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Smallholder Farmers' Perception of the Impacts of Climate Change and Variability on Rain-fed Agricultural Practices in Semi-arid and Sub-humid Regions of Kenya

Jokastah Wanzuu Kalungu [1,2*], Walter Leal Filho[2],David Harris [1]

1. International Crops Research Institute for the Semi-Arid Tropics, P. O. box 39063 - 00623, Nairobi, Kenya
2. Hamburg University of Applied Sciences, Applications of Life Sciences, Lohbruegger Kirchstraße 65, Sector S4 / Room 0.38, 21033 Hamburg, Germany

*Email of corresponding Author: jwanzuu@yahoo.com

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Abstract

Despite the widespread scientific debate concerning the impacts of climate change and variability (CC & V), not much is known about rural farming households' perceptions of these impacts on their agricultural practices. This is especially so in Africa. In order to address this pressing research need, this study documents those perceptions using data from household interviews at four sites in Kenya selected using a temperature analogue approach. A pair of sites was selected with a semi-arid climate (Katumani and Kambi ya Mawe) and a second pair selected with a sub-humid climate (Kabete and Muguga). Within each pair, sites have similar rainfall totals and patterns but have mean annual temperature differences of between 1.5 and 30^0C. Thus the warm sites (Kambi ya Mawe and Kabete) are expected to be representative of the cool sites after global warming. Eight agricultural practices that influence productivity were selected for analysis. Significantly, more farmers at the drier sites reported having perceived more changes in the past 30 years than in the past 10 years in nearly all the selected agricultural practices (χ^2 =147.68, Cramér's V=0.52, p≤0.001 df=7 for 30 years and χ^2 =135.95, Cramér's V=0.187, p≤0.021 df=7 for 10 years). In addition, there was a strong association between the perceived changes and the regions (semi-arid and sub-humid) for the last 30 years (χ^2 =147.68, Cramér's V=0.52, p≤0.001 df=7). The study also showed that there was significant association between the observed changes in agricultural practices and household gender (χ^2 =43.51; p ≤ 0.001). Interestingly, female-headed households observed changes in 62.5% of the selected agricultural practices in all the regions. These perceived changes could be classified as adaptation strategies for the changing climatic conditions. However, successful implementation of farming technologies and methods that are adapted to climate change will require a gendered approach and agro-ecological sensitive strategies for different regions.

Keywords: Agricultural practices, Climate change, Perceived changes, Smallholder farming

1. Introduction

The agriculture sector is the backbone of the economies of most of the developing world, employing about 60 percent of the workforce and contributing an average of 30% gross domestic product (GDP) in sub-Saharan Africa (World Bank 2011). Smallholder farmers are the majority in this sector and form the backbone of agricultural production in Africa (Dixon *et al.* 2004). These smallholder farmers are estimated to be about 36 million across the continent and have an average access to 2 hectares or less of land for their agricultural production (Jaeger 2010; Nagayets 2005). Due to their dominance in the sector, they make a huge and important contribution to the domestic food production, while at the same time producing export crops that earn foreign exchange for these economies (Quan 2011). In Kenya, agriculture as an income-generating sector contributed 21.4% and 24% of the country's GDP in 2010 and 2011 respectively (KPMG Kenya 2012). In addition, smallholder farmers provide 75% of the labour force and 75% of the market output produce (Alila & Atieno 2006). With reliable and consistent climatic conditions, the contribution of smallholder farmers could lead to economic stability of agriculture dependent countries that include most African countries. Unfortunately, agriculture to a large extent is affected by different production factors, both natural and man-made. One such factor is climatic variability which is characterised by extremes of temperatures and rainfall that ultimately bring about frequent floods which often alternate with droughts. Climatic instability negatively affects agricultural productivity leading to substitution through importation or a shift to other sectors. These effects have a direct impact on smallholder farmers, who mostly rely on rain-fed agriculture for their production. This is because smallholder farmers, the main contributors of domestic food, mostly rely solely on rain-fed agriculture and have a limited means of coping with this adverse weather variability (FAO 2012). Productivity variation attributed to these continual climatic changes is also known to cause changes in agricultural production trends. Taking the

