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Effects of Rainfall Change and Variability on Gender Nutritional Vulnerability: Innovations and Institutional Support for Adaptation by Smallholder Farmers in Kenya

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Abstract:
Rainfall is a major determinant of the agricultural potential of any agro-ecological system. The present global climate trend has resulted in climate hazards that include persistent drought, floods and rainfall variability in both time and space especially in tropical countries. Any change in rainfall is therefore likely to impact either positive or negatively on food security and nutrition. The purpose of this study was to find out how smallholders in Kenya have perceived such changes over a period of thirty years. Five (5) sites in Kenya's major Agro-Ecological Systems, representing varying degrees of vulnerability to impacts of climate change and variability were purposively selected. Data was collected in three phases: Reconnaissance, inception meetings and focus group discussions using semi-structured questionnaires. Rainfall data for at least thirty years was collected from weather stations within the study sites. Mean annual rainfall varied from one study area to another: Kajiado (875mm), Mbeere (870mm), Kilifi (800mm), Bungoma (1500mm) and Nakuru (1250mm). Rainfall amount was found to fluctuate considerably per site, but increasing slowly over time, rainy season decreasing and storms becoming more frequent. Dry periods were also becoming more frequent in all sites. These changes impacted negatively on food security in all agro- ecological systems, regardless of the agricultural potential, with women and children's nutritional status being compromised the most. Government, non-government and private organizations were supporting rainfall change adaptation innovations, with varying levels of effectiveness. The study recommended that adaptation innovations should have a gender focus, and that partnership between supporting institutions will enhance their effectiveness.

Keywords: *Rainfall change, food security, adaptation innovations, gender*

1. Introduction

1.1. Background Information

Climate change and variability, and the occurrence of extreme weather conditions are among the major risk factors affecting agricultural production and food security in Sub-Saharan Africa (SSA) (Badolo KindaSomlanare, 2012). The rainfall pattern in the region is influenced by large-scale inter-seasonal and inter-annual variability resulting in frequent extreme weather events such as droughts, floods, and rainfall variability (Haile, 2005). Projection by IPCC (2012), indicate that in the coming decades with climate change, rainfall variability and extreme climatic events are expected to adversely affect agricultural production and food security. By 2020 yields from Africa's rain-fed farm production could decrease by 50% as a result of changes in climatic conditions (Parry et al. 2007). Rainfall variability has been identified as a common climatic stressor on rural livelihoods across the world in that, any change in its timing and/or fluctuation in amount results in adverse consequences (Warner et al. 2009), and Kenya is not spared. A changing and variable climate therefore, aggravates or becomes a multiplier of climate risks, resulting to declining food production.

Agriculture in Kenya remains the most important and dominant industry that contributes about 27% of the GDP, 20% of employment, 75% of the labor force, and over 50% of revenue from exports (Deloitte & Touche, 2017). Rainfall determines the livelihood pattern of rural and urban dwellers because about 90% of agriculture which provides food for the population is rain-fed and follow precipitation pattern closely (Government of Kenya [GOK], 2009; United Nations Environmental Programme [UNEP], 2008). Smallholder farmers are the key players in Kenyan agriculture and account for 75 percent of the total agricultural output and 70 percent of marketed agricultural produce. Unfortunately, they are highly vulnerable to climatic and environmental hazards, as their options for diversifying resources and income sources are limited (Little & Mcpeak, 2006). Therefore, short-term as well as long-term variations in rainfall patterns have adverse consequences on crop and livestock farming in Kenya. Consequently, availability, stability, access to, and utilization of food needed by the entire population for a healthy life (FAO, 2006) has been compromised.

On the basis of rainfall, Kenya is divided into three main production zones. First is the high rainfall zone, which receives more than 1000 mm of rainfall annually, occupies less than 20 percent of the productive agricultural land, and carries approximately 50 percent of the country's population. Most of the food and cash crops as well as livestock are produced in this zone under semi-intensive and intensive systems. The second production zone is the medium rainfall zone, which receives between 750 mm and 1000 mm of rainfall annually and occupies between 30 and 35 percent of the country's land area. It is home to about 30 percent of the population. Farmers in this zone keep cattle, small livestock and grow drought-tolerant crops. The third production zone consists of the low rainfall areas, which receive 200-750 mm of rainfall annually. It is home to about 20 percent of the population, 80 percent of the country's livestock and 65 percent of the country's wildlife (GOK, 2009). The performance of rain-fed agriculture is variable due to the diverse agro-climatic zones. A large proportion of the country, accounting for more than 80 percent, is semi-arid and arid, with an annual rainfall average of 400 mm and therefore, of low agricultural potential. In these areas, droughts are frequent and crop fails in one out of every three seasons. Most of the area is rangeland suitable for ranching and pastoralism (GOK, 2010).

1.2. Indicators of Rainfall variability

Climate change affects rainfall through rainfall variability which is conditioned by the hydrological cycle, and observable rainfall patterns (Easterling et.al. 2016). Communities across the world report that both the timing and the pattern of seasonal rains are changing dramatically. For example, rainfall is reported to be more erratic, shorter and heavier; even within recognizable seasons, 'unseasonal' events such as heavier rains, drier spells, unusual storms, and dense fogs are increasing. (Devereux & Sabates- Wheeler, 2012). These changes, due to the global Earth system are being experienced locally as changes in water availability, drought, storm surge damage and land loss (Parry et al, 2007). The result is food systems that are highly sensitive to rainfall variability, in the predominant rain-fed agriculture in much of Sub-Saharan Africa (Zewdie, 2014).

1.3. Impacts of Rainfall Variability on Food Security and Nutrition

Climate change is expected to lead to a 50% decline in agricultural output by 2020. This would not only endanger the food security situation but also increase the vulnerability of smallholder farmers in developing countries. The chronic hunger situation is expected to worsen due to declining water resources, frequency, intensity and duration of extreme weather, resulting in a 5-8% increase in arid and semi-arid lands by the 2080s (IPCC,2007). Globally, total rain falling during heavy rainfall events is increasing, and models suggest that there will be more heavy rainfall events as the climate warms (Pall et al., 2011). Impact such as increasing frequency of extreme weather events has put severe pressure on food and nutrition security. Excessive rainfall leads to flooding, which have a significant effect on food availability and access, by destroying crops over wide areas, critical livelihood assets as well as devastating food stores, farming equipment and agricultural land due to sedimentation (Thornton, 2014). Unpredictable rainfall not only affects negatively stability of crop and livestock yields and food supplies but also physical, economic, and social access to food because as agricultural production declines, food prices rise, and purchasing power decreases. Food utilization is also distressed through effects on human health and the spread of malaria and water-borne diseases in geographical areas which were previously not affected (FAO, 2009). The rain-fed agricultural production system is vulnerable to seasonal variability which affects the livelihood outcomes of smallholder farmers who depend on this system of agricultural production (Kasei, 2014).

