as applied by most households are constructed in sloppy areas and provide an array of functions, including conservation of water and soil by slowing runoff, promoting infiltration and water storage and reducing wind erosion (Blanco-Canqui and Lal, 2008). Blanco-Canqui and Lal (2008) add that in drier areas, terraces enhance plant available water as well as groundwater recharge. To conserve the minimal moisture available, the mechanism is commonly applied in arid areas and more so in hilly landscapes (Mwang`ombe et al., 2011).

Cultivation of cover crops is widely applied in farming communities and involves cultivation of certain multipurpose legumes to manage changes in water availability (Mahu et al., 2011). Contour ploughing on the other hand aims at controlling soil erosion as a result of runoff by increasing soil water infiltration (Blanco-Canqui and Lal, 2008). As such, the aim of the mechanism is to mainly avoid effects of runoff, which leads to soil erosion while at the same time enhancing water conservation. Agro forestry as practiced by few of the households in Wote mainly aims at controlling erosion in the event of erratic rains. The practice has been documented in other studies on adaptation to erratic rains in semi-arid lands and involves planting of certain trees and shrubs along the farm edges or within crops (Mahu et al., 2011).

Crop diversification in the event of erratic rains aims at reducing the risk of losing all crops if rains fail or exhibit within season variability (Woodfine, 2009). The mechanism was noted by (Recha, 2011) in his study on adaptation strategies in semi-arid eastern Kenya.

Cultivation of drought resistant crops in the study area aims at facilitating crop survival in the event that rains fail or the amount of rain is minimal, a mechanism that is popular in semi-arid areas as noted by other studies such as (Mwang`ombe et al., 2011). Akon-Yamga et al. (2011) also found out that farmers engaged in cultivation of drought resistant varieties in a related study in Ghana and Gambia, West Africa.

Households in Wote also instituted assets sale, extension services, joining of community groups and values addition. Most households in the study area resorted to sale of assets perhaps when all response avenues are exhausted. Assets include means of production available at household level and are applied in their livelihood activities (Cooper et al., 2008). There could be a wide range of reasons that force households in extreme circumstances to opt to, sell key assets such as land and even livestock. These include paying off debts, paying school fees, purchase of inputs: a decision that reduces their chance of survival in future (Orindi and Murray, 2005). It is highly likely these reasons inform households in the study area and could have impacts on the ability to exhibit resilience in subsequent impacts. Such response involving disposal of livestock and other key assets is as a last result. Extension services include supply of information concerning improved farming practices in the face of extreme climate events and related calamities and have changed or evolved over time due to new farming needs and threats. Extension service aid farmers in Wote on decisions revolving around adaptive capacity, avoiding maladaptation and more so improved and new farming practices such as grafting and cultivation of improved crop varieties. Other studies have further indicated and demonstrated the critical role and need of extension services in; improved farming knowledge and more so their continued contribution in improving adaptive capacity in the face of climate change and variability among small scale farming households in SSA (Kabubo-Mariara and Karanja, 2007; Mustapha, 2013) as well as improvement in yields (Muyanga and Jayne, 2006).

Community based organizations (CBOs) enable households in Wote to engage in collective farming which diversifies their income. Such income enables the households to have alternative income and food sources in the event of crop failure in their individual farms. Studies have indicated additional benefits of households having membership in such CBOs. These include ease of access to loans (Hammill et al., 2008; Muyanga and Jayne, 2006) and related microfinance services provided by: governments, credit unions and SACCOs (Hammill et al., 2008). The authors add that such microfinance institutions aim to fill the gap left by traditional banks, which are unable to effectively offer such services due to barriers such as lack of collateral. They also state that some micro finance institutions do offer non-financial services such as education, training and healthcare among their members, which directly and indirectly contribute to improved household assets base, and improved farming practices. In addition to financial benefits community based organizations in Wote work towards improving individual farming practices in the face of climate variability for example by implementing shared knowledge from other farmers and more so benefiting from group capacity building by NGOs and government agencies. This vital benefit is also reported by Ngigi (2016) in their work on adaptation options for small holder farmers in East Africa.

Post-harvest processing as instituted by few households involves applying technologies that aim at improving harvests or developing multiple products from harvests or on farm produce. Examples in the Wote area include sisal processing and use of hand driven mechanical maize mills. Value addition aims at improving the shelf life, marketability and profitability of farm products or rather raise their value tremendously which improves on the income or benefits to the households. Furthermore, enterprise diversification including value addition (or processing) is a practical option to adaptation against climate change extremes (Ngigi, 2016).