example of Kenya, for instance, this is a worsening situation considering that the frequency of the country's famine cycles have reduced from 20 years (1964-1984), to 12 years (1984-1996), to 2 years (2004-2006) and currently to annually (2007/2008/2009/2010/2011/2012) (Mutimba *et al*. 2010). Unfortunately, the economic costs of droughts and flood affect the whole economy. For instance, the 1998- 2000 floods affected 1 million people while the 1998-2000 droughts cost Kenya's economy $4.8 billion, an equivalent of 14% of the country's GDP (Downing *et al.* 2008). In 2009, over 3.5 million Kenyans faced severe food shortages as a result of failed rainfall seasons, which led to intense drought (Asiti 2010). Despite the uncertainties, the smallholder farming community plays a huge role in addressing world poverty and eradication (FAO *et al*. 2012). This is through combating the effects of climate change and variability by adoption new approaches to their agricultural systems. Unfortunately, awareness about climate change in developing countries is still rather low compared to the developed world, with African countries rated as the least aware (Pelham 2009). Research on how to mitigate the impacts of climate change and variability to agricultural productivity is still very limited (Antai *et al.* 2012). In Kenya, studies have shown that awareness of climate change, variability at community level is still low and farmers have been found to have a problem in differentiating between impacts arising from climate change and problems caused by local environmental degradation (Mutimba *et al.* 2010). This lack of farmer awareness influences negatively on their adoption of appropriate adaptive technologies. One approach of alleviating the impacts of climate change is through the adoption of appropriate agricultural practices such as soil and water management, soil fertility management, weed control, pest and disease control amongst others. These practices are mainly used by farmers with the aim of improving their agricultural production through reducing risks associated with farming. For individual farms, agricultural practices begin with tilling the soil for seed establishments, addition of plant nutrients and employing pest control methods (FAO 2012). For example, research has shown that proper land preparation at the initial stage determines the quality and quantity of harvest that the farmer gets at the end of the season (Kamau 2005). However, some of the agricultural practices continue to reduce the natural protection provided by vegetation cover hence subjecting land to severe soil erosive losses (Khisa *et al*. 2002). Thus, adopting good farming practice influences the agricultural production (Branca *et al.* 2010). The Government of Kenya is promoting several farming improvement programmes such as the soil management project with the aim of increasing soil fertility and crop production (Nyangena 2008). This can be attributed to the failure of traditional farming practices to meet Kenya's food requirements for the whole population, necessitating the application of scientific methods that can curb this problem. The impact of climate change and variability on smallholder rain-fed farming has been a subject of debate amongst policymakers and agricultural practitioners. Despite these widespread debates, not much is known about the smallholder farmers perceptions on the impacts of climate change and variability on their agricultural practices. Further still, there has been little focus on how male-headed and female-headed households mitigate impacts brought about by climate change. There is very little documented information on farmer's perceptions on agricultural practices. Studies have emphasized on the perception of farmers on climate change and variability and the relationship between farming practices and food security (Bryan *et al.* 2010; Kristjanson *et al.* 2011; Nyanga *et al.* 2011; Osbahr *et al.* 2011; Rao *et al.* 2011; Silvestri *et al.* 2011). Understanding how farmers perceive climate change and whether there are variances in perception between male and female-headed households could shed light in how productivity at the local level could be enhanced. The perceptions could indicate how farmers manage long-term changes associated with climate change and variability, which can be associated with their adaptive capacity. This will be helpful to researchers and government by enabling them to tap on to existing adjustments farmers are already making order to sustain their productivity. Moreover, the variations in smallholder farmers perceptions on agricultural practices amongst different agro ecological zones and across different timelines is yet to be properly documented in Kenya. Knowing farmers' perceived changes in agricultural practices in smallholder systems will allow researchers, eextension educators and farmers to develop research agendas and adopt practical practices that meet present and future farming needs in specific agro ecological zones. This study sought to fill this gap by assessing the smallholder farmers' perceptions of the impacts of climate change and variability on their agricultural practices. It also seeks to research the gap on limited literature regarding how male- and female-headed households perceive changes in farming practices as a result of variations in climate.

2. Methodology

2.1 Study Sites

The study was carried out in two crop and agro ecological production zones in Kenya: the Kenya Agricultural Research Institute (KARI) Katumani in Machakos County and Kambi ya Mawe in Makueni County both representing the semi-arid regions where water scarcity is perceived as a major challenge to agricultural production. The other two sites are KARI Kabete in Kikuyu District and Muguga in Limuru District representing the sub-humid regions as shown in Figure 1 & 2 and their surrounding farming communities. The choice of these sites tended to bridge the gap between the semi-arid and the sub-humid regions of Kenya in evaluating how

smallholder farmers in this region perceive climatic changes and how the cope with such conditions.