Many countries are already dealing with climate change impacts resulting from irregular, unpredictable rainfall patterns, increased incidence of storms and prolonged droughts (FAO/WFP (2009). As a result of Rainfall change and variability, food and nutrition insecurity has been experienced over the years and is getting worse. In Kenya, ten million people suffer from chronic food insecurity and poor nutrition, and between two and four million people require emergency food assistance at any given time. In addition, nearly 30% of Kenya's children are classified as undernourished, and micronutrient deficiencies are widespread, (GOK, 2011). However threats posed by rainfall change to food security and nutrition are likely to be spatially variable given the diverse agro-ecological zones and their vulnerability. For food security, the risk is of poorer nutrition or reduced access to food supplies than would be expected under "normal" climate conditions, (FAO, 2009).

The impact of rainfall change is most severe on smallholder farmers because of their limited adaptive capacities due to poverty. These cultivate mainly, using farm labor and the farm provides the main income. Pastoralists, who almost all depend on sale of livestock and livestock products to buy staple foods and other necessities, are included in this category, (Little & Mcpeak, 2006). Increased frequency of extreme weather events put severe pressure on food availability, stability, access, and utilization., Stability of crop and livestock yields and food supplies is negatively affected by variable weather conditions. Access to food is affected negatively by rainfall change because as agricultural production declines, food prices rise, and purchasing power decreases. Last, climate change poses threats to food utilization through effects on human health and the spread of diseases like malaria in geographical areas (Schmidhuber & Tubiello, 2007; FAO, 2009). Prolonged recurrent droughts have become a serious hazard affecting agriculture and water supplies. (Thornton et al. 2014). In semiarid areas, the effect of reduced rainfall is more pronounced and more widespread on food production because droughts can dramatically reduce crop yields and livestock numbers, water resources and productivity. Even on irrigated agriculture, reduction in rainfall in the upper areas of a river course influences the volume and flow of water downstream. (ibid). In rangelands, drought diminishes the primary production of crops and rangeland vegetation and the secondary production of livestock which depends on primary production. Droughts also have severe detrimental impacts on nutrition: In Kenya, children born in drought-prone areas are 50.4% likelier to be stunted and 71.1% likelier to be severely stunted (FAO/WFP, 2012). Moreover, in areas with limited access to clean water and sanitation infrastructure, diarrheal disease is a leading killer, and contributes directly to child mortality and poor food utilization by limiting absorption of nutrients. (FAO/WFP, 2009).

1.4. Gender Nutritional Vulnerability to Rainfall Change and Variability

Food insecurity is on the rise, particularly in sub-Saharan Africa, with an increase of almost 3% from 2014 to 2016 due to extreme climate-related events (FAO/WFP, 2017). Men and women are affected differently by extreme climate-related disasters. In inequitable societies, women are more vulnerable than men due to socially constructed gender roles that affect access to resources (Thornton et al. 2014). Globally, 60 % of malnourished people are women and girls (World Bank, 2012), The physiological needs of pregnant and lactating women make them more susceptible to malnutrition and micronutrient deficiencies. Thus, twice as many women suffer from malnutrition as men, and girls are twice as likely to die from malnutrition as boys, (FAO/WFP, 2017), This is in contrast to their pivotal role in the three components of food security: food availability (production), food access (distribution), and food utilization (Habtezion, 2016). The role of women in ensuring household food security and their dependence on natural resources to do this increases their vulnerability to disasters (Neumayer & Pluemper, 2007). In Sub-Saharan Africa, for instance, women are often acknowledged as owners of crops, but not of land. Women also lack access to adequate and timely climate information. They also have little say and little support in caring for the nutritional needs of themselves or their children (ibid).

Despite strenuous workloads and long workdays, which are ever increasing, women serve food to children, men, and elderly first, eating last despite their own high caloric expenditures. In related circumstances, men receive the largest, best and first share of the meals and that women only eat after the men and children are satisfied (Mwangome et al., 2010). In cases of crop failure due to harsh climatic conditions, cultural factors often make it easier for men to leave their farms in search of employment elsewhere, leaving women behind to struggle to feed their families and make ends meet. In many cases, women have diminished assets and resources to help them plan for and potentially avert the next crisis (World Bank, 2009). Women nutritional status is therefore likely to be most affected in the case of rainfall change and variability.

1.5. Innovations for Adaptation and support institutions

Response to rainfall change and variability involves the development of effective adaptation strategies to minimize the effect and maximize the available opportunities. Adaptation measures can reduce negative impacts of rainfall variability (Ebi et al., 2011). These measures comprise the growing of alternative crops, intercropping different crop varieties, use of drought tolerant seed varieties, employing irrigation and water harvesting techniques, crop insurance, early warning and monitoring systems, construction of dykes, human migration, changing planting dates, diversifying in and out of agriculture, reliance on safety nets and social networks, and sale of assets. One constraint to adaptation is that some of the adaptation technologies such as irrigation systems and dykes require huge capital expenditures. Institutions at the national level, local government and organizations play a key role in enabling such adaptation. Increases in rainfall variability, which are largely unpredictable in the short and long term, have made institutions to be more proactive and responsive (Kabubo- Mariara & Karanja, 2007).

2. Statement of the Problem

Adaptation is the process of adjusting to climate change, both experienced and expected, on a long-term basis (International Relief Information Network [IRIN], 2012). Emerging strategies have more institutional support from Non-Government, Government and private organizations compared to the indigenous ones. Some of the emerging strategies include famine relief services, provision of water, irrigation schemes, food diversification projects and nutrient supplementation. However, there seems to be a mismatch between this support and extent to which food security and nutrition has been achieved by gender, in the context of rainfall variability. There is therefore, need to understand how smallholder farmers and pastoralists perceive rainfall variability, how it has affected the household members' food security and nutritional status, institutional support for adaptation strategies and how smallholders evaluate the support institutions. Such information can inform policy on institutional role in climate change adaptation, and the design and implementation of climate-smart technologies that can respond effectively to rainfall change and variability risk.

