FACTORS INFLUENCING CLIMATE VARIABILITY ADAPTATION STRATEGIES AMONG SMALL-SCALE FARMERS IN KITUI COUNTY, KENYA"

LENAH MUTINDI MULYUNGI [(a)]
Co-author: Sharon Chepkemboi Waswa [(a)]
(a) Kenyatta University, Nairobi, Kenya

ABSTRACT

Climate variability poses a major challenge for small holder rain fed agricultural production with a relatively greater impact on small scale farmers worldwide. Kitui County, Kenya, particularly remains relatively less focused on climate change and farmer understanding of climate variability response strategies. This study sought to assess variability in climate (rainfall and temperature) in Kitui County from 1980-2012 and assess influence of household socio-economic factors on farmer's level of knowledge on climate variability adaptation techniques. The study also investigated the challenges faced by farmers in applying climate variability adaptation techniques. To achieve the objectives outlined above, a survey design was employed and a sample of 387 respondents selected. Majority of the respondents were small scale farmers in Kitui County. Questionnaires were designed and administered to the selected subjects to solicit data on climate adaptation techniques and socioeconomic factors influencing farmers' knowledge levels on climate variability adaptation techniques. Data were statistically analysed using Statistical Package for Social Sciences and results discussed and presented in tables, charts and graphs. The study found that climate has over the years varied with temperatures having increased by 2^0 C in the 1980s and early 1990s. The rainfall has reduced to less than 600mm with the lowest rainfall (226mm) being recorded in 2006. This implies that the Kitui County is becoming drier and hotter. These findings were ascertained by majority of the respondents (91.1%) who agreed that rainfall patterns had varied in the last ten years. The study found that there were no significant differences on how local farmers adapted to the changes in climate with regard to income, age and even ownership of land. An exception however, was on education levels with the study finding significant statistical differences ($p<0.005$) on how farmers with different levels of education adapted to climatic variability and change.

Key Words: Knowledge Levels, Climate Variability, Adaptation Strategies, Small Scale Farmers

INTRODUCTION

1.1 Background

Agriculture is relied upon by majority of the rural population in sub-Saharan Africa for their livelihood (Umesh *et al*., 2015). Rain fed agriculture is highly sensitive to climatic conditions and is one of the most vulnerable sectors to the risks and impacts of climate change (Parry *et al*., 2001). Developing countries remain vulnerable to climate variations and this in turn affects their agricultural sector which contributes significantly to their GDP (DFID, 2004). Climate variation continues to affect farmers who lack adequate information on climate variability implications on agriculture, especially with regard to rainfall and temperature (Ochieng, 2016).

Previous studies (Doll *et al.,*2015 and Alteri and Nicholls, 2017) suggest that low adoption of climate variability adaptation techniques in light of variations in rainfall and temperature may have negative impacts on rain fed agricultural production (Manda *et al*., 2015); however, through adoption, adverse impacts associated with climate variability can be minimized (Ziervogel & Ericksen, 2010; Easterling *et al*., 1993). Based on these studies, research on adaptation techniques has been done and adaptation techniques for small scale farmers proposed. These techniques include crop diversification, water harvesting and conservation, soil conservation and farm production technologies.

There is inadequate information however, on knowledge levels of these techniques among farmers and its influence on the adoption of these adaptation technologies among small holder farmers. Empowering farmers with knowledge enables them to be in a better position to make well informed decisions to select appropriate techniques and technologies in managing their resources for improved agricultural production and livelihood (Wegulo *et al*., 2009). This calls for the need to determine farmers' knowledge levels on climate variability adaptation and to determine if knowledge influences their adoption.

Rain-fed agriculture is highly sensitive to and vulnerable to climate variations (Parry *et al*., 2001; Reilly & MSchimmeipfenning, 1999). Kitui County's climate has over the years been characterized by unreliable and irregular rainfall patterns which makes the small scale farmers more vulnerable to impacts of climate variability. A study by Omoyo *et al.* 2015, showed that climate variability affects crop production in semi-arid lands like Kitui where agricultural production has declined over the years. This has contributed to food insecurity, and has aggravated incidences of hunger and levels of poverty in the county (CGK, 2014). Climatic variability has negatively affected food production and has further reduced the capacity of land to support exisiting livelihoods (Khisa,2014). This has led to unpredictable and reduced crop yields and loss of livestock leading to perennial food shortages and overreliance on relief food to meet the local food deficit (GOK , 2005).

Despite the fact that research has been widely conducted to provide strategies to help semiarid areas adapt to climate variability, adoption among farmers in Kitui County remains low. Adoption of climate adaptation technologies depends on farmers' capacity creation through knowledge dissemination and training on proper management of their agricultural resources hence improving their livelihoods (Wegulo *et al*., 2009). This study therefore sought to assess farmers' knowledge levels on adaptation techniques and the uptake of these technologies.

1.2 Objectives

To achieve this general objective, the study addressed the following specific objectives:

1. To assess climatic variability (rainfall and temperature) in Kitui County from 1980 to 2012
2. To assess the influence of household socio-economic factors on farmer's level of knowledge on climate variability adaptation techniques.
3. To investigate the challenges faced by farmers in application of climate variability adaptation techniques.

1.3 Hypothesis

The study was guided by the following hypothesis:

- Households' Socio-economic factors significantly influence farmers' knowledge level and uptake of climate variability adaptation techniques.

1.4 Conceptual Framework

Small scale farmers' knowledge levels on climate variability adaptation techniques may be influenced by various socio-economic factors. Knowledge on adaptation techniques contributes to farmer decision on adopting proposed climate adaptation techniques. Adoption of the techniques may contribute to increase in crop yields and increased water conservation which leads to food security and increased household income levels (Pramova *et al.,* 2012). On the other hand, failure to adopt climate variability adaptation techniques leads to soil moisture loss, soil erosion, and low food production hence food insecurity.

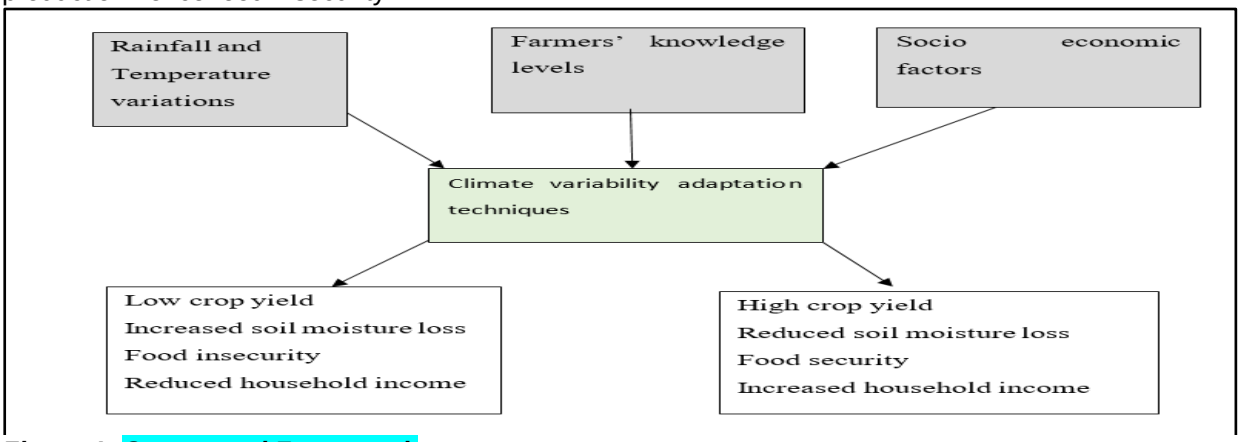

Figure 1: Conceptual Framework

Key

Independent variables
Dependent variable
Outcomes of either technique adoption or rejection

LITERATURE REVIEW

2.1 Climate Change and Variability

Climate change is a global phenomenon affecting both developed and developing nations. It is undeniable that the variability of climatic factors, especially precipitation and temperature are so pronounced in the current era than any other time in the past. According to Gregory, (2016) the rise in the burning of fossil fuel, sparked by high level of industrialization and land use changes, especially in the developed nations has contributed to rapid changes in the earth's climate. Christiane *et al*., 2016 asserted that the increase in greenhouse gases emission particularly carbon dioxide has exacerbated global warming. According to Oluduro & Lavrysen, 2015, over the past 100 years, the concentration of carbon dioxide in the atmosphere has increased to almost 400 parts per million as compared to 278 parts per million in the pre-industrial era. As a result, the global average temperature has risen by about 1 Degree Celsius.

Oluduro and Lavrysen (2015), argue that global warming and climate change have multifaceted effects such as reducing agricultural production, loss of human livelihoods, increase of human diseases, sea levels rise, and other social and environmental problems. Gregory (2016) was also categorical to note that global climate change causes the retreat of the polar ice and the glaciers in the temperate regions of the earth causing the sea levels to rise. As a result, the water in the seas overflow and cause flooding, which in turn causes destruction of property, death, displacement, loss of biodiversity, agricultural losses, environmental damages, pollutions, and other subsequent effects such as poverty, diseases, and hunger (Shao *et al.,* 2017). Markedly, the complex nature of the effects of global climate change is supported by Cooper *et al*., (2013), who argued that climate change has caused changes in the cloud cover and the intensities or frequencies of precipitation.