2.2 Sample Size and Household Interview

A stratified random sampling design was adopted for this study with the key strata featuring the number of years in the farming sector and gender. In this sampling, a total of 400 households were targeted while ensuring that 200 (50%) of the interviewees were farmers with over 30 years of farming experience and the other 200 (50%) having farming experience of between 10 years and above but not more than 15 years. The farmers with less than 10 years farming experience were not considered for this study since the data to be collected from this group could not give a clear representation of the required perception and full information about the climatic changes and variability. We also considered a large number of households to ensure that each of the strata gave the required information.

2.3 Data Collection

Data collection involved household interviews held at semi-arid regions (KARI Katumani in Machakos, KARI Kambi ya Mawe in Makueni) and sub-humid regions (KARI Kabete in Kikuyu and KARI Muguga in Limuru). This was via a semi-structured questionnaire on selection of eight common agricultural practices, which have been shown to greatly have an influence on agricultural productivity under varying CC & V conditions was made. These included pest and disease control, water management, planting methods, land preparation, soil fertility management, weed management, knowledge and access to information and crops grown. According to FAO (2012) common agricultural practices refer to both activities at the individual farm level and policies established to set farming standards on a wider scale. Studies indicate that farmers' use their indigenous knowledge to adapt to reduce the negative impacts of climate change (Mertz *et al.* 2009; Ishaya & Abaje 2008; Nzeadibe *et al.* 2012; Anik *et al.* 2012). The study was performed between June to September 2011.

2.4 Data analysis

The data collected included quantitative parameters. The data collected were quantified and inputted as nominal data into the Statistical Package for Social Science (SPSS, Version 19) and Excel analytical packages and the results presented through simple descriptive statistics such as crosstabs.

3. Results and Discussions

3.1 Perceived Changes of Agricultural Practices

From the results, the two regions reported having perceived more changes in the past 30 years than in the past 10 years in nearly all the selected agricultural practices. However, higher percentage of farmers acknowledged having noted significantly more changes at semi-arid than sub-humid regions for the past 30 years (χ^2 =147.68, Cramér's V=0.52, p≤0.001 df=7, χ^2 =135.95, Cramér's V=0.187, p=0.001 df=7). However, the two leading perceived changes in terms of percentages of the households are similar. These are pest and disease control and changes in crops grown by the farmers (Table 1). Despite the difference in climatic conditions, the farmers from the two regions observed increased use of pest and disease control as well as growing of different crops over time to match changing rainfall patterns. According to Boko *et al*. (2007), the emerging of new traits and varieties of crops offers farmers greater flexibility in adapting to climate change. The traits make the varieties tolerance to drought and heat, and early maturation in order to shorten the growing season and reduce farmer's exposure to risk of extreme weather events. Studies have shown that new varieties and traits could lead to less intensive use of other inputs such as fertilizers and pesticides (Mortimore & Adams 2001). Furthermore, earlier studies in Austria, Italy, Greece, Poland, Russia, and Serbia found out that the risk of plant diseases, pest and weed damage to agricultural crops has increased significantly with occurrence of new diseases, pests and weeds associated with direct consequence of climate changes (Jevtić *et al.* 2009). In Kenya, several pigeon pea varieties such as Mbaazi 3, Katumani 60/8, among others have been developed which are resistant to disease and insect attacks as well as tolerant to moisture stress (GoK 2012). Progressively, cultivars suited to different agro ecological zones, in breeding for *Fusarium wilt* has also been developed (GoK 2012).

3.2 Perceived changes in productivity

According to IPCC (2007) increased temperatures is expected to reduce crop yields and increase levels of food insecurity even in the moist tropics with predictions that during the next decade millions of people particularly in developing countries will face major changes in rainfall patterns and temperature variability regimes. This is expected to increase risks in the agricultural sector (Gornall *et al.* 2010). Due to these risks, farmers have been adjusting their farming practices. The agricultural practices also have both direct and indirect influence on crop productivity. The results show that 80% of farmers from all sites perceived more changes in productivity for the past 30 years despite differences in climatical conditions. At this stage, farmers were not required to distinguish the type of changes observed. For instance, 74.4% of farmers in semi-arid region perceived changes in productivity while 57.85% of farmers from sub-humid region perceived changes in productivity for the past 10 years as shown in Figure 3. However, there was difference in percentage for the observed changes in productivity for the last 10 and 30 years. The observed changes for 10 years ranged between 57.85% and 74.4%

and for the last 30 years ranged between 85.95% and 83.7%.