3. Purpose of the Study

The purpose of the study was to identify smallholders' perception of rainfall change and variability and impacts on food security, gender vulnerability to food insecurity, adaptation innovations and perceived effectiveness of institutional support for adaptation in Kenya. The ensuing knowledge can inform policy on gender sensitive climate adaptation strategies. The knowledge can also be useful in generating recommendations on appropriate and effective approaches for institutional support for climate change strategies.

3.1. Objectives of the Study

The study aimed at investigating:

- Smallholder farmers' perception of rainfall change and variability
- Impact on food security across seasons
- Perceived gender nutritional vulnerability to food insecurity
- Adaptation innovations for rainfall variability currently used by smallholder farmers
- Institutional support for common adaptation innovations and effectiveness

4. Methodology

4.1. Research Design

The study used participatory action research design, which employed both qualitative and quantitative measures. The design was appropriate because part of the study involved explaining of human behavior that is better understood qualitatively and more so, when self-reporting is preferred as in the case of this study. This involved focus group discussions of key stakeholders in food security.

4.2. Study Sites

Five (5) sites in Kenya's major Agro-Ecological Systems, representing varying degrees of vulnerability to impacts of rainfall change and variability were purposively selected. These regions include:

- Arid and semi-arid pastoral Livestock area of Kajiado County in Southern Kenya
- Semi-arid areas (in transition) of Mbeere Sub-county in South Eastern Kenya
- Lake Basin High potential food crop/livestock area of Bungoma County in Western Kenya
- Highland Medium potential crop/livestock area of Nakuru County in Central Rift Valley
- Coastal lowland crop/livestock area of Kilifi County.

The study also involved a reconnaissance survey of the agricultural potential of the purposively selected agro ecological systems.

The study sites that represent different agro-ecological zones in Kenya are shown in Figure 1.

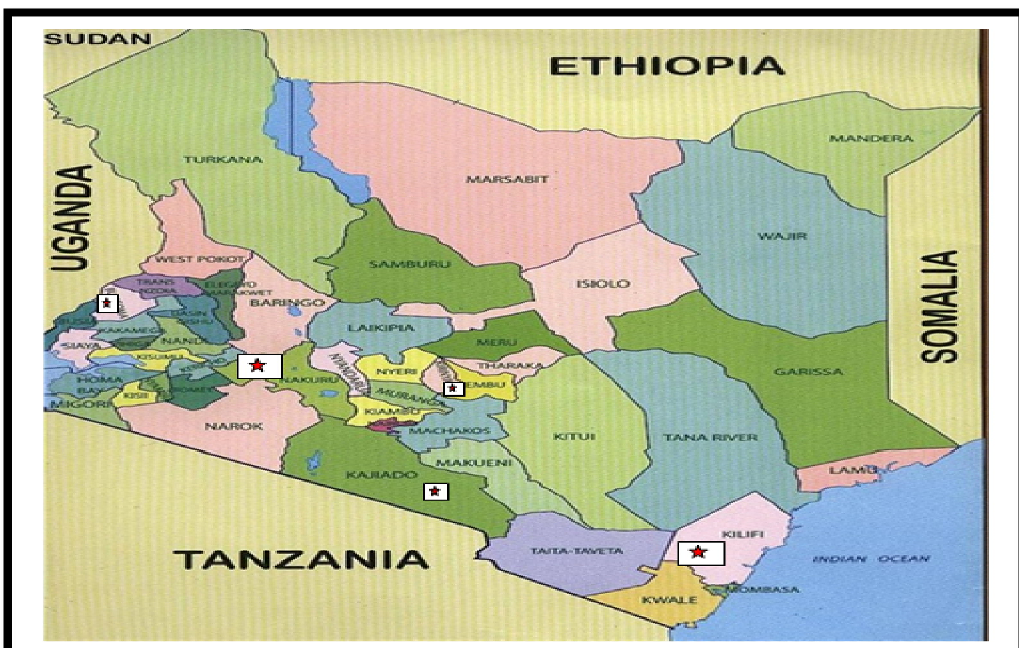

Figure 1: Map of Kenya Showing Location of Study Sites (Adapted From Arids Lands Newsletter, 2013)

4.2. Population and Sampling

The target population was all smallholder farmers and pastoralists in the five selected counties of Kenya, representative of the major agro- pastoral systems, and whose vulnerability to climate change varies from one county to another. Purposive sampling was used to ensure that only relevant actors in food security were selected. This involved consultations with the sub-county Agricultural officers, who provided a list of 30 key players in food security in each of the selected counties. These key players were selected to participate in the focus group discussions.

4.3. Data Collection and Analysis

The researchers collected information pertaining agro-ecological potential of each study site. and, rainfall information for a period of about thirty years, from documents in relevant government offices. The information also included adaptation innovations for food security by farmers.

Three workshops for focus group discussions were organized for each site between July 2011 and June 2013.Three workshops enabled the research team to obtain collective views and perceptions on rainfall change and variability, food security, gender vulnerability to food insecurity, and support available from institutions, for adaptation innovations. Checklists containing various themes of rainfall change and variability, food security and nutrition, adaptation innovations and supporting institutions, were used to guide the discussions. Responses were recorded and content analysis done in order to group each response under the relevant theme. The findings were further discussed with the participants in order to validate their responses. The information was then revised to ensure accuracy and representativeness of the data under each sub-theme of the study.

In measuring of rainfall change and variability, both qualitative and quantitative methods were applied. The former is, based on information given by respondents related to extreme events. Although this information may be useful, it could be biased due to faulty perceptions and experiences. The latter approach, involved quantitative measures of rainfall over time, provided by meteorological data available from different weather stations. This approach is reliable because it takes into account rainfall time series information that is updated and matched with each locality of the study.

5. Results and Discussion

5.1. Perceived Indicators of Rainfall Change and Variability by Study Sites

Results in Table 1 indicate that frequent droughts, shifts in the rainfall seasons and unpredictable rainfall patterns were rainfall change and variability indicators common to all the sites. Unlike other study sites, Nakuru was the only site with less flood occurrences while Mbeere shared all its rainfall change indicators with at least one other site. Bungoma reported increased frost occurrences and destructive lightning. This observation may be due to the county's location on the slopes and foothill of Mount Elgon, and nearness to Lake Victoria, while reduced flood occurrences in Nakuru may be attributed to the relatively high sandy and porous volcanic soils that easily allow water to percolate.