That is, some regions of the earth are receiving more or less amounts of rainfall that are mainly unpredictable and sometimes unreliable. In fact, most regions, especially in Africa, Latin America, and Asia are highly affected by the prolonged droughts that result in considerable crop failures and loss of livestock.

Christoph, (2009) asserted that the global local variation in climatic factors influence the decisions of the people due to the consequences that climate change has on the political, economic, social, environmental fronts. Examining the effects of climate change, he also noted that it influences the lives and livelihoods of humans, which makes adaptive techniques and responses necessary. Most importantly, the effects of climate change are felt at the local levels due to localized impacts on communities. Climate variability at the localized levels has had tremendous impacts on the livelihoods of communities, especially those that are more vulnerable to changes in climate. Nonetheless, Oluduro and Laverysen (2015) noted that the global effects of climate change are widespread and nations are striving to adapt to the climate change.

2.2 Climate Variability in Africa

Just as climate change affects the whole world, the phenomenon is a reality in Africa. Gregory (2016) notes that the impact of climate change is expected to be intense in parts of the African continent, Asia, and Latin America. The argument is supported by Olivia *et al.* (2016) who argues that many African nations still depend on rain fed agriculture as the mainstay of the economy despite the fact that such agriculture is highly vulnerable to the effects of climate variability and change.

African communities with low income and limited knowledge capacities on climate variability are vulnerable to global warming and other climatic changes. According to Ottichilo *et al.* 1991, the African population has limited capacity to adapt to the known and unknown changes in climate. He argues that Africa is expected to have varied impacts as certain sections will be wetter while others drier with the eastern section of Africa being expected to get wetter while the southern section becoming hotter. Nonetheless, the impacts are not universal in the named sections since climate change has localized effects based on the variability of the climatic factors. As a result, adaptation techniques and responses are mandatory so as to develop sustainable ways of reducing the impacts of climate change.

Scheffran (2015) explains that climate change threatens food security in the African continent just like in Asia as the majority of the communities are losing their livelihoods due to climate change induced effects i.e. floods, pests, diseases, and prolonged droughts. Additionally, crop yield and livestock production is expected to change as a result of the extreme weather conditions. Rainfall has also become more unreliable and unpredictable, which greatly affects rain-fed agriculture; hence, people are urged to shift to technologies such as irrigated agriculture. However, climate change also reduces water availability and makes irrigation expensive and sometimes impossible.

According to Oluduro (2015), adaptation in Africa is expected to be fragmented and disrupted by factors such as political conflicts, fragmentation of communities, poor business environments, lack of policies or poor enforcement of policies in place. Governments are striving to provide information to local communities, as well as incentives, and establish an enabling environment to respond to the changes in climatic factors. In both the Asian and the African contexts, climate change is intensifying the hazards and risks of natural disasters such as flooding, drought, pests, and diseases. Melese & Mulinge (2015) reveal that, the vulnerability of the agriculture sector in Africa and especially Kenya is inevitable because of the notable variability of climatic factors. The study asserts that changes in temperature and precipitation have direct influence on the characteristics of land and water regimes. The problem is exacerbated by the fact that the majority of small scale farmers in Africa have lower coping capacities, resources, and knowledge needed to adapt to the changes of climate.

Inadequate political will to support the marginalized and less advantaged small scale farmers also poses challenges to climate change adaptation. As a result, the volume of food production is expected to immensely reduce leading to increased hunger, suffering, poverty, diseases, and negative implications on the wellbeing of the people. There is therefore an urgent need to improve the adaptive capacities of the local communities through well thought out, enactment, implementation, and enforcement of projects, policies, programs, and plans that gear towards helping the vulnerable small scale farmers to cope and adapt to changes in temperature and precipitation patterns.

2.3 Climate Variability Adaptation Techniques in Agriculture

Undeniably, there are various definitions of adaptation and the capacity of adaptation according to several sources of literature. According to Melese and Mulinge (2015), the word adaptation was derived from evolutionary biology and natural sciences to mean adjustment in human and natural systems in response to the expected or potential impacts and stimuli of climate change. In this context, the main aim of adaptation is to reduce or moderate the effects and capitalize on the beneficial opportunities. Salih (2015) was categorical to identify different types of adaptation such as planned, anticipatory, and autonomous adaptations. He further asserts that, planned adaptation happens due to deliberate decisions that are pegged on awareness of the effects of climate change and instituting action/measures to maintain, return to, or reduce the impacts to the desired state. He defines anticipatory adaptation as that, that is conducted before the happening of climate change. Kysar (2011) also agrees that anticipatory adaptation to climate change calls for preemptive or preventive measures that are put in place to avoid the impacts of expected climate change. Autonomous adaptation involves the conscious responses that are sparked by the alterations to the natural systems, human welfare, and markets. Most importantly, it is vital to stress the argument by Melese and Mulinge (2015) that the adaptive technologies and responses are necessary to be put in place so as to reduce the vulnerability of communities while increasing the chances of benefiting from the opportunities of climate change.

The world's population has been increasing at a high rate and is expected to reach 9.8 million by 2050 with more than half of the anticipated growth expected to occur in Africa (United Nations, 2017). This requires agricultural production to increase by 70% by 2050 to meet the population's food demand (FAO, 2010). Several adaptation technologies aimed at water and soil management have been suggested. These adaptation techniques include changing crop variety, changing planting date, mix crop and livestock production, planting trees, soil and water management, off-farm employment and irrigation/water harvesting (Deressa *et al.,* 2009: Amwata , 2015).

Use of improved crop varieties, agro forestry, soil conservation, changing planting dates and irrigation are the most used adaptation strategies in African countries (Deresa *et al*., 2009). Bryant *et al.* (2000) argues that adoption of agricultural techniques is based on how perceptions of climate variability are translated into agricultural decisions. Hence, the fact that implementation aligns with research and policy to form the existing findings on adapting to climate variability effects.

Small holder farmers face multiple challenges at the adaptation stage with several factors potentially impeding their access to and use of emerging adaptation strategies. These include static, poorly functioning or poorly integrated input and output markets; poor infrastructure; inadequate and ineffective public extension systems; lack of credit and insurance markets (George, 2013).

Markedly, adaptation to climate changes requires a detailed assessment of the effects. The concept of adaptation assessment involves identification of alternative ways of adapting to the effect of climate change. Salin (2015), also added that adaptation assessment requires evaluation of various issues based on different criteria such as costs, benefits, availability, efficiency, feasibility, and effectiveness of the measures to be adopted. The assessment; therefore, follows defined steps. Jackson (2017) mentioned that the first step of adaptation assessment is to engage different stakeholders and define the roles and responsibilities of all entities. Secondly, the partakers of adoption should examine the present adaptations to the variation of climatic factors and the extreme conditions. The third step involves assessment of the adaptive responses to the impacts of climate change in the future followed by assessing the limitations to the adaptations such as resources, personnel, and the costs involved. Salin (2015), further said that the fifth step involves assessing the barriers to adapting to the changes such as political will and legislations. Most importantly, the study added that the subsequent step entails linking the adaptations to sustainable development so as to benefit the current and the future populations. Lastly, it is necessary for the stakeholders to address the uncertainties related to climate change and the adopted strategies. In essence, if all the steps are taken into account, the small-scale farmers will be prepared for the variability of climatic factors and even cope with the expected negative consequences.

2.4 Factors Influencing Farmers' Knowledge Levels and its impact on Adoption of Technology

Several socio-economic factors serve as key drivers that influence farmers' knowledge and choice of adaptation farm techniques in Africa (Deresa *et al*., 2009; Mideksa, 2009). Some studies assert that improvement in education and knowledge dissemination are key policy measures that help in

stimulating local participation in natural management initiatives including agricultural management (Anderson & Thampallai, 1990; Shields *et al*., 1993; Heinen, 1996). Nkonya, *et al* (2008) found that education levels affected adoption of improved maize seed crop in Tanzania with each additional year of education increasing the probability of adoption by 5%. Educated farmers are expected to have more knowledge and information about climate variation and the various adaptation technologies that they can use ((Maddison, 2006).

Another key variable is awareness about climate change and adaptation strategies, that is, whether farmers have some information about climate variation and various adaptation methods. This can be obtained through radios, Televisions and newspapers. Awareness on climate variation and different adaptation methods gives a farmer a wide range of options for responding to climate change and allows them to choose those methods which are more convenient for them.

Accessibility to agricultural extension services is another major factor considered to influence knowledge (Labarthe, 2013). Farmers with access to extension services had more knowledge on climate change adaptation and were more likely to adopt improved cut off drains and 'fanyajuu' technology as part of their adaptation in Haiti (Anley *et al.,* 2007). However other studies have found no significant relationship between accessibility to extension services and knowledge levels or adoption rate (Nkonya *et al*., 2005). Jones (2003) and Baethgen & Magrin (1995) postulate that availability and access to extension service provides farmers with information and knowledge promoting their ability to make wise decisions on alternative crop management practices to cope with climate change.