3.3 Trend of the Perceived Changes

Climate change and variability have had negative effects to agricultural production in Kenya. This is because the country experiences major droughts every decade and minor ones every three to four years (Herrero *et al.* 2010). There is also a predicted significant reduction of cropping area because of climate change (Herrero *et al.* 2010). In this study, the trend shows that all farmers (100%) from the two regions perceived that productivity has been decreasing for the past 30 years as shown in Table 2. The reduction of crop production was attributed to either low rainfall or erratic rainfall patterns coupled with extreme temperature conditions. However, 19.8% of farmers from the semi-arid region perceived that there has been an increase in agricultural productivity as compared to 7.8% of the farmers from sub-humid region for the past 10 years (Table 2). Studies show that 45% farmers from Nebraska, USA, who practiced sustainable farming practices showed that their increased yields was an evidence to differentiate them from traditional agricultural producers (Knutson *et al.* 2011). Contrary, farmers have not perceived increase in agricultural productivity in the past 30 years at both regions. The small percentage of farmers who have noticed increase in productivity for the past 10 years concurs with slow but gradual increase of use of agricultural practices for the past 10 years as compared to the past 30 years. These agricultural practices were significantly been observed at the semi-arid and warm regions than in sub-humid and cool regions. According to the study, there was a major improvement in knowledge and access to information. This may be due to easy access to media. Currently, farmers are now well informed with over 116 radio stations in Kenya compared to ten radio stations in 1999 (Majani 2012). This makes it easy for farmers to make informed decisions through listening to weather updates and agricultural production information. There has also been an increase in new varieties of crops grown for the past 10 years in Kenya. Farmers also had stopped growing some crop such as potatoes, yams and bananas due to low yields associated with low rainfall and opted for drought resistant and early maturing varieties. Use of climate change and agricultural information could improve diversification of agricultural production. The trend of the perceived changes for all agricultural practices for the past 30 years is similar for the four sites. These perceived changes could be classified as adaptation strategies for the changing climatic conditions. Adaptation measures have been established to guard farmers against losses due to increasing temperatures and decreasing precipitation (IPCC 2007). According to Hellmuth *et al.* (2007), there is a link between farmers practicing improved farming practices to cope with climate variability. Diversification of options at the household level has been shown to be critical for incomes and food security with the households that are engaged in more cropping and non-agricultural activities tending to be better off than those that are engaged in fewer (Thornton *et al*. 2007). Even though land preparation has a direct effect on crop yields, farmers perceived that it had been on a declining trend. This may be due to a reduction of agricultural land due to sub-division which hinders land mechanization. It can also be attributed to high cost of equipment over the years as well as lack of labour availability. Some of the agricultural practices that are gaining popularity with farmers are water management, weed management, soil fertility management, increase of crops grown by the farmers, weed management as well as use of pest and disease control measures. These agricultural practices have been shown to have a positive impact on productivity. For instance, studies done in Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Niger, Senegal, South Africa and Zambia showed that when temperatures change, farmers tended to plant different varieties, move from farming to non-farming activities, practice increased water conservation as well as use sheltering techniques (World Bank 2007).

3.4 Perceived changes on agricultural practices and gender of households

A gender analysis of the perceived changes on agricultural practices since farming showed that 62.5% of female-headed households observed changes on the selected agricultural practices both in semi-arid and sub-humid regions .There was also a strong association between perceived changes and household gender for the last 30 years (χ^2 =43.51; $p \leq 0.001$). This may be because women get involved in agricultural activities more than men (Odame *et al.* 2002). In farming, women participate in numerous agricultural tasks including mainly cleaning the field during land preparation, transporting inputs to the field, weeding, harvesting, transporting, threshing and storage of the production. In addition, women are also involved in managing home garden crops, poultry raising, feeding, watering and cleaning of livestock and milking is also important (Teklewold 2013). Studies have shown that gender affects the distribution of work among other issues (Welch *et al.,* 2000). According to Saito *et al.* (1994), Kenyan women provide 84 % more family labour than Kenyan men, while Nigerian women provide 33 % more than Nigerian men. In addition, families headed by women tend to be smaller and have fewer farming adults than male-headed households (Saito *et al.* 1994). Interestingly, access to knowledge and information and crops grown were common changes observed by female-headed and male-headed households. In semi-arid region, the two leading observed changes for the female-headed household was pest and disease control (66.3%) and access to knowledge and information (41.6%). For the male-headed households, access to knowledge and information (49.9%) and crops grown (38.9%) were the leading observed changes in agricultural practices (Table 3). In sub-humid region, access to knowledge and information (33.33%) and water management (27.9%)

were the practices were the female-headed households mentioned as having noticed more changes. The observed changes by male-headed households are changes of the crops grown (46.6%) and access to knowledge and information with 41.1% (Table 3).