	Study Sites				
Perceived Indicator	Kajiado	Nakuru	Bungoma	Mbeere	Kilifi
Frequent droughts	x	x	x	x	x
More dry spells within a rainy season	x		x		
Shortened rainy /growing season	x			x	x
Rainfall season shift	x	x	x	x	x
Decreasing rainfall amounts	x	x	x		
Poor spatial rainfall distribution			x		
Increase in Hailstorms		x	x		
Increase in wind storms			x	x	x
Decrease in wind storm		x			
Destructive lightning more frequent			x		
Unpredictable rainfall pattern	x	x	x	x	x
Frost occurrences has increased			x		
Floods occurrences increased	x		x	x	x
Less flood occurrences		x			

Table 1: Perceived Indicators of Rainfall Change and Variability by Study Sites
(x - Presence of indicator)

Respondents had clear awareness about changes in rainfall pattern and the indicators relevant to their locality. This is contrary to the findings of the first comprehensive study of global opinions on climate change of 2007-2008 by Loiserowitz, (2007), which showed that, industrialized countries were more aware than developing countries.

5.2. Rainfall Data Analysis

The parameters analysed were mean annual rainfall amounts, and mean monthly rainfall amounts. The results showed that in most of the sites, the rainfall change exhibit a marked increase over time (Figures 2-11).

5.2.1. Kilifi area

Rainfall data for Kilifi at the coast was available from Mtwapa research station for the years between 1980 and 2008. The rainfall data showed almost no increase over time (Figure 2).

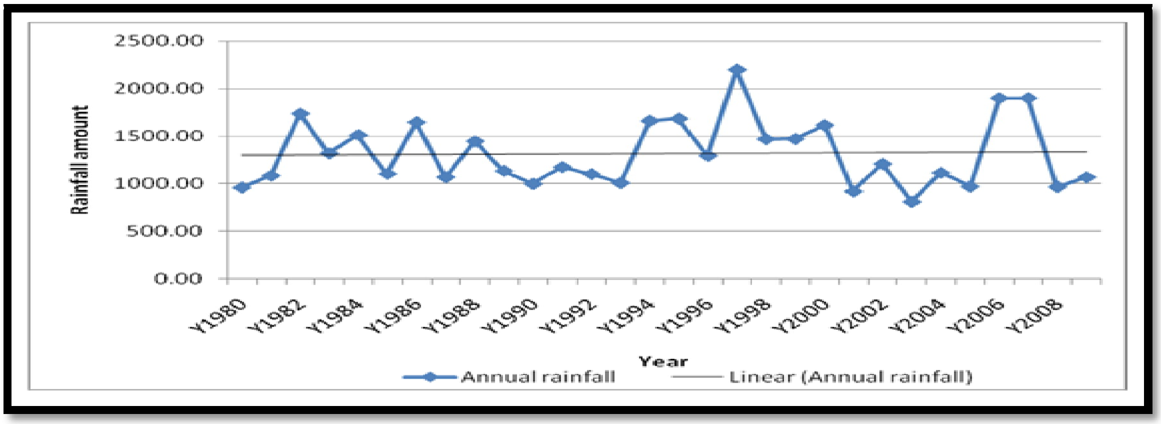

Figure 2: Mean Annual Rainfall Amount between 1980 And 2008 In Kilifi (Mtwapa Station)

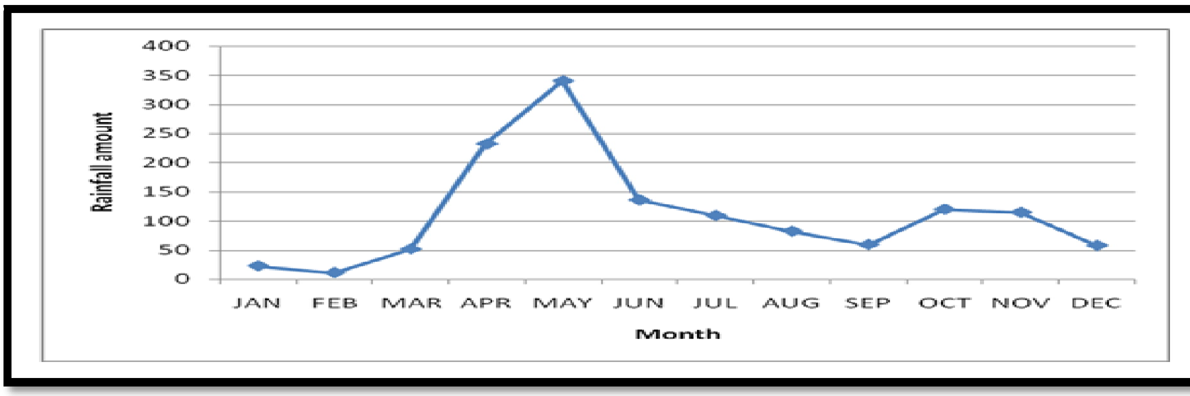

Figure 3: Mean Monthly Rainfall Amount at Mtwapa Between 1980 and 2008

The rainfall for Kilifi was bimodal although the April-May peak was much higher than the October- November one.

5.2.2. Kajiado

The data for Kajiado was obtained from Isinya Maasai Rural Training Centre (MRTC) station from the year 1962 to 2010. The data depicted an increasing trend over time (Figure 4). Mean monthly rainfall depicted two distinct peaks. and the difference not very large (Figure5).