Older farmers have authority on decision making which makes them advantaged in terms of technology adoption (Temesgen *et al*., 2009). On the other hand, younger farmers have the chance of accessing education and this makes them receptive to change (Bekele & Drake, 2003). According to Asfaw & Admassie (2004), the probability of male-headed households to acquire information on new farming techniques is higher than in the female headed households. Female headed households are less likely to adopt soil and water conservation measures because of their restricted access to information, land and other resources due to traditional social barriers associated with women.

2.5 Research Gaps

From the literature review, this study identified that there are several adaptation technologies available to farmers (Rickards& Howden 2012: Umesh *et al*., 2015). These adaptation strategies are mainly autonomous adaptations where farmers change their livelihoods in response to varying climate (Benson *et al*., 2015). However, there is inadequate literature on level of adoption and farmers' knowledge levels in the study area. The Socio-economic factors likely to influence farmers' knowledge level on adaptation strategies are also inadequately covered (Kristjanson, *et al*., 2012). This study therefore sought to assess the socio-economic factors influencing farmers' knowledge levels on climate adaptation strategies in Kitui County, Kenya.

METHODOLOGY

The study employed an exploratory survey design. This research design is most useful in situations where limited information is available and the researcher wishes to have the flexibility to explore future areas of research (Cooper & Schindler, 2006). The primary goal of exploratory research is to diagnose a situation, screen alternatives and generate new ideas. It is an appropriate way to provide ground work for later and more rigorous research. (Polonsky & Waller, 2005). The study was carried out in Kitui West Sub-County of Kitui County in Kenya, Africa. The location had a total of total population of 102,314 people (KNBS, 2009) and 12,266 households at the time of the study.

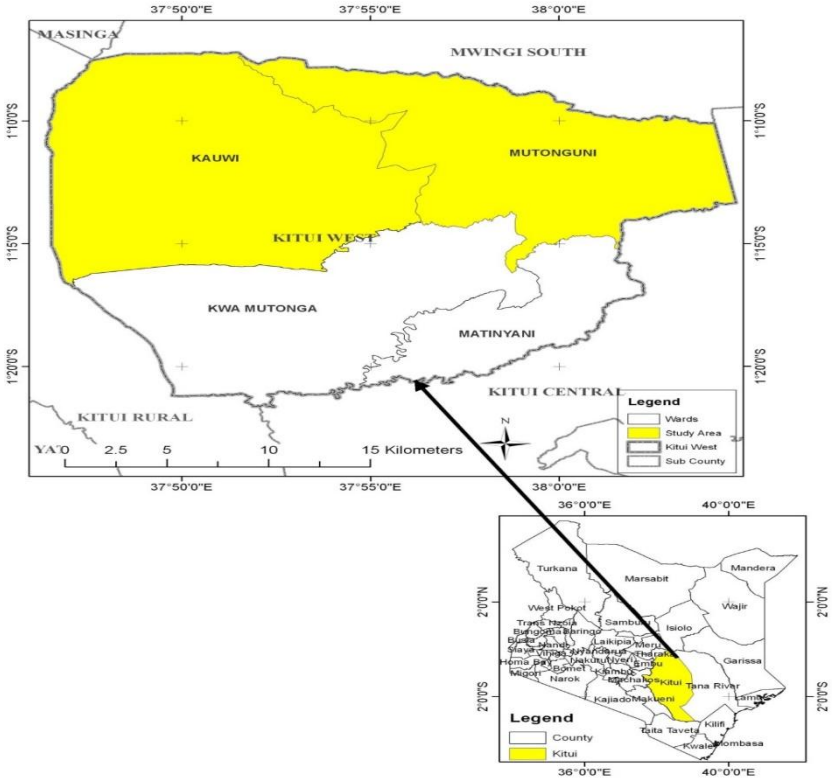

Figure 2: Study Area Map, Source: Survey of Kenya, 2016

The sample frame included individual famers and famer's group leaders. The target population for this study was 12,366 households distributed in Kauwi and Mutonguni wards (Figure 1). Sample size of respondents was determined using a formula adopted from Yamane (1967) which is ideal for a large target population greater than 10,000.

$$n = \frac{N}{1+N(e)^2}$$

Where

n = sample size derived

N=Population size

e= Level of precision (at 0.05)

Therefore;

$n = \frac{12366}{1+12366(0.05)^2} = 387$ households

A proportional random sample was selected from each of the two wards so as to yield a sample size of 387 as outlined in Table 1. Simple random sampling was then used to obtain sample size of 387 using household list which was obtained from the respective ward offices.

Table 1: Target population and sample size

S/N	Ward	Target Households	Sample
1.	Kauwi	6,346	199
2.	Mutonguni	6,020	188
	Total	**12,366**	**387**

Climatic data (rainfall and temperature) for the period 1980-2012 for Katumani weather station (number 9137089) were obtained from the Kenya Meteorological Department for analysis to explore how variations in precipitation and temperature had occurred in the study area over the last 32 years. This station was chosen because it was the nearest to the study area and had regular weather records for more than 30 years. Kitui County did not have a manned weather station at the time of data collection and therefore did not have consistent weather readings. Reliability of data collection instruments was done by discussing questions with the university supervisors after which they were validated by conducting test retest method. Ethical issues included respecting privacy and confidentiality of the respondents during the time of data collection. A total of 387 structured questionnaires were administered to 387 households to obtain data which included the socioeconomic factors influencing farmers' knowledge levels on climate adaptation

techniques, and challenges faced in implementation of the adaptation techniques in a bid to establish training needs for farmers.

The study employed descriptive statistics, such as frequencies, mean and standard deviation as well as inferential statistics to test the statistical differences on the adoption of climatic coping strategies in Kitui County. Temperature and rainfall data for the period 1980-2012 from the meteorological stations was analysed using SPSS to present patterns on trends and anomalies in temperature and rainfall. The results were then presented in tables, charts and graphs.

RESULTS AND DISCUSSION

4.1 Socio-Demographic Attributes of the Participants

4.1.1 Gender, Age and Education

Results on Table 2 shows that 58.0% of the respondents were male while 42.0% were female. A proportion test shows that the number of males were significantly more than that of women (p=0.03). Cumulatively, the results further indicate that majority (64.4%) of the people interviewed were aged between 35 and 65 years whereas respondents aged below 35 years and those aged above 65 years were 24.4% and 11.2% respectively. The age groups were classified based on African Youth Charter (A YC) which defines a youth as every person between the ages of 15 and 35 years (African Union Commission, 2006). An analysis of equality of size of the categories showed that the number of persons across the categories were significantly different (p=0.000). Table 2 further shows that close to half of the sampled participants (45.9%) had primary education while 28.9% had attained 'O' level education. The results further indicate that one in every ten respondents (12.6%) had attained tertiary education while on the contrary, 12.6% had no formal education. However, the differences between respondents with primary, secondary and tertiary levels of education was significant (p=0.000). These results imply that the rate of uptake on climate variability adaptation techniques would be low due to the small percentage (12.6%) of respondents with tertiary education and a higher percentage of farmers who had only attained primary education.

Table 2: Socio-demographic profiles of the participants

Attribute	*Indicators*	*n*	*%*	*Expected*	*Actual*	*Sig*
Gender	Male	207	58.0	178.5	207	0.003
	Female	150	42.0	178.5	150	
	Total	**357**	**100.0**		**357**	
Age of the respondent	34 yrs. and below	87	24.4	119	87	0.000
	35-65 yrs.	230	64.4	119	230	
	Above 65 yrs.	40	11.2	119	40	
	Total	**357**	**100.0**		**357**	
Education level	No Education	45	12.6	89.3	45	0.000
	Primary	164	45.9	89.3	164	
	Secondary	103	28.9	89.3	103	
	Tertiary	45	12.6	89.3	45	
	Total	**357**	**100.0**		**357**	

4.1.2 Monthly Income Levels for the households

The respondents were asked to state the level of income realized at the household by all its members from all possible sources, such as employment, farming, businesses and trade among others. Table 3 shows that majority of the sampled households (65.3%) reported a monthly income of less than Kshs: 10,000 while respondents whose income was between Kshs.10,000 and Kshs. 30,000 or above Kshs. 30,000 were 29.1% and 5.1% respectively. A chi square test was done to check whether the proportions of the income differed significantly across the income levels. The non-parametric chi square test found that the proportions of the different income levels was significantly different from each other. This is perhaps due to the high number of the people who earned less than Kshs. 10,000 (65.3%) compared to those who earned over Kshs. 30,000. This demonstrates an area with some high levels of poverty in the country with each household member earning approximately KES 48 per day.