3.5 Reasons for Differences in Observed Changes in Agricultural Practices

An overwhelming majority of farmers from the semi-arid region perceived that these changes in productivity and the selected agricultural practices are stimulated by changes in climatic conditions in the region. Rainfall and temperature are a major determinant of agricultural production in sub-Saharan Africa (Barrios *et al.* 2008). Some of the impacts of climate change and variability are the reduction of agricultural productivity which causes production instability and poor incomes in areas developing world and especially Africa (FAO 2012). However, majority of the farmers from sub-humid region attributed the perceived changes to both climatic conditions and land factors. Increased temperatures, low or erratic rainfall, crop pests and diseases as well as lack of water were mentioned as the major factors contributing to perceived changes in agricultural practices. Eighty six percent of the farmers at semi-arid region attributed the perceived changes to low or erratic rainfall as compared to 38 % of farmers from sub-humid region as shown in Figure 4. Farmers from semi-arid region usually link low yields to lack of rainfall. Interestingly, 83% of the farmers from semi-arid said the changes were due to lack of water as compared to 72% who cited temperatures. Even though the farmers claimed that even if it rained in the morning hours, at the evening the soil looked dry due hot sun and high temperatures, it was not the leading cause of the perceived changes. This may because it may be difficult for the farmers to make differences in temperature ranges. The farmers in semi-arid had counteracted this by use of mulching, manure and changing to crops that are drought resistant as well as early maturing maize varieties such as KDV2 and KDV4. Despite sorghum and millet being one of the recommended drought resistant crops, farmers insisted of not planting such crops because their children did not enjoy eating them and insisted on maize related meals. In addition, as compared to the last thirty years when children used to help their parents on their farms (mostly scaring birds) before going to school as compared to the current situation where this no longer happens. This has thus contributed to lack of labour to scare birds and this was a hindrance for continual growing of some of these drought resistant crops. Seventy eight percent of farmers linked crop and pest diseases attack as a third course of perceived changes in semi-arid region as compared to 5% from sub-humid. At sub-humid region, low rainfall was also not an impediment in their production. Their main constraint for crop production at this region was small land holdings. While semi-arid region farmers cited increase of high temperatures (72%), the farmers from sub-humid region cited low temperatures (35%) that cause frost to be the cause of low productivity. This condition is linked to increased incidences and occurrences of fungal diseases with most farmers abandoning the growing of such crops as tomato. Further, land is also a major issue with 68% attributing low productivity to uneconomical use of farmland.

4. Conclusion

Households in semi-arid areas are adapting to changing circumstances with climate parameters playing a key role in their decision-making. This study has also shown that there is also a major improvement in knowledge and access to agricultural information among farmers with improved and easy access to media for both semi-arid and sum-humid regions. The households in the arid zone observe positive major changes in their farming practices but their productivity is still low. There is therefore need for further research into the reasons why this is the case. In the sub-humid region, the main concern was small land holding and not so much about climate parameters – there was no significant difference in farming practices across the years. This could mean there is need may be need for farmers in these areas to focus more on intensification. At the same time, measures adopted by farmers to cope with climate change and climate variations in the study sites could be a good starting point for policy makers to consider local adaptive capacity when promoting adaptation strategies. The findings presented in this paper may assist researchers and extension educators in developing research agendas and hopefully perform extension activities that are relevant to farmers' experiences. The successful implementation of farming technologies and methods that are adapted to climate change will require a gendered approach and agro-ecological sensitive strategies for different regions.

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Table 1. Perceived changes in agricultural practices for the past 30 and 10 years at semi-arid and sub-humid regions

Agricultural practices	Semi-arid region (% of households) N=100		Sub-humid region (% of households) N=100	
	10 years	30 years	10 years	30 years
Pest and disease control	47.1	54.6	16.8	22.3
Water management	30.2	34.5	8.8	14.8
Soil fertility management	16.1	23.9	12.4	22.8
Planting method	10.1	14.7	5.2	9.9
Land preparation	9.5	13.2	1.9	3.6
Weed management	2.3	3.4	3.8	6.3
Knowledge and access to information	31.3	33.3	29.1	39
Crops grown	32.5	38.2	27.2	47

Table 1 outlines the perceived changes from the two regions for the past 30 years and 10 years.