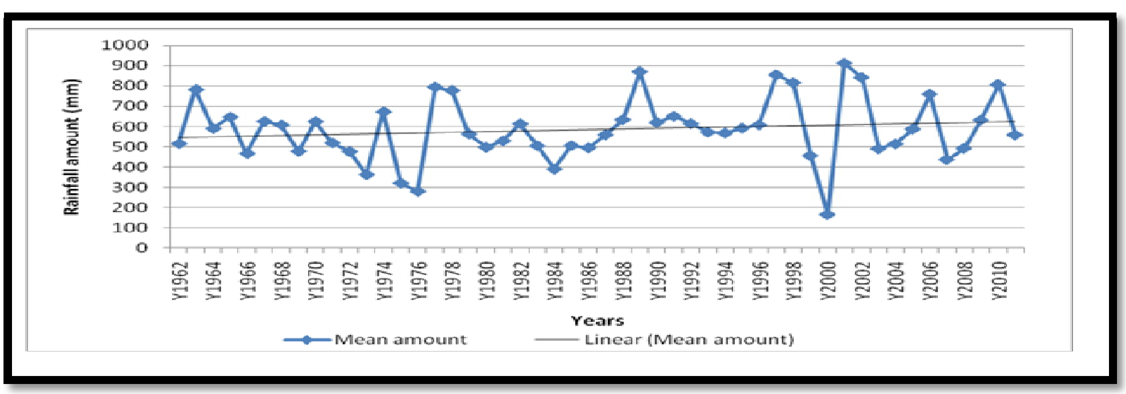

Figure 4: Annual Rainfall For Kajiado Since 1962

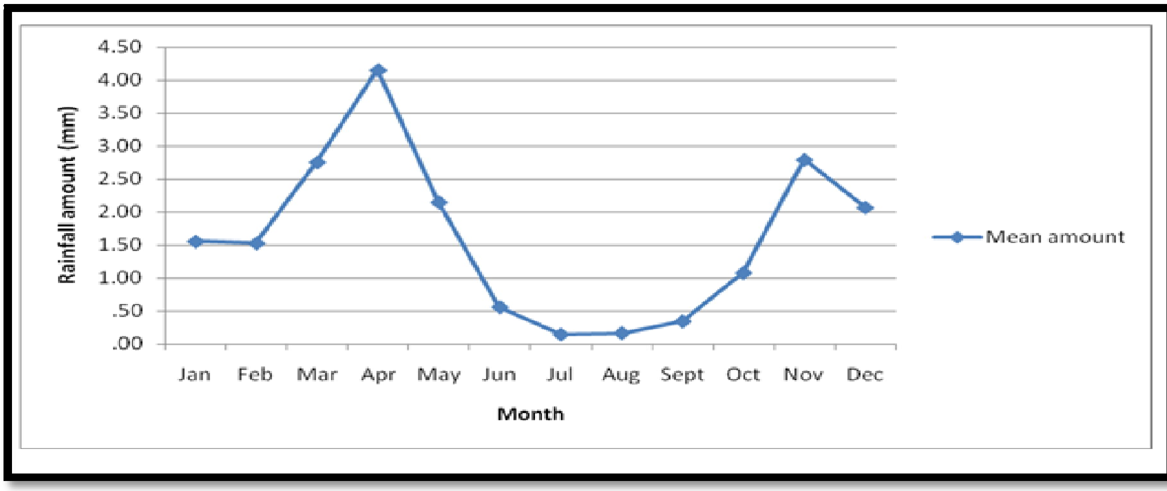

Figure 5: Mean Monthly Rainfall Amount For Kajiado Between 1962 And 2010

5.2.3. Mbeere

The data for Mbeere site was obtained from Kiritiri weather station. The available data covered the shortest period among of all the sites, a period of only ten years (2001 to 2010). The annual rainfall portrayed an upward trend (Figure 6).

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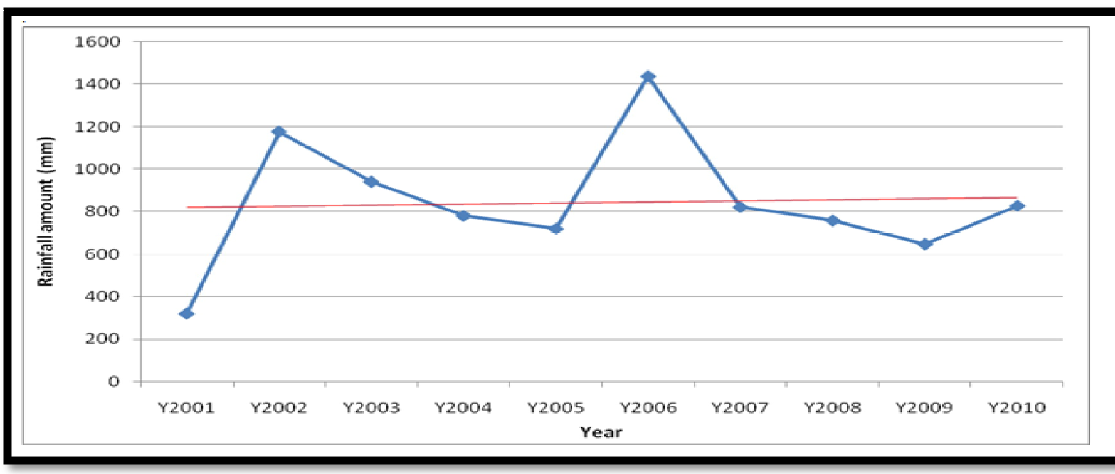

Figure 6: Annual Rainfall Amount In Mbeere

The main rainfall peak was received at a time different from the other sites. This was in the month of November when the other sites had the lower peak (Figure 7).

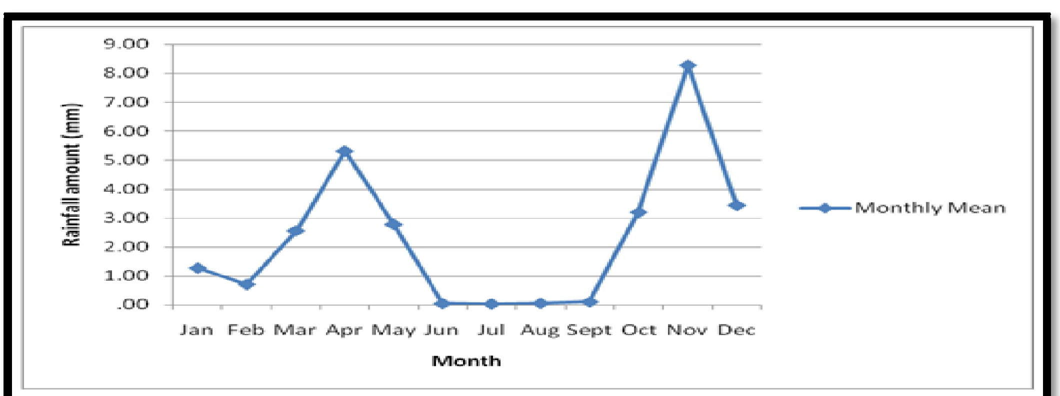

Figure 7: Mean Monthly Rainfall Amounts For Mbeere

5.2.4. Nakuru

The data for Nakuru site was taken from Menengai station. The data covered the longest period of all the sites, from the year 1927 to 2011. The general trend in rainfall was an increase with time (Figure 8). The annual rainfall at this site was tri-modal with the highest peak in April, the second largest in August and the lowest in November. (Figure 9)