Table 3: Monthly Income Levels for the house holds

Household Income Sources	**n**	**%**	**Expected**	**Actual**	**Sig**

Up to Kshs 10,000	233	65.3	119	233	0.000
Kshs 10,001 - 30,000	104	29.1	119	104	
Over Kshs 30,000	20	5.6	119	20	
Total	**357**	**100.0**	**357**	**357**	

4.1.3 Membership to Agricultural Support Groups

The study sought to know whether the sampled population belonged to any agricultural group which forms the units through which agricultural services are disseminated to the farmers by the government and donors. These services include but not limited to provision of information on improved farm inputs, farming techniques and skills to farmers. The results showed that majority (72.8%) of the respondents were not members of any Agricultural group. Only 27.2% of the respondents belonged to at least one group. Some of the groups that had many members were Mutini SHG with 16 members followed by New Jerusalem Farmers which had 11 members. Kuweta Na Kikwa SHG was third with 10 members who registered their affiliation to it. This indicates that most of the farmers in Kitui West are not members of agricultural groups and hence are not able to benefit from agricultural knowledge that are offered through the groups. Research shows that farmers who belong to, and participate in agricultural groups or cooperatives have higher probability of gaining knowledge on climate variability adaptive strategies compared to those farmers who do not participate in such groups (Mohamed *et al*., 2014). This is because farmers in these groups share knowledge and innovation ideas discuss problems and challenges with each other.

4.1.4 Size of the farm and type of ownership

The study sought to determine the average sizes of the respondents' farm in acres since this could have an influence on farmers use of climate variability adaptation techniques. The sample average for the farm size was found to be 6.09 Acres. (SDEV = 4.61). Table 4 shows the results on farm ownership. Majority of the respondents (87.1%) reported to practice agricultural activities on private farm while those who depended on communal and public farms were 37 and 9 respondents respectively. This indicates that majority of the participants in the study owned their farms. A chi square test on the proportion of land ownership (Table 4) showed that there existed significant differences among the proportion of land ownership ($p<0.05$). Further analysis showed that the mean size of farm under crop cultivation was higher than that of pasture. Crop cultivation mean=4.4; 95% CI= (4.0, 4.8) whereas pasture mean=1.9; 95% CI= [1.7, 2.1].

Table 4: Chi square test on equality of the proportions on land ownership

	Observed N	Expected N	Chi square	df	Sig
Private	311	119.5	465.801	2	0.000
Communal	37	118.3			
Public	8	118.3			
Total	**356**				
Mean size of land under cultivation at 95% CI, Mean=4.4 , CI= (4.0, 4.8) acres					
Mean size of land under pasture at 95% CI, Mean=1.9, CI=(1.7, 2.1) acres					
Average size per household 6.09 acres					

4.2 Climate Variability in Kitui West Sub- County

4.2.1 Temperature Changes in the Region

This study examined the average temperature experienced changes from the year 1980 to the year 2015 to ascertain the variations that have taken place. Figure 3 shows that the day time temperatures in Kitui as shown by the information collected by KMD. The information shows that average temperatures in the region were initially less than 29°C between the years 1980 to 1999. The average annual temperatures increased to an average of more than 29°C between 1999-2008 before increasing further to average level of more than 30°C and then recording the highest average level of 31.8°C in 2014. The data shows that average temperatures have increased from values below 29°C to more than 30°C implying that the area has continually become hot over time.

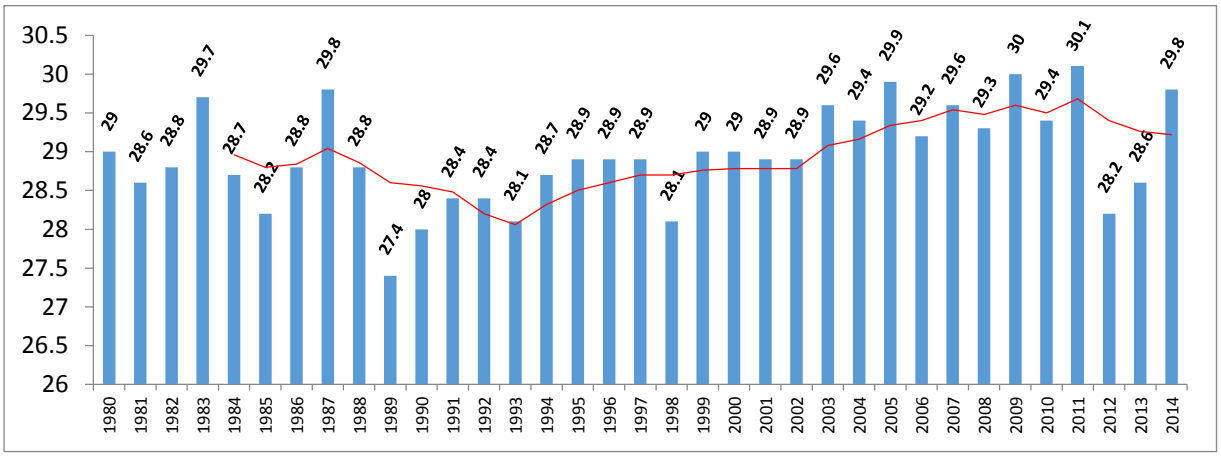

Figure 3: Temperature (Degree Celsius) for Kitui Station (1980-2015) with 5 yr. moving average (Source: Data from KMD)

The results show that the long-term air temperature fluctuated all the years with sharp drop to about 28 °C degrees for the period 1980-1990.The trend from the period 1990-2014 had been upward characterized by steady rise, sharp drops and also flat levels that rise to a mean of about 30 °C degrees.

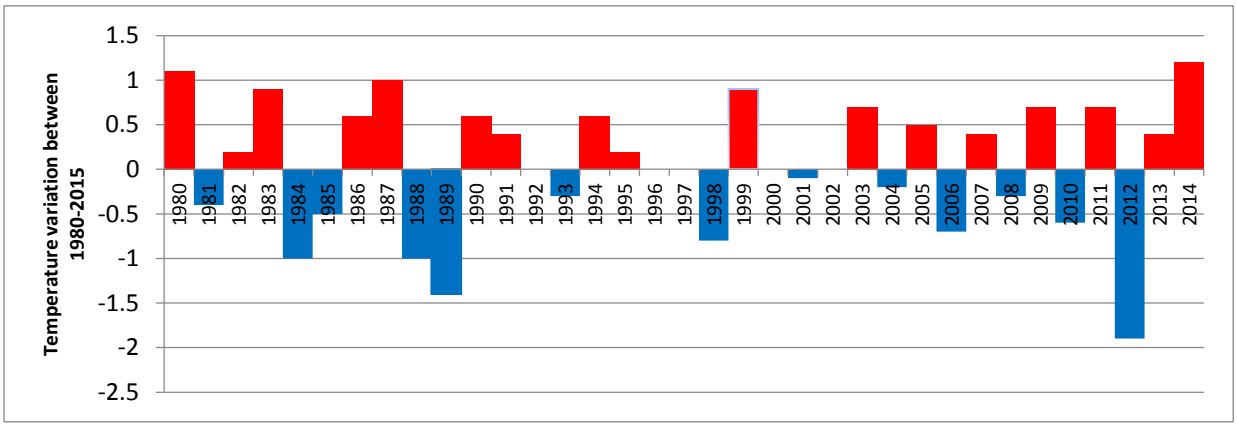

Figure 4: Temperature Variation for the long-term rain season (1980-2015)

4.2.2 Temperature variations based on 10-year period

Table 5 shows the output of chi square analysis and whether there is a statistically significant difference between ten-year groups. The results show that the significance value is 0.001 (i.e., p = .001), which is below 0.05 and, therefore, there is a statistically significant difference in the temperature variations between the 10 year periods under consideration in this study. This shows that the temperature in Kitui County varied over the years (1980-1990, 1991-2001 and 2002-2012). This conforms to the findings from previous studies as well as the responses given by the respondents who participated in the study.

Table 5: Ten (10) year period statistical differences on temperatures

Period Observed	Chi square	df	Sig.
1980-1990	194.541	.2512	.001
1991-2001	251.132	.2921	.000
2002-2012	368.127	.2331	.000

In order to know which of the specific periods differed, Tukey post hoc Multiple Comparisons, tests were conducted which contains the results of the Turkey post hoc test. A Turkey post hoc test revealed that the temperature variation was significantly different between the period {1991-2000 and 2001-2015} (p=0.002); and also between {1980-1990 and 2001-2012} (p=0.003). The results further show that there was no statistically significant difference between the periods {1980-1990 and 1991-2000} (p = .968).

Table 6: Post hoc analysis of the temperature variations

Turkey HSD

(I) period	(J) period	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1980-1990	1991-2000	.0691	.2822	.968	-.627	.765
	2001-2015	-.9659*	.2696	.003	-1.631	-.301
1991-2000	1980-1990	-.0691	.2822	.968	-.765	.627
	2001-2015	-1.0350*	.2766	.002	-1.717	-.353
2001-2015	1980-1990	.9659*	.2696	.003	.301	1.631
	1991-2000	1.0350*	.2766	.002	.353	1.717

*. The mean difference is significant at the 0.05 level.

4.2.3 Rainfall variations in the region

The Figure 5 shows the rainfall patterns in Kitui as shown by the information collected by KMD. The trend in the 5-year moving average is characterized by drops and increase in rainfall over the years (1980-2015). Further; the figure shows that the precipitation in Kitui County has remained below 500mm in the past for the period 2007-2015.