Table 2. Trends of Perceived changes in agricultural practices in the past 30 and 10 years in semi-arid and sub-humid regions

Trend of observed changes	Sub-humid region (% of households) N=100		Semi-arid region (% of households) N=100	
	10 years	30 years	10 years	30 years
Productivity				
Increased	7.8	0	19.8	0
Decreased	66.6	100	36.1	100
Fluctuates	25.6	0	44.1	0
Land preparation				
Improvement in preparation	7.5	0.6	6.3	2.1
Poor land preparation	92.5	99.5	93.7	97.9
Planting method				
Improved	92.5	97.5	94.1	99.1
Deteoriated	7.5	2.5	5.9	0.9
Water Management				
Increased/improved	70.2	65	91.3	85
Decreased	29.8	35	8.7	15
Soil fertility management				
Increased	88.8	87.9	90.1	87.1
Decreased	11.2		9.9	12.9
Pest and disease control				
Increased	56.7	68.9	84	78.7
Decreased	43.3	31.2	16	21.3
Weed management				
Increased	94.7	100	96.2	99.4
Decreased	5.3	0.15	3.8	0.6
Knowledge and access to information				
Increased	69.1	8.4	70.8	2.05
Reduced/Unreliable)	30.9	91.6	29.2	97.95
Crops grown				
Increased/changed	73.5	44	73.4	41
Decreased/stopped	26.5	56	26.6	59

Table 2 outlines the trends of perceived changes in agricultural practices in the past 30 and 10 years in semi-arid and sub-humid regions.

Table 3. Perceived agricultural practices by household gender since farming

	Semi-arid region (% of households) N=200		Sub-humid region (% of households) N=200	
Agricultural practices	Male	Female	Male	Female
Pest and disease control	38.0	66.3	20.7	27.1
Crops grown	38.9	35.6	46.6	49
Water management	33.2	37.6	23.1	27.9
Knowledge and access to information	49.9	41.6	41.4	33.3
Soil fertility management	26.6	15.8	21.8	25
Planting method	14.3	15.8	10.5	8.3
Land preparation	11.1	17.8	3.4	4.2
Weed management	33.2	37.6	23.1	27.9

Table 3 outlines the perceived agricultural practices by household gender since farming.