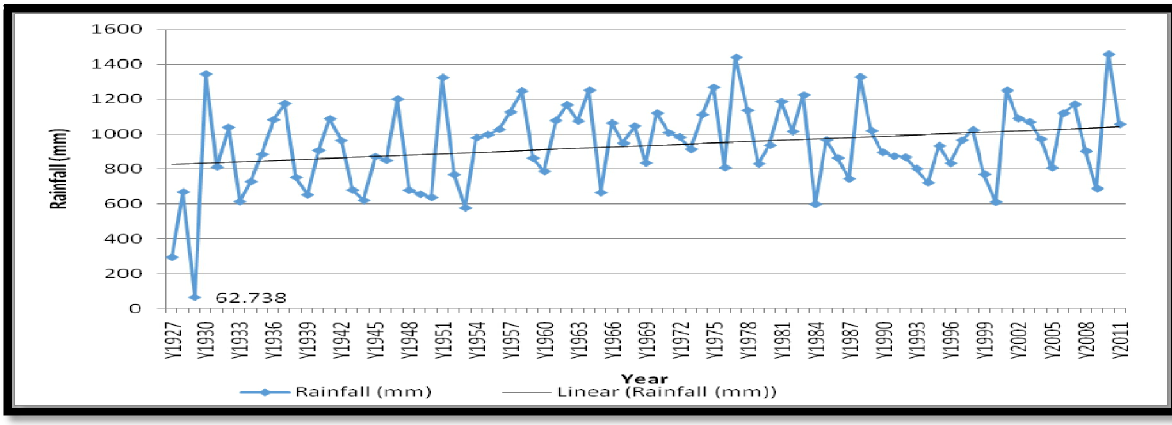

Figure 8: Annual Rainfall Amount Since 1927 At Nakuru

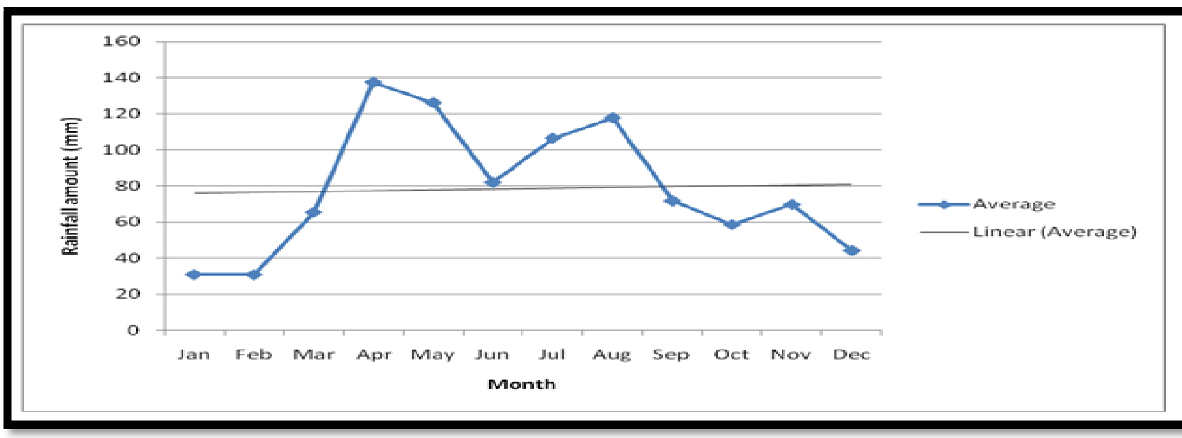

Figure 9: Mean Monthly Rainfall Amount In Nakuru Since 1927

5.2.5. Bungoma

The rainfall data from Bungoma site was obtained from Nzoia Sugar station and covered the years 1983 to 2011. However, data for three years (2003, 2004 and 2005), was not available.

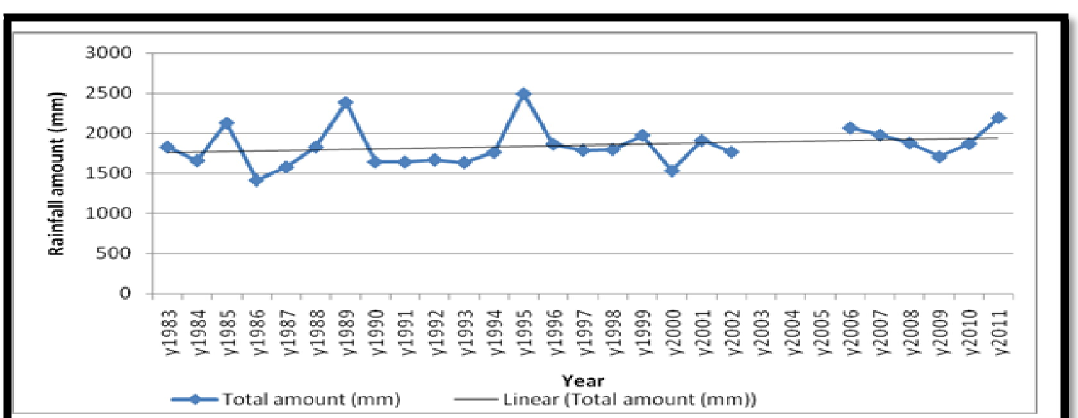

Figure 10: Annual Rainfall Amount in Bungoma between 1983 and 2011 (Nzoia Sugar Station)

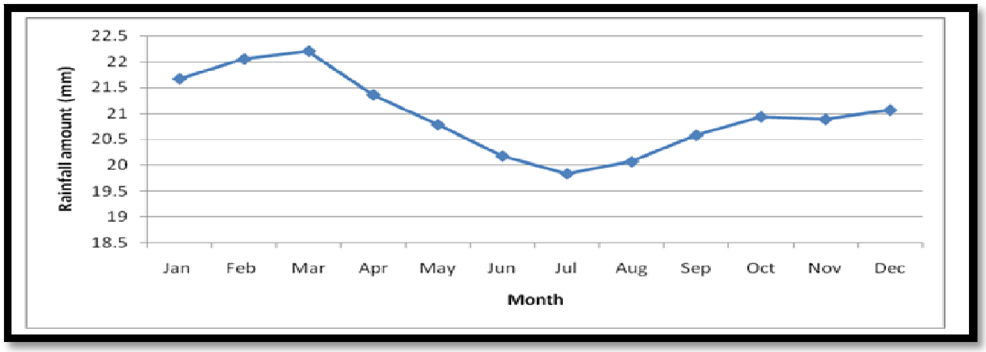

Figure 11: Mean Monthly Rainfall Amount In Bungoma Between 1983-2011

The rainfall data for Bungoma did not show much fluctuation although generally, it increased every 4-5 years. The rainfall received was high with about 1500mm being the minimum over the period when data was available. The trend showed an increase over time (Figure 10). The annual pattern was bimodal although the difference between peaks was small (Figure 11 above).