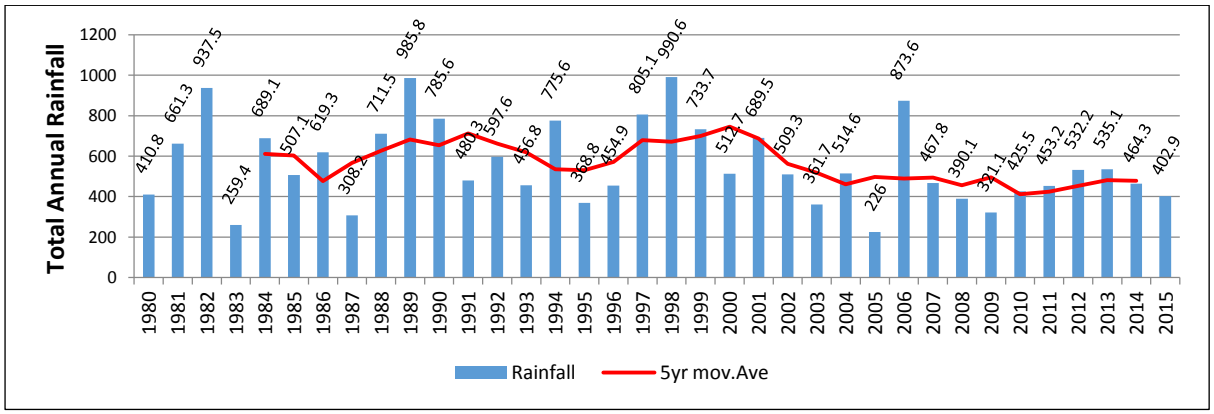

Figure 5: Rainfall variation for the period (1980-2015) with 5 yr. moving average (Source: Data from KMD)

Figure 6 depicts the standardized rainfall deviation within the period under consideration (1980-2015). The blue bars indicate the years with above average rainfall with 1981 showing the highest positive rainfall anomaly whereas the red bars represent years recording rainfall below average with 1982 showing the highest below the long term average. The year 1998 received high rainfall because of El Nino which resulted in comparatively higher rainfall amounts than the other years. The standardized anomalies results obtained show a fluctuating rainfall pattern across the years over Kitui which makes it hard for the farmers to freely forecast rainfall trend for a future season.

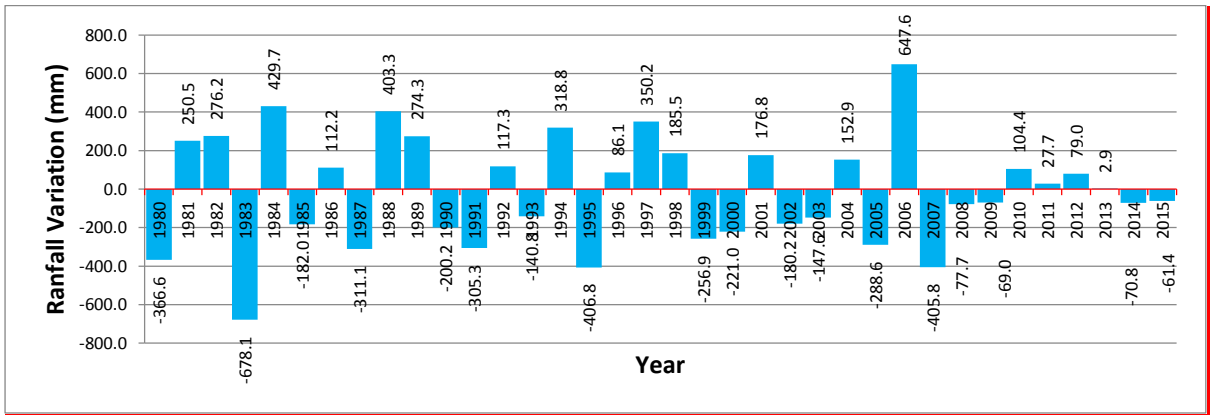

Figure 6: Rainfall Variation for the long-term rain season (1980-2015) MAM

4.2.4 Rainfall Variation among 10 year periods (1980-2015)

Table 7 shows the output of the ANOVA analysis and whether there is a statistically significant difference between ten-year group means of precipitation. The results show that the significance value is 0.175 (i.e., p = .175), which is above 0.05 and, therefore, there was no statistically significant difference in the rainfall variations between the 10 year periods under consideration in this study.

Table 7: ANOVA test on rainfall variations for 10-year period (1980-2015)

Rainfall	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	152373.530	2	76186.765	1.848	.175
Within Groups	1236843.872	30	41228.129		
Total	1389217.402	32			

A Tukey post hoc test also showed that the rainfall variation was not significantly different between the period {1980-1990 and 1991-2000} (p=0.996); and also between {1980-1990 and 2001-2015} (p=0.219). This is confirmed by the p values which are above 0.05.

In conclusion analysis on rainfall and temperature trends in the study area indicate that Kitui County has experienced both rainfall and temperature variability which makes it very unpredictable and unreliable for agriculture. The study results corroborate with Kurukulasuriya *et al*., (2006) who reported that Sub-Saharan Africa (SSA) is predicted to be particularly hard hit by global warming because it already experiences high temperatures and low and high variability of precipitation.

Table 8: Post Hoc analysis on 10-year period for rainfall variations

Tukey HSD

		Mean			95% Confidence Interval	
(I) period	(J) period	Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1980-1990	1991-2000	7.44455	88.71767	.996	-211.2686	226.1577
	2001-2015	144.66788	84.75665	.219	-64.2802	353.6160
1991-2000	1980-1990	-7.44455	88.71767	.996	-226.1577	211.2686
	2001-20125	137.22333	86.93958	.270	-77.1063	351.5530
2001-2015	1980-1990	-144.66788	84.75665	.219	-353.6160	64.2802
	1991-2000	-137.22333	86.93958	.270	-351.5530	77.1063

4.3 Respondents views on Indicators of Climate Variability

The residents of Kitui County who participated in the survey were asked to provide information on indicators of climate variation in the study area which were presented to them on a five point Likert type scale (1 = “Strongly Disagree”; 2= “Disagree”; 3 = “Neutral”; 4 = “Agree”; 5 = “Strongly Agree”). Table 9 shows that majority of the respondents (46.8%) strongly agreed that rainfall patterns in the past ten years before the day of the study had changed. In addition, 11.0% of the respondents were neutral on that indicator. Of the interview respondents, 11 of them disagreed while only 2 of them strongly disagreed. Moreover, the results on Table 9 indicate that almost a half of the respondents (47.3%) strongly agreed that the temperature levels have increased during the day over the past 10 years while 33.8% agreed. The results further show that 15.5% of the respondents were neutral on the hypothesis that the temperature levels had increased while only 7 respondents disagreed and 5 strongly disagreed.

Respondents were asked to express their degree of agreement or disagreement on the rate in which the crops had been withering. The results indicate that majority 47.5% of the respondents strongly agreed that crops had been withering more often over the past 10 years whereas a third of them (33.8%) agreed. Further, the results indicate that 11.6% of the respondents were neutral while only 6.2% were in disagreement. A change in the amount of rainfall received in a period is an indication of climate variation. The results on the table 9 show that 44.8% of the respondents strongly agreed that the amount of rainfall received per rainy season had declined in the past 10 years whereas 38.9% agreed on the same hypothesis.

The results further show that the respondents were in strong agreement with the indicators of climate variation. As indicated by the results, majority of the respondents strongly agreed that there was a shift in the rainfall and temperature patterns in a period of ten years that had passed before the time of the study which leads to the conclusion that climate variation was evident in the past ten years. The

respondents were in agreement that it was impossible to predict when rains would fall in preparation for the planting seasons.

From the analysis, it was noted that households in the study area were aware and had observed variation in climate parameters of rainfall and temperature. These observations confirm the scientific analyses of temperature and rainfall data of the study area that indicates that there has been a decrease in rainfall and increase in temperature levels.

Table 9: Overall rating of the indicators of climate variation

	Climate variation indicator	n	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Rainfall patterns have changed in the past 10 years	355	46.8%	38.6%	11.0%	3.1%	0.6%
2	The temperature levels have increased during the day over the past 10 years	355	47.3%	33.8%	15.5%	2.0%	1.4%
3	Crops have been withering more often over the last 10 years	354	47.5%	34.7%	11.6%	6.2%	0.0%
4	Amount of rainfall received per season has reduced over the past 10 years	355	44.8%	38.9%	12.1%	3.4%	0.8%
5	Rivers have been drying up faster over the past 10 years	355	46.2%	36.6%	14.4%	1.4%	1.4%
6	Number of hot days have increased over the past 10 years	353	45.9%	31.7%	13.0%	9.1%	0.3%
7	Nowadays you can't clearly predict when the rains will fall	355	31.8%	42.3%	21.4%	4.2%	0.3%

Key: 1 = "Strongly Disagree"; 2= "Disagree"; 3 = "Neutral"; 4 = "Agree"; 5 = "Strongly Agree"

4.4 Socio-Economic Factors and Climate Variability Adaptation Techniques

4.4.1 Level of Income and Climate Variability Adaptation Techniques

The study sought to establish whether there were any significant differences on how people with different levels of income adapted to climatic changes. ANOVA test was done and the results are presented on Table 10. There were no statistically significant differences between respondents' income and their extent of adaptation to climatic techniques as determined by one-way ANOVA. This is confirmed by the significance level value (p value) on Table 10 which is greater than 0.05 (p>0.05). This indicates that adaptation of strategies applied to mitigate the climate variability in Kitui West Sub-county was independent of the income levels of the residents.