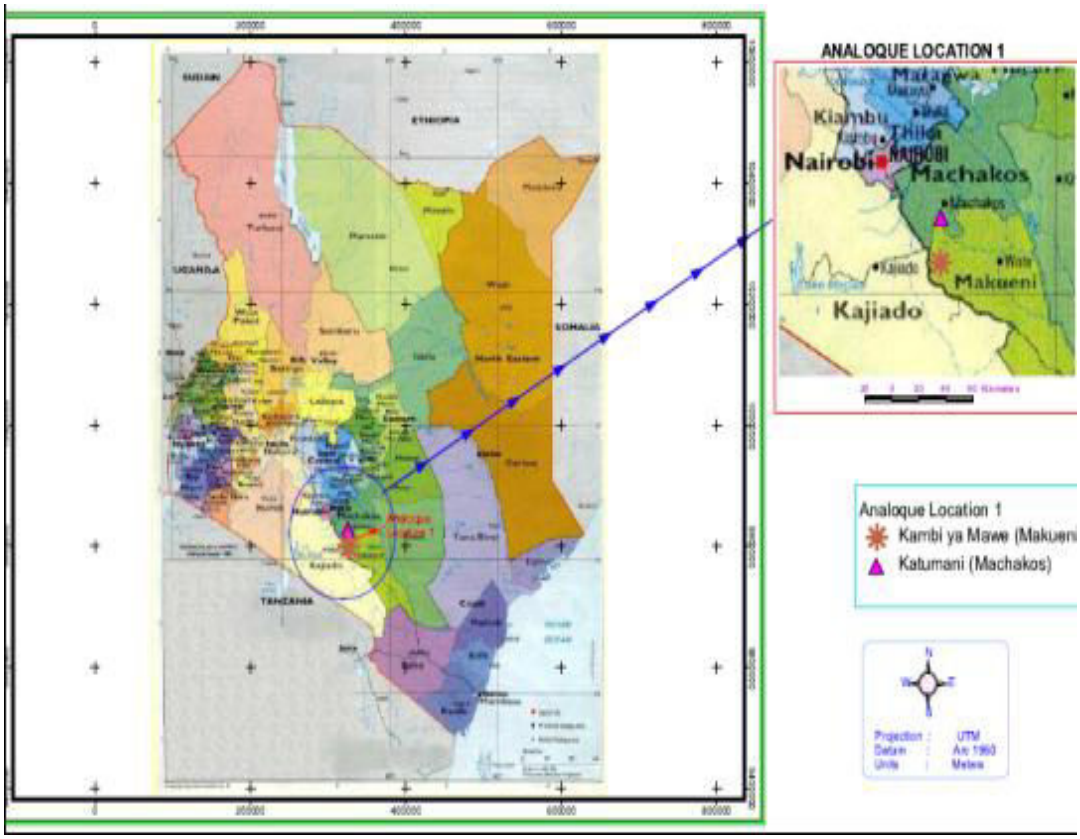

Figure 1. KARI Katumani (Machakos) and Kambi ya Mawe (Makueni)

Figure 1 shows the study sites at semi-arid region

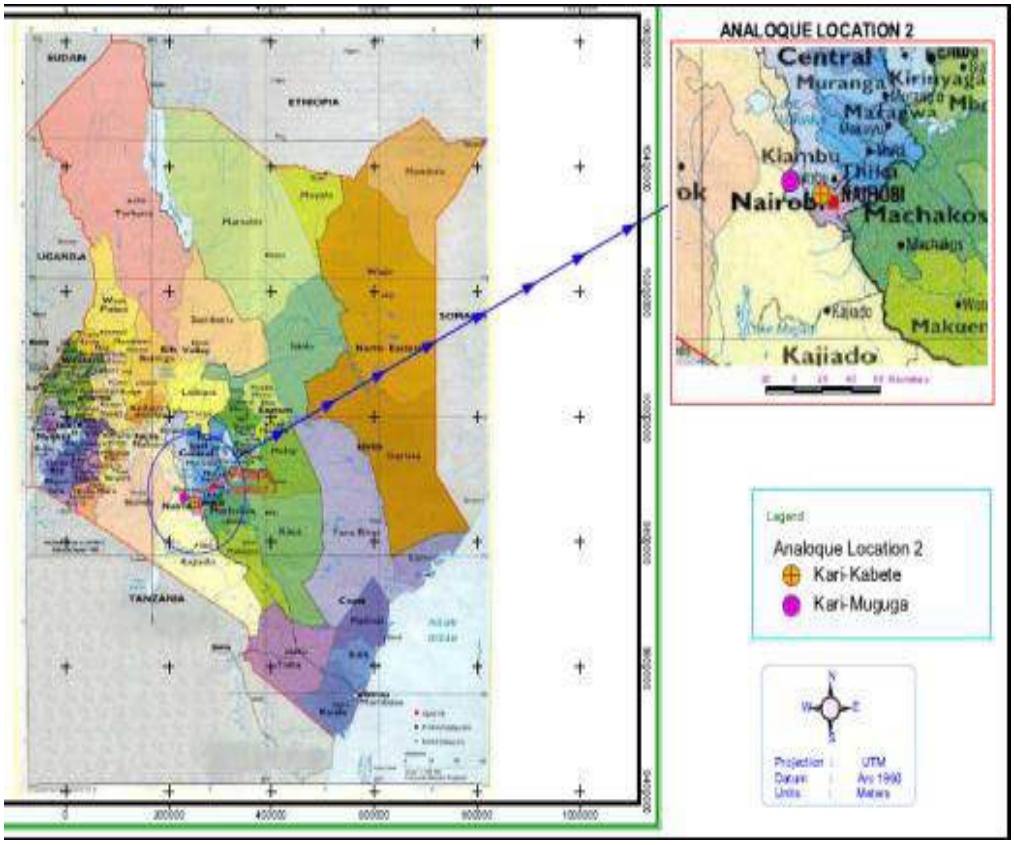

Figure 2. KARI Kabete (Kikuyu) and Muguga (Limuru)