The rainfall changes have shown different trends between the sites of study areas. These have consequences on food security dynamics within different regions of Kenya. From the figures 2 -11, it is evident that rainfall is generally slightly increasing, contrary to the perceptions of the smallholder farmers that rainfall is decreasing (Table 1). This perception may be influenced by the relatively frequent droughts and resultant crop failures and death of livestock, which from the face value may mean reduced rainfall amounts. These findings confirm the assertion by Easterling et al. (2016) that extreme events are more observable than normal events. Mtwapa in Kilifi at the coast does not show any change in rainfall annual amounts over the years, may be due to the influence of land and sea breezes.

The annual totals indicated that, the wet years are usually followed by dry periods. The effects of these fluctuations in annual rainfall distribution on food security are intensified by changes on the onset, cessation, and duration of rainfall. Most of the study sites receive Long Rain Season (LRS) in March-May period which is showing a shift towards coming late and ceasing earlier. This rain water fluctuation cause has adverse effects on food production, access, stability and utilization, with dire consequences on human nutrition.

5.3. Effect of Rainfall Change and Variability on Food Security

<u>5.3.1. Availability and Affordability of Carbohydrate Cereals and Root Crops</u>

The effect was assessed by the extent to which food was available and affordable during normal and abnormal seasons, experienced in the sites. Maize (*Zea mays*) was available in all the sites in both favorable and unfavorable seasons, and cheap in Bungoma, Nakuru and Mbeere but expensive in Kilifi and Kajiado. The wide and all seasons' availability are explained by the importance the Kenya government places on Maize as the key determinant to Kenya's food security. In case of projected shortage, the government imports or at least facilitates importation to offset any deficit. Millet (*Pennisetum typohides*) and sorghum (*Sorghum vulgare*) were available in Nakuru and

	Food Affordability (x-Cheap; xx-Expensive; xxx-Very expensive) in Study Sites' Markets														
Foods Available in all Seasons	Kajiado			Bungoma			Nakuru			Kilifi			Mbeere		
Cereals															
Maize		xx		x			x				xx		x		
Sorghum	x							xx					x		
Millet								xx					x		
Wheat products			xxx		xx			xx				xxx		xx	
Rice		xx			xx			xx			xx			xx	
Root Crops															
Sweet potatoes				x				xx						xx	
Cassava		xx		x					xxx		xx		x		
Arrowroots		xx			xx			xx						xx	
Irish potatoes		xx			xx		x					xxx			xx

Table 2: All Seasons Food Availability and Affordability of Carbohydrates and Root Crops

Mbeere, and cheap in the latter site where the two cereals are the main staples and thrive under low rainfall conditions. Nakuru being cosmopolitan attract commodities in its market from neighboring Provinces of Rift Valley, Central, and Western, where the two cereals are also grown. Wheat products and rice were also available and perceived as either expensive or very expensive. For the former, the all season's availability is governed by both local production and imports, and ease of processing. Cereals can be processed or added value to a form that is easy to prepare and consumed by all categories of people. For wheat, rice and maize, commercial processing, social acceptability and ease of transportation facilitate distribution and marketing.

Table 2 also indicates that Irish potatoes (*Ipomea batatas*) and cassava (*Manihot esculentum*) were the most widely available root crops although the former was very expensive in Mbeere sub-county and Kilifi county, while the latter was cheap in Bungoma and Mbeere. In these areas, production of Irish potato is not tenable due to unfavorable agro-climatic conditions. However, Irish potato was cheap in Nakuru, which is one of the main potato producers. In Kenya, potatoes are almost entirely sold in the local market and there is increasing demand for the tuber. The demand is linked to changes in consumption habits, mainly in urban centers, where potato chips have become a more popular part of the diet. Chips processing has also become the major form of value addition for potatoes. Apart from households, restaurants, hotels and canteens are major potato consumers. Cassava was locally grown and generally affordable which may be indicative of its potential to alleviate food insecurity.

5.3.2. Availability and Affordability of Protein Foods (Legumes, Pulses, Nuts and Meat)

In Table 3, beans (*Phaseolus vulgaris*) and cowpeas (*Vigna unguiculata*) were available in all the sites, and perceived as cheap in Bungoma, Nakuru and Mbeere, but expensive in Kajiado and Kilifi, hence affordable. The two legumes have a wider ecological adaptability compared to other legumes. Kilifi area had only two legumes available, which indicates a narrow variety- a threat to food security. In Nakuru, most of the legumes available (except beans) were perceived as very expensive. Green grams (*Vigna radiata*), cowpeas, ground nuts (*Arachis hypogea*) and pigeon peas (*Cajanus cajan*) are not locally produced and their availability may have been influenced by the multi-ethnic population with diverse food preferences compared to other sites where one ethnic group comprise the larger population.

	Food Affordability (x-Cheap**; xx-**Expensive**; xxx-**Very expensive) **in Study Sites' Markets**														
Proteins Available in all Seasons	Kajiado			Bungoma			Nakuru			Kilifi			Mbeere		
Legumes, Pulses & Nuts															
Beans		xx		x			x				xx		x		
Green Grams		xx			xx				xxx					xx	
Cow Peas		xx			xx				xxx		xx		x		
Ground Nuts		xx			xx				xxx						
Pigeon peas			xx						xxx					xx	
Livestock Food Products															
Milk		xx			xx			xx						xx	
Meat (Beef, Mutton, Goat)		xx				xxx			xxx			xxx		xx	
Fish				x					xxx		xx			xx	
Eggs					xx			xx				xxx		xx	
Poultry					xx			xx					x		

Table 3: All Seasons Availability of Legumes, Pulses, Nuts and Meat

From Table 3, Meat from cow, goat and sheep was perceived to be very expensive in all seasons, in Nakuru, Bungoma and Kilifi. These sites practice more of crop farming than livestock. On the other hand, Kajiado is primarily a livestock keeping agro-ecological zone although meat was perceived to be expensive. The Maasai of Kajiado being livestock herders, (cattle, sheep and goats) rely mainly on cow, goat and sheep products (such as the animal's meat, milk and blood). This may have created the demand for meat products, making them expensive. Kajiado being livestock herders, (cattle, sheep and goats) rely mainly on cow, goat and sheep products (such as animals' meat, milk and blood). This may have created the demand for meat products, making them expensive. Fish and poultry were the only two animal proteins, perceived to be cheap in Bungoma and Mbeere respectively. For fish it is obtained from Lake Victoria which may not be as sensitive to climate change as other larger livestock. Mbeere being a semi-arid area produces a lot of goat meat, which the community prefers to poultry. Hence, low demand for poultry and consequently cheap.