These findings contradict the initial findings by Mohammed *et al*., (2014) who found out that there is a positive and significant relationship between family income and adoption of adaptive strategies to climate change effects such that farmers with high income are likely to be more knowledgeable and apply climate change adaptive strategies than farmers with lower incomes. However, the study findings agree with Gbeibouo (2009) who argues that household income positively and significantly influences the farmers' knowledge on climate variability adaptation techniques and further adoption of adaptive techniques to climate change. This is based on the assumption that wealthier farmers have more access to information materials and can use their resources to implement new technologies. In addition, people with high levels of income are perceived to be able to possess gadgets that can enable them to receive and disseminate information. This would give them a wide range of information as well as mitigation processes that can be adapted to avert the adverse effect associated with climate change.

Table 10: ANOVA test between level of income and use of climate coping strategies

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.854	2	.427	1.963	.142
Within Groups	76.734	353	.217		

Total	**77.588**	**355**

4.4.2 Age and use of techniques to adapt to climatic changes

The study sought to test whether people with different ages adapted differently to the climatic change in Kitui. ANOVA test was done and the outcome is presented on Table 11. The results show there was no statistically significant differences on how people adapted to climatic changes in Kitui. The lack of association is implied by the p value obtained, which is greater than 0.05. This shows that there were no significant differences in climate coping techniques among various age groups which is an implication that people would adapt to climate variation in a similar way.

Table 11: ANOVA test between the respondents' age and use of climate adaptation strategies

ANOVA

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1.024	2	.512	2.362	.096
Within Groups	76.563	353	.217		
Total	**77.588**	**355**			

4.4.3 Land ownership and adaptation techniques

The respondents were asked the type of land ownership they possessed. Further analysis was performed to determine whether there were statistical differences between type of land ownership and the climate variability adaptation techniques. Table 12 shows the ANOVA test results.

The results show no significant difference (, p=0.500 (p >0.05) between the type of land ownership of the respondents and climate coping techniques applied by the locals. This indicates that type of climate variability techniques applied was independent of the residents of Kitui West sub-county. These climate variability techniques included terraces on-farm water harvesting techniques that should be dug early before onset of rains probably to prevent loose soil particles being easily carried away by the first rains. Famers often using Zai pits as a way of responding to reduced rainfall. The growing of crops such as cassava, millet and pigeon peas since they are more drought resistant than maize in order to minimize crop failure due to climate variation.

In addition, planting drought resistant crops such as those mentioned is one way of adapting to climate variability. It also include change of planting dates to reduce impact of variability in temperature and rainfall and as well as to change planting dates so as to adapt to the changing rainfall patterns.

Table 12: ANOVA test between type of land ownership and use of adaptation strategies

ANOVA

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	.519	3	.173	.790	.500
Within Groups	77.069	352	.219		
Total	**77.588**	**355**			

The results on Table 13 show that the strength of association of the household size and the uptake of the climate adaptation techniques is very low (r= -0.268) which indicates that there is a negative correlation between the variables. The p-value for the correlation between climate variability adaptation techniques and household size is less than the significance level of 0.05, which indicates that the correlation coefficients are significant.

Table 13: Correlation between household size and climate variability adaptation techniques

Correlations

		Extent of adaptation techniques	Total household size
Adaptation techniques	Spearman's Correlation	1	-.268**
	Sig. (2-tailed)		.000
	N	356	346
Total household size	Spearman's	-.268**	1

	Correlation		
	Sig. (2-tailed)	.000	
	N	346	347

4.4.4 Education and Climate Variability Adaptation Techniques

Education is assumed to be an important factor in accessing advanced information on new improved agricultural technologies and increased agricultural productivity (Elahi, *et al.,* 2015). ANOVA test was done to determine whether there were any significant differences on the adaptation strategies used by the households based on different levels of education. The results are shown in Table 14.

The ANOVA test in this regression tested whether there were any differences between level of education and use of climate-variation adaptation strategies. Significance difference would be confirmed by the value of p (significance level). A p value less than 0.05 indicate presence of differences between the variables. From Table 14, p value is given as 0.001which is less than 0.05 ($p<0.05$). This shows that there were significant differences in the adoption of climate variability adaptation techniques among various groups of respondents with different levels of education. This means that people with different levels of education adapted differently to the climatic changes. To identify how differently educational groups adapted to adaptation strategies, a Turkey Post Hoc analysis was conducted.

Table 14: ANOVA test -Education level and use of climate coping strategies

ANOVA

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	3.548	3	1.183	5.622	.001
Within Groups	74.040	352	.210		
Total	**77.588**	**355**			

The Post hoc analysis shows that those people who had tertiary level education and those with low education levels had significant differences ($p<0.05$) in adapting to climatic change. A close examination of the differences indicates that people with tertiary education levels adapted to climatic conditions more compared to those who had no information and those who had primary education. This shows that people with more education adapted more strategies of coping with climatic conditions. These findings concur with Maddison, 2006 who found out that educated farmers are expected to have more knowledge and information about climate variation and the various adaptation technologies that they can use. In addition, knowledge on climate variability adaptation techniques increases with increase in the years of schooling, therefore farmers who have higher education levels are more likely to have knowledge, a greater ability to understand and respond to anticipated climatic changes, have greater access to information and can use various climate variability adaptation techniques on their farms (Mohamed *et al*., 2015). Nkonya *et al.,* (2008) notes that education level affected adoption of improved maize seed crop in Tanzania with each additional year of education increasing the probability of adoption by 5%.

Table 15: Post hoc analysis for Education

Category of education level	Level of education of respondent	**Mean Difference**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	Upper Bound
No formal education	Primary	0.029	0.077	0.983	-0.171	0.228
	Secondary	-0.091	0.082	0.684	-0.302	0.121
	Tertiary	-0.274*	0.097	0.025	-0.524	-0.025
Primary	No formal education	-0.029	0.077	0.983	-0.228	0.171
	Secondary	-0.119	0.058	0.166	-0.268	0.030
	Tertiary	-0.303*	0.077	0.001	-0.502	-0.103
Secondary	No formal education	0.091	0.082	0.684	-0.121	0.302
	Primary	0.119	0.058	0.166	-0.030	0.268
	Tertiary	-0.183	0.082	0.116	-0.395	0.028
Tertiary	No formal	.274*	0.097	0.025	0.025	0.524

education					
Primary	.303*	0.077	0.001	0.103	0.502
Secondary	0.183	0.082	0.116	-0.028	0.395

4.5 Challenges Faced by Farmers in Implementation of Techniques

The respondents provided information on the challenges they faced on implementing climate variability adaptation techniques. The results on Table 16 shows that to a great extent respondents agreed that lack of information on climate variability adaptation techniques makes it difficult to apply the technologies (Mean=4.14) and some of the techniques were expensive to them (Mean= 4.01). However, there was some variability as shown by the standard deviation indicating that some of the respondents disagreed that lack of information was really a challenge as well as the cost of some adaptation techniques. The skewness was negative indicating that despite the variability in responses, most of the participants in the study agreed lack of information on adaptation techniques and the cost of implementing the techniques posed a challenge to the farmers. The results further show that a big number of the respondents agreed that some of the techniques required a lot of manpower (Mean=4.00) and hence the farmers could not make use of it. In addition, majority of respondents agreed that in Kitui west sub-county farmers had limited access to equipment (Mean=3.85). Finally, respondents agreed that small land size made it difficult to diverse crop as an adaptation technique.

Table 16: Challenges that farmers face in adaptation technique

	N	Mean	Std. Dev	Skewness Statistic	Std Er
Lack of information on climate variability adaptation techniques makes it difficult to apply the technologies	347	4.14	1.04	-1.27	0.056
Some techniques require high financial cost that I can't afford	347	4.01	1.35	-1.35	0.072
Some techniques require a lot of labour to use hence I don't apply them	347	4.00	1.09	-0.97	0.058
Limited access to equipment is a major challenge in adoption of climate variability techniques	347	3.85	1.24	-1.15	0.067
Small land size makes it difficult for me to diversify crops as an adaptation technique	347	3.68	1.26	-0.73	0.067

Key: 1 = "Strongly Disagree"; 2= "Disagree"; 3 = "Neutral"; 4 = "Agree"; 5 = "Strongly Agree"

Discussion of the Findings

The first research objective sought to assess variability of climate (rainfall and temperature) in Kitui County in the period 1980 to 2015. The study found out that rainfall in the period 1980-2015 had a fluctuating trend with peaks experienced after a period of ten years. There was a noticeable decrease in amount of rainfall received in the study area and this is further supported by the respondents who asserted that there was a declining trend in rainfall received and increased dry spells. This is in addition to extreme climatic conditions such as El Niño and La Niña. On the other hand, temperatures levels have been increasing from one year to another. This variation has a negative impact on agricultural production in the study area.