Socio economic factors and adaptation

The results suggest that gender of the main respondent, largely the household head, influences adaptation to climate change. Perhaps this is because men, who are the household heads, play a key decision making role and even the final say towards the choice and level of investment in adaptation. Similarly the age of the key household members, the respondent and correspondent, affected the level of adaptation strategies. From the results, it can be interpreted that the older the household heads and spouses, the more likely they are to institute more adaptation strategies. This could be due to their experience with extreme events and their impacts including the ability to make decisions based on nature, frequency and extremity. Land size as a key resource affects adaptation level significantly and more so positively. This implies owning a larger land resource would increase the ability of the household to adapt probably by having a larger acreage to practice mechanisms such as crop diversification.

Other studies have identified similar and differing relationships between the selected socioeconomic characteristics and adaptation strategies. Adebisi-Adelani and Oyesola (2013) in their work in Osun state of Nigeria among selected horticultural farmers, identified similar socioeconomic factors affecting adaptation. These include age, which indicates the experience of the farmer plays a key role in determining their adaptation. A related study by Apata et al. (2009), in arable crop farmers in south west Nigeria, noted that age and land size are important factors influencing coping with climate change calamities. Deressa et al. (2009) in their work in Ethiopia similarly noted a significant relationship between selected adaptations with age and gender of the household head.Income has been identified as a key factor influencing adaptation for example, Apata et al. (2009), Adebisi-Adelani and Oyesola (2013) though in this study the influence was positive (β=.083) but not significant (ρ>0.05=0.497). In their work in Ethiopia, Deressa et al. (2009) noted that both on farm and non-farm income did influence certain adaptation strategies. In deed as Notenbaert et al. (2013a) report in their related work in Mozambique, availability of adequate income facilitates the households' acquisition of new varieties, irrigation technologies and other inputs as well as ability to use available information which improves their adaptive capacity. This argument applies to households in the study area as indeed economic endowment translates to the ability to invest in a wide range of response options.

The model results indicate household size does not influence adaptation significantly (ρ>0.05=0.132) but show a positive relationship (β=.185) a similar observation made by Adebisi-Adelani and Oyesola (2013). This direction could imply a larger household is in a position to participate in multiple and even intensive on farm duties, including working in other person's farms to supplement their income. Other studies such as Apata et al. (2009) found that household size significantly influences adaptation while in their case the relationship was negative. Large household sizes have been associated with take up of labor intensive adaptation mechanisms such as irrigation (Notenbaert et al., 2013a). Education (Number of years) did not show a significant relationship with adaptation and additionally depicted a negative correlation. Clay et al. (1998) and Anley et al. (2007) in their context however found that education and access to farmer training contribute to better adaptation. While results do not show this nature of relationship, education is a driver of household emancipation. A household is able to accrue additional income from formal employment, which is invested in multiple, or alternative response strategies. This income could also build a stronger resilience in a household.

Vulnerability

Social vulnerability to climate variability is a key aspect in determination of vulnerability to climate change and further should be central in interdisciplinary research as it helps solve causes rather than symptoms (Adger, 1999). An array of approaches have been applied in climate vulnerability studies such as the use of household vulnerability indexes (Notenbaert et al., 2013a) as well as reference to selected vulnerability markers including food security (Gabrielsson et al., 2013; LVBC, 2011; Recha, 2011) or specific climate extremes experienced (LVBC, 2011).

As Table 5 demonstrates, the average number of food insecure months in the study area was approximately 3

($\bar{x}$=3.75, σ=1.491) with most households experiencing 3 months food insecure months (Mo=3). The highest number of food insecure months reported was 8 with 1 as the lowest number. Such food insecurity includes the household's ability to have one meal in a day rather than at least three. This demonstrates the wider dimension of food insecurity including reliable access and affordability. Households in the study area highly ranked agricultural based income since most; 86% rely on farm produce with 50% relying on animal products as a key source of income. This distribution of income sources ,in particular reliance on rain fed farming, further demonstrates the households high risk and vulnerability from extreme events notably occurrence of drought, pests and diseases.