5.3.3. All Seasons Availability and Affordability of Vegetables and Fruits in the Local Markets

Kenya has many indigenous (both wild and domesticated) and exotic edible vegetables. However, Table 4 below reveals that, a relatively few of those grown are available in all seasons. It may be that domestication of these is low due to agricultural systems emphasizing production of exotic varieties. Alternatively, the quantities produced may be too little to reach the local market or lack of methods to preserve them. Vegetables are generally more sensitive moisture stress and therefore in a dry season, their production is not assured. Similar findings were reported by (Ekesa et al. (2009) in a study on "Accessibility and Consumption of Indigenous fruits and vegetables in western Kenya"; and Fukushima et al. (2010) in Kilifi. Cowpea leaves and tomatoes were the most widely available and generally affordable vegetables. For Cowpea, (Vigna unguiculata), its availability and popularity can be attributed to its ability to withstand harsh conditions and its yield is always higher than that of the other indigenous vegetables. In addition, its leaves and seeds are used as food. The availability of tomatoes in all counties across seasons is accounted for by the wide adoption of greenhouse farming technology, triggered by unpredictable weather conditions, population growth and reduced land acreage (GOK, 2011). The crop also does well during the dry season under irrigation. Although Mbeere does not produce cabbage, there is constant supply from the neighboring Kirinyaga County, where the vegetable is produced under irrigation throughout the year.

Table 4 further shows that Mango (*Mangifera indica*) was the most widely available and cheap fruit in the main producing sites of Mbeere and Kilifi. Domestication and breeding of the mango in Kenya and the resultant

	Food Affordability (x-Cheap; xx-Expensive; xx-Very expensive) in Study Sites Markets														
Vegetables Available in all Seasons	Kajiado			Bungoma			Nakuru			Kilifi			Mbeere		
Kale			xxx				x				xx				xxx
Cabbages							x					xxx			xxx
Cowpea leaves		xx		x							xx		x		
Indigenous vegetables			xxx	x					xxx		xx				
Carrots							x								
Tomatoes	x				xx			xx			xx				xxx
Spinach								xx			xx				
Pumpkin leaves									xxx		xx		x		
Onions	x						x				xx				xxx
Fruits															
Citrus			xxx					xx		x					x
Pawpaw		xx		x				xx							
Avocado	x				xx		x								xxx
Mango		xx			xx			xx		x			x		
Bananas		xx		x					xxx					xx	

Table 4: All Seasons Availability and Affordability of Vegetables and Fruits in the Local Markets

Promotion of its production by the Ministry of Agriculture Livestock Development and Fisheries has led into extension and increase in production beyond the traditional production areas and season.

5.4. Gender Vulnerability to Rainfall Change and Variability Induced Food Insecurity

Tables 2 (a, b and c) show that foods that constitute a balanced were available in all the sites. Most were perceived as either expensive or very expensive. This implies that in a country like Kenya where about half the population subsist on less than one US dollar a day, some of the foods especially animal products, fruits and vegetables may be beyond the reach of many, resulting into malnutrition. Black et al. (2008), found that climate change has an effect on food prices and in addition to its effect on food access, high food prices can also influence people to consume less preferred quality of food items and allocate food only to certain household members. However, vulnerability to food insecurity differed across gender categories as shown on Table 5.

	Nutritional Status (Wn); Well nourished (Mn); Moderately nourished; (Mal); Malnourished														
Site/ Gender	Kajiado			Bungoma			Nakuru			Kilifi			Mbeere		
	Wn	Mn	Mal	Wn	Mn	Mal	Wn	Mn	Mal	Wn	Mn	Mal	Wn	Mn	Mal
Men		x		x			x				x			x	
Women			x		x		x				x			x	
Boys		x		x			x				x			x	
Girls		x			x		x				x			x	
Children under 5 years			x			x		x				x			x

Table 5: Perceived Gender Vulnerability to Food Insecurity by Household Members during Adverse

In all sites, nutrition status of men and boys was better than women's and children under 5 years. This may be an indication of gender bias in sharing of food, especially in times of scarcity, where males are preferred to females and children. Besides, mothers in times food shortage tend to share out food to the rest of family members, leaving little for themselves. This can be attributed to their natural instinct of caring, while children lack the capacity to fend for themselves.

	Study Site				
Innovations	**Kajiado**	**Bungoma**	**Nakuru**	**Kilifi**	**Mbeere**
Water supply by Tankers	x				
Water harvesting and conservation	x	x	x	x	x
Value addition and preservation of cereals, root crops, fruits and vegetables (Drying, milling. Baked and fried products)	x	x	x	x	x
Food supplements for children under 5 years and expectant mothers to mitigate effects of nutritional deficiencies/ food shortage	x			x	x
Small scale drip and furrow irrigation	x		x	x	x
Famine relief	x				x
School feeding programme- by NGOs	x				x
Food shops and food hawking increasing	x	x	x	x	x
Improving grain storage facilities –Metal Silos and barns at farm level	x		x		x
Planting high yielding crop varieties	x	x	x	x	x
Planting drought tolerant crop varieties	x	x	x	x	x
Livestock upgrading for higher yields	x				x
Agroforestry	x	x	x	x	x
Green house farming	x	x	x		

Table 6: Innovations for Adapting Food Security to Rainfall Change and Variability
(X - Presence of Innovation)

Common innovations included expansion of value addition to a wider variety of food crops, planting high yielding and drought tolerant crop varieties, water harvesting and conservation, increase in food shops and food hawking, and agroforestry. Other innovations that are on the rise and reported in three to four sites include Greenhouse farming (that may or may not be combined with drip irrigation), use of metal silos for grain storage, small scale irrigation of vegetable crops, and food supplements for expectant mothers and children under five years. The latter is mainly a program by the ministry of health for the semi-arid areas of Kajiado, Kilifi and Mbeere. Counties of Kajiado and Mbeere had the widest range of