The second objective of the study was to assess the influence of household socio-economic factors on farmer's level of knowledge on climate variability adaptation techniques. The study established that there was no significant mean difference with regard to the age and knowledge of the adaptation strategies. The results show that there was no statistically significant difference on the means of the income and awareness of the climate variability adaptation techniques. Further analysis of the data found that the types of land ownership as well as the household size were not related to the strategies adopted to mitigate climate change among the residents in Kitui County. This leads to the rejection of the hypotheses households' Socio-economic factors significantly influence farmers' knowledge level on climate variability adaptation technique used.

The third objective of the study was to investigate the challenges faced by farmers in application of climate variability adaptation techniques. Climate variability has direct impact on agricultural production which poses instability in food security of a given country. In order to counter the adverse

effects, farmers need to adopt various strategies to be in a position to have produce regardless of the change in the climate. The researcher however found that there were challenges which were holding back the farmers in Kitui County from implementing the strategies to mitigate the climate change. These challenges included; Lack of information on climate variability adaptation techniques which made it difficult to apply the technologies, high financial, and a lot of labour requirement to use, limited access to equipment and small land size which made the respondents unable to diversify crops as an adaptation technique.

Conclusion

Climate variability is a reality in Kitui west Sub-County as observed in the varying trends on rainfall and temperatures. Majority of the residents in the study area are farmers and rely on rain fed agriculture for their livelihood therefore, there is urgent need for the households to utilize climate variability adaptation techniques to cushion themselves from the impacts of climate variability.

The study concludes that farmers are faced with various constraints most of which are institutional in nature and can be covered with improving the institutional services in terms of access, use and viability for climate adaptation techniques. Some of the respondents are not well versed with the information required to mitigate climate change in Kitui County and this hinders their ability to implement adaptation techniques. However, most of the respondents know the various strategies to deal with climate change. The level of income, age and the size of the household are not associated with the knowledge levels of the respondents on climate variability adaptation techniques. The level of education plays a role on the strategy a farmer is likely to adopt. Generally, most farmers have limited knowledge on climate variability which can be associated to the socio-economic factors.

Information on climate change mitigation, equipment, cost of implementation of various techniques, labour and land sizes are influential factors that determine farmers' adoption of climate variability techniques. Lack of information on climate variability adaptation techniques was identified as a major challenge to the respondents hence need for more training and availing of information to the farmers.

To increase the knowledge level of climate variability adaptation strategies among small scale farmers in Kitui County; a continuous monitoring of climatic factors (temperature and rainfall) should be done and information disseminated to farmers to enable them prepare adequately for any changes and variations that may occur as well as enable them enhance their resilience. Secondly, sensitization of the County residents on climate change mitigation should be initiated to increase awareness on adverse effects of climate variability.

COMPETING INTEREST

Authors have declared no competing interests exists.

REFERENCES

Amwata, A. D., D, N., & M., N. (2015). Factors Influencing Pastoral and Agropastoral Household Vulnerability to Food Insecurity in the Drylands of Kenya: A Case Study of Kajiado and Makueni Counties. *International Development*.

Anderson, J., & Thampallai, J. (1990). *Soil conservation in developing countries.Agriculture and rural development department.* Washington DC: World Bank.

Anim, F. (1999). A note on the adoption of soil conservation measures in the Nortern Province of South Africa. *Agricultural Economics 50,*, 336-45.

Anley , Y., Bogale, A., & Haile-Gabriel, A. (2007). Adoption decision and use intensity of soil and water conservation measures by smallholder subsistence farmers in Dedo district,Western Ethiopia. *Land degradation and Development*, 18,289-302.

Asfaw, A., & Admassie, A. (2004). The role of education on adoption of chemical fertilizer under diffferent socioeconomic environments in Ethiopia. *Agricultural Economics*, 215-228.

Baethgen, W., & Magrin, G. (1995). Assessing the impacts of winter crop production in Uruguay and Argentina using crop simulations models. (C. Rosenzweig,, L. Allen, L. Harper, S. Hollinger, & J. Jones, Eds.) *American Society of Agronomy*, 207-227.

Bekele, W., & Drake, L. (2003). Soil and water conservation decision behaviour of subsistence farmers in the Eastern Highlands of Ethiopia:A case study of the Hunde Lafto area. *Ecological Economics*, 56,437-51.

Benson, K., James, B., & John, N. (2015). Climate Change adaptation Strategies by Farmers in Yatta District,Kenya. *African Journal of Environment*, 714-718.

Bryant, R., Brklacich, M., Johnstone, R., Smithers, J., Chiotti, Q., & Singh, B. (2000). Adaptation in Canadian Agriculture to Climate Variability and Change. *Climate Change*, 181-201.

Bryman, A. (2008). *Social Research Methods* (3rd ed. ed.). Oxford University Press.

Burch, S. (2010). Transforming Barriers into Enablers of Action on Cliamte Change:Insights from three municipal case studies in British Columbia. *Global Enviromantal Change*, (20) 287-297.

Christianee, S., Marietta, F., & Anna, S. (2016). *Food Security in Sub-Saharan Africa: A fresh look on agricultural mechanisation How adapted financial solutions can make a difference.* Bonn: Deutsches Institut fur Entwicklungspolitik.

Christoph, M. (2009). *Climate Chnage Impact on Sub-Saharan Africa: An overview and Analyss of Scenarios and Models.* Bonn.

Commission, A. U. (2006). *Africa Youth Charter .* African Union Commission.

Cooper, D. R., & Schindler, P. (2006). *Business Research Methods.* New York: McGraw-Hill Irwin.

County Government of Kitui, C. (2014). *County Intergrated Development Plan 2013-2017;Planning for Sustainable socio-economic growth and development.*

Croppenstedt, A., Demeke, M., & Meschi, M. (2003). Technology Adoption in the Presence of Constraints:the Case of Fertilizer Demand in Ethiopia. *Econ*.

Davidson, A., Munir, A., & Tanvir, A. (2001). Dilemas of agricultural extension in Pakistan:Foodd for thought. *Agricultural Research and Extension Network*, 116.

Deresa, T., Hassan, R., Alemu, T., Yesuf, M., & Ringler, C. (2009). Determinants of Farmers' Choice of Adaptation Methods to Climate in the Nile Basin of Ethiopia. *Global Environmental Change*, 248-255.

Deressa, T., Hassan, R., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of Farmers' Choice of Adaptation Methods to ClimateChange in Nile Basin of Ethiopia. *Global Environ. Change*.

DFID, D. (2004). *Climate Change in Africa.Key sheets on climate change and poverty.*

Dolisca, F., Carter, R., McDanie, J., Shannon, D., & Jolly, C. (2006). Factors influencing Farmers' participation in forestry management programs:A case study from Haiti. *Forest Ecology and Management*, 324-31.

Easterling, W., Crosson, P., Rosenberg, N., & McKenny, M. (1993). Agricultural Impacts and Responses to Climate Change in the Missouri-Lowa-Nebraska-Kansas(MINK) region. *Climate Change*, 24:23-61.

Elahi, E., Zhang, L., Abid, M., Altangerel, O., Bakhsh, K., Uyanga, B., . . . Xinru, H. (2015). Impact of Balance of Use of Fertilizers on Wheat Efficiency in Cottton Wheat Croppingg System of Pakistan. *International Journal of Agriculture*.

FAO. (2008). *Climate Change and Food Security:A Framework Document.* ROME: FAO.

FAO. (2010). *Crop and Food Security Assessment Mission to Zimbabwe.* Rome: FAO.

Fussel, H., & Klein, R. (2006). Climate Change Vulnerability Assessments:An Evolution of Conceptual Thinking. *Climate Change*, Vol.75,301-329.

George, I. (2013). *Evaluation of Climate Change Adaptation Stategies and Their Effect on Food Production Among Smallholder Farmers in Bungoma County, Kenya.* Nairobi.

Gladys, V., Otiegi, S., & Mikalitsa, S. (2014). Effect of Climate Change on Small Scale Agricultural Production and Food Security in Kitui District,Kenya. *Agricultural and Natural Resources Sciences*, 34-44.

Government of Kenya. (2005). *Kitui District Strategic Plan 2005-2010 for implementation of National Population Policy for Sustainable Development.* Nairobi: National Coordinating Agency for Population and Development.

Gregory, W. (2016). *Climate Change and Migration: Security.* Oxford University Press.

Hallegatte, S. (2009). Strategies to adapt to an uncertain climate. *Agricultural Economics*, 13; 1-9.

Hansen, J., Sato, M., Ruedy, R., Lo, K., Lea, K., & Medina-Elizade, M. (2006). Global Temperature Change. *Proceedings of the National Academy of Sciences*, (pp. 103,29).

Heinen, J. (1996). Human behaviour,incentives and protected area management.Conservation Biology. *Global Environmental Change*, 19,240-247.