In an attempt to cope with extreme events farmers in the study area have instituted an array of adaptation mechanisms targeting specific calamities and land resource changes. While such array of adjustments has been instituted by households in the study area, there are underlying factors that are contributing to sensitivity and subsequent impacts associated with the key extreme events experienced notably drought. To put this argument into perspective, there is an array of factors leading to a cycle of food insecurity in the study area while households have employed adaptation mechanisms. Gabrielsson et al. (2013) argue that "when exposure, sensitivity and limited adaptive capacity reach a vantage point there is a likelihood of greater vulnerability due to destructive feedback on the human-environment system". Such limited adaptive capacity could be associated with reliance on autonomous and reactive means, with reference to experiences despite the poor performance of such means. In this regard, mechanisms such as drought resistant crops practiced repeatedly could be failed by the case of poor land fertility reported by the households. It is additionally likely that crops fail due to multiple impacts: as reported that drought, erratic rains, pests and diseases are key calamities that in other instances occur concurrently.

Relating adaptation strategies to food shortage

Results demonstrate that food shortage as an indicator of vulnerability (Gabrielsson et al., 2013) exhibits a significant association with adaptation strategies. This relationship can be interpreted that households will tend to invest in the number and variety of adaptations based on instances and severity of food insufficiency. It is hence highly likely the greater the occurrence of food insufficiency (in number of months) at household level, the larger the number of adaptations or greater effort to respond. This effort could perhaps include a diversified approach that encompasses a variety of means not limited to crop based strategies. While the results show this relationship is small, this in no way waters down the association. The strength of the relationship whether small strongly shows among the households food insufficiency can be denoted as a key reference point when instituting adaptation strategies. Furthermore, while this association is narrow, in a large way it illuminates the importance of understanding food security in answering questions on adaptation. This includes efforts to institute sustainability at household level through climate smart practices (Nkonya et al., 2015) that enhance adaptation and minimize and eliminate poverty (Sanchez, 2000).

CONCLUSION AND RECOMMENDATIONS

This research sought to understand the vulnerability of selected small-scale farmers through reference to selected socio economic indicators. It is apparent that the households are mainly agriculturalists, heavily dependent on rain fed agriculture. As pertains exposure to extreme events, it has been found out that drought is the main climate related calamity affecting households in the study area. The study also reveals that exposure to such climate related events, has resulted into several impacts.

The study indicates that the key effect, drought, has been associated with crop failure, food shortage, water shortage as well as effects on livestock and human health. In the face of such climate change and variability impacts, households in the study area have devised an array of indigenous and modern adaptation mechanisms. The study concludes by outlining the evident sensitivity and vulnerability of the households with reference to the key occupations and income source such as farming. At the same time, experienced extreme events and associated impacts mainly food insufficiency are highlighted as indicators of vulnerability.

Enhancement of adaptive capacity among Wote small-scale farmers cultivating the drought tolerant focus crops is necessary to enhance sustainable development at the local level. The findings demonstrate appropriate and informed resilient crop based adaptation mechanisms have a high potential in assisting small scale farmers achieve food, income and livelihood security. The existing association between food shortage and adaptation strategies underpins this importance.

Based on these findings and literature, the study recommends the following actions to reduce household's vulnerability. These are replicable and relevant to smallholder farming systems in semi-arid areas of SSA that experience climatic extreme events such as erratic rains, dry spells and drought. First, action can be taken to scale up locally made and or homegrown technologies and innovations employed by smallholder households to reduce their sensitivity to extreme events. This is because high potential adaptation mechanisms will be informed by local perceptions and more so, manifestations with climate change and variability. Secondly, there is need to enhance adoption of alternative ecologically friendly income sources, for example non-on farm income generating activities and at the same time exploring benefits of value addition and/or on farm processing. Thirdly, the study recommends that households could join community groups to enhance access to community-based loans and other benefits such as improved farming practices. Another approach is provision of climate innovation services such as the use of mobile phone platforms to urgently inform small holder farmers on impeding dry spells prior to planting. Lastly, the study recommends further research including alternative approaches to vulnerability assessment such as utilization of quantitative household composite vulnerability indexes, the use of recent vulnerability methodologies proposed by the IPCC and incorporation of land use and cover change analysis as well as climate scenarios to project future effects on crops and landscapes. Another interesting research would be exploring the nexus between food-water and energy access at the household level.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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