Figure 2 shows the study sites at the sub-humid region

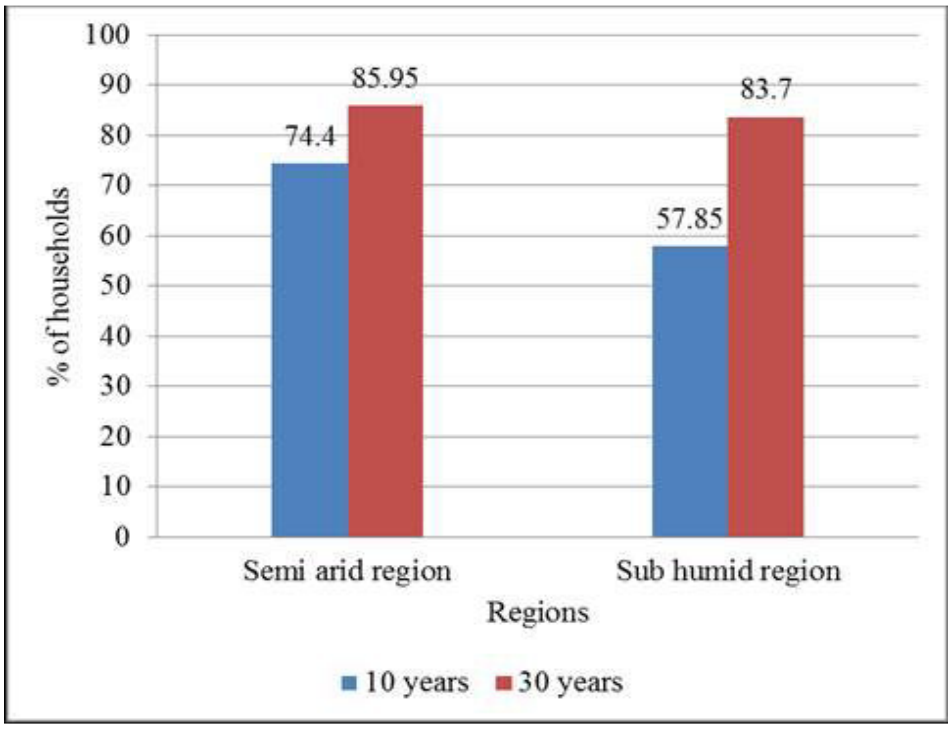

Figure 3. Perceived changes in productivity at the two regions

Figure 3 shows the percentages of households who have observed changes in productivity for the past 30 and 10 years.

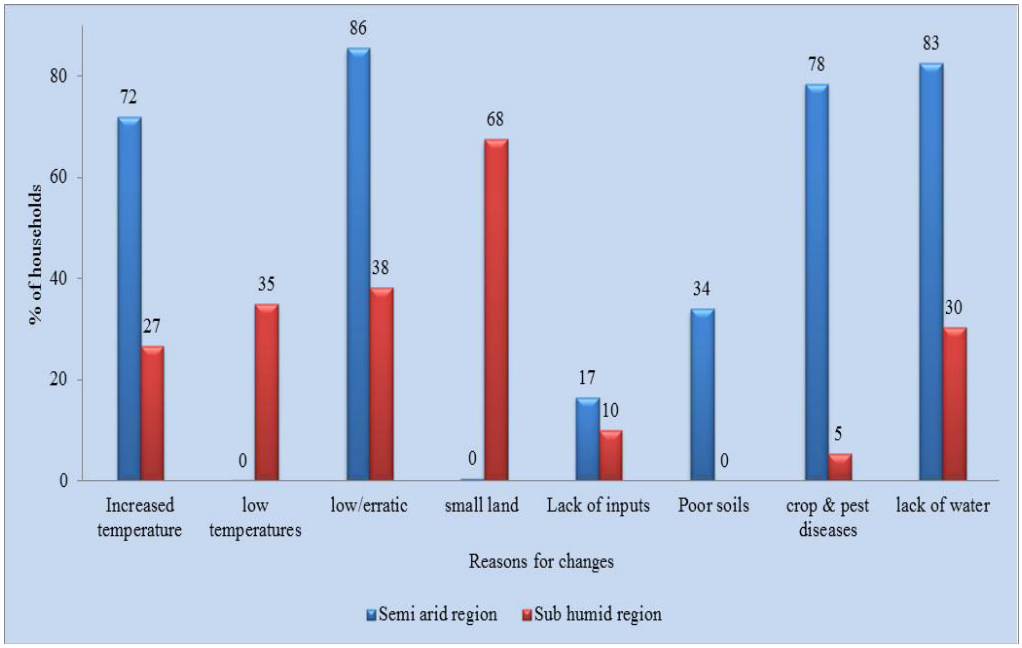

Figure 4. Reasons for differences in observed changes in their agricultural practices

Figure 4 outlines several reasons the households gave as the causes for the observed changes