Howden, S. M., Soussana, J., Tubiello, F. N., Chhetri, N., Dunlop, M., & Meinke, H. (2007). Adapting Agriculture to Climate Change Effects. *Academic Sci*.

IPCC. (2001). *Impacts,Adaptation and vulnerability.* Cambridge,UK: Cambridge University Press.

IPCC. (2007). *Impacts,Adaptation and Vulnerability.Contribution of Working Group II to the Fourth Assessment Report of the IPCC.* Cambridge,UK: Cambridge University Press.

Jones, J. (2003). *Agricultural responses to climate variability and climate change.Paper presented at Climate Adaptation.Net Conference Insights and Tools for Adaptation:Learning from Climate Variability.* DC: Washington.

Kabuga, N., & Qaim, M. (2011). Knowledge Assymetries and Technology Adoption:The case of Tissue Culture Bananas in Kenya. *85th Annual Conference of Agricultureal Economics Society Warwick University.* Warwick University.

Kandlinkar, M., & Risbey, J. (2000). Agricultural Impacts of climate change:If adaptation is the answer,what is the question? *Climate Change*, 45:529-539.

Katz, E. (2002). *Innovative Approaches to Financing Extension for Ariculture and Natural Resource Management:Conceptual considerations and analysis of experience.* Lindau,Switzerland.

Kenya, G. o. (2009a). *National Population and Hosusing Census Report.* Nairobi: Kenya National Bureau of Statistics.

kenya, G. o. (2009b). *Food Security Analysis: Kenya Agricultural Sector Development Startegy.* Nairobi: Ministry of Agriculture.

Khisa, G. V., S, B. O., & S., M. M. (2014). Effects of Climate Change on Small Scale Agricultural production and Food Securit in Kitui District, Kenya. *Journal of Agriculture and Natural Resources Sciences*.

Kristjanson, P., Neufeldt, H., Gassner, A., Mango, J., Kyazze, F. B., & Desta, S. (2012). Are food insecure smallholder households making changes in their farming practices?Evidence from East Afrcia. *Food Security*, 4:381-397.

Kurukulasuriya, P., Mendelsohn , R., Hassan, R., Benhin, J., Deressa, T., & Diop, M. (2006). *Will African Agriculture Survive Climate Change?* The World Bank.

Luers, A. L., & Moser, S. C. (2006). *Preparing for the Impacts of climate change.Advancing the debate on adaptation.Report prepared for the California Energy Commission,Public Interest Energy Research Program and the California Environmental Protecction Agency.* California: Sacramento.

Luers, A., & Moser, S. (2006). *Preparing for the Impacts of Climate Change.Advancing the debate on adaptation.Report prepared for the California Energy Commission,Public Interest Energy Research Program and the California Environmental Protection Agency.* California: Sacramento.

Maddison, D. (2006). *The Perception of and adaptation to limate change in Africa.Centre for Environmental Economics and Policy in Africa.* Sout Africa: University of Pretoria.

Manda, J., Alene, A., Gardebroek, C., Kassie, M., & Tembo, G. (2015). Adoption and Impacts of Sustainable Agricultural Practices on Maize Yields and Incomes:Evidence from Rural Zambia. *Journal of Agricultural Economics*.

Melese, G., & Mulinge, M. (2015). *Impacts of Climate Change and Variability on Pastoralist Women in Sub-Saharan Africa.*

Mideksa, T. (2009). Economic and DistributionalImpacts of Climate Change;The case of Ethiopia. *Global Environmental Change*, Vol.20, pp 278-286.

Mohammed , N. U., Wolfgang, B., & Jason, S. E. (2014). Factors Affecting Farmers' Adaptation Stategies to Environmental Degradation and Climate Change Effects: A farm Level Study in Bangladesh. *Climate*.

Moser, S., & Ekstrom, J. (2010). A framework to diagnose barriers to climae change adapatation. *Proceedings of the National Academy of Sciences*, (pp. 107,(22026-22031).

Niang, I., Ruppel, O., Abdrabo, M., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). *Climate Change 2014:Impacts,Adaptation,and Vunerability.Part B:Regional Aspects.Contribution of Working Group II to the fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros et al.,(eds)].* Cambridge: Cambridge University Press.

Nkonya, E., Pender, J., Kaizzi, C., Kato, E., Mugarura, S., Ssali, H., & Muwonge, J. (2008). *Linkages Between Land Management,Land Degradation and poverty in SubSaharan Africa:The Case of Uganda.* Washington,DC: International Food Policy Research Institute.

Nkonya, E., Pender, J., Kato, C., & Mugarura, S. (2005). Policy options for increasing crop productivity and reducing soil nutrient depletion and poverty in Uganda. *IFPRIEPTD.*

Nyong, A., Adesina, F., & Osman, B. (2007). *The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel.* Global Change.

O'Brien, L., & Leinchenko, K. (2000). Double Exposure;Assessing the impacts of climate change within the context of economic globalisation. *Global Environmental Change*, 221-232.

Ochieng, J., L, K., & J, M. (2016). Adapting to Climate Variability and Change in Rural Kenya: Farmer perceptions,strategies and climate trends. *United Naions Sustainabke Development Journal*.

Olivia, S., Sophie, A., Florent, B., & Dim, C. (2016). Climate Change Impacts in Sub-Saharan Africa: From Physical Changes to Their Social Repurcussions. *Springer*.

Oluduro, O., & Lavrysen, L. (2015). *Mitigating the effects of climate change in subsaharan Africa via an effective international legal standard: a case study of Nigeria.*

Ottichilo, W., Kinuthia, J., Ratego, P., & Nasubo, G. (1991). *Waethering the storm: Climate Change and Investment in Kenya.* Nairobi: Stockholm Environment Institute.

Parry, M., Arnell, N., McMichael, T., Nicholls, R., Martens, P., Kovats, S., . . . Rosenzweig, C. (2001). Millions at risk:Defining critical climate change threats and targets. *Global Environmental Change*, 11,181-183.

Polonsky, M., & Waller, D. (2005). *Designing and managing a Research Project: A Business student's Guide.* USA: Sage Publications, .

Pramova, E., Locatelli, B., Djoudi, H., & Somorin, O. A. (2012). Forests and Trres for Social Adaptation to Climate Variability and Change. *WIREs clim change,3*, 581-596.

Reilly, J., & MSchimmeipfenning, D. (1999). Agricultural Impact Assessment;Vulnerability and the scope for adaptation. *Climate Change*, 43:745-788.

Rialp, A., & Rialp, J. (2006). *International Marketing Research:Opportunities and Challenges in The 21st Century.* UK: Emerald Group Publishing.

Rickards, L., S., M. H., & S., M. H. (2012). Transformational Adaptation:agriculture and climate change. *Crop Pasture Sci.*, 63 : 240 – 250 .

Ringler, C. (2010). Climate Change and Hunger:Africa's Smallholder Farmers struggle to Adapt. *Eurochoices*, 9:16-21.

Romani, M. (2003). *The impact of extension services in times of crisis:Cote d.Ivore.* UK: Centre for the study of African Economies,University of Oxford.

Salih, M. (2015). *Local Climate Change and Society.* Abingdon.

Shields, M., Rayuniyar, G., & Goode, P. (1993). A longitudinal analysis of factors influencing increased technology adoption in Swaziland. *Developing Areas*, 27,469-84.

Smith, J., & Lenhart, S. (1996). Climate Change adapation policy options. *Climate Research*, 193-201.

Temesgen, T., Rashid, M., Claudia, R., Tekie, A., & Mahmud, Y. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change*, 248-255.

Thacher, T., & Schelhas, J. (1997). Farmer participation in reforestation incentive programs in Costa Rica. *Agroforestry Systems*, 35,269-89.

Turner, B., Kasperson, R., Matson, P., McCarthy, J., Corell, R., Christensen, L., . . . Polsky, C. (2003). A framework for vulnerability analysis and sustainability. *Science*, 8071-9.

Umesh, A., Pouyan , N., & Sean, A. W. (2015). Cliamte Change and Eastern Africa: A review of Impact on Major Crops. *Food and Energy Security*, 124-125.

Umesh, A., Pouyan, N. A., & Sean, A. W. (2014). Climate Change and Eastern Africa.A review of impact on major crops. *Food and Energy Security*, 110-111.

United Nations, D. o. (2017). *World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP/248. .* New York.

Wegulo, F., Wandahwa, P., Shivuga, W., Tabu, I., & Inoti, S. (2009). *Sustainable Development in Africa,The role of higher educaton:Engaging communities in soil fertility Management for sustainable agricultural production:Case studies from Kakamega and Nakuru districts.* Egerton university,Kenya.

Yamane, T. (1967). *Statistics, An Introductory Analysis.* New York: Harper and Row .

Yu, J., & Wallace, H. (2016). Measuring public agricultural research and extension and estimating their Impacts on Agricultural Productivity: New Isights from U.S Evidence. *Agricultural Economics*.

Ziervogel, G., & Ericksen, P. J. (2010). Adapting to climate change to sustain food security. *Climate Change*, 1:525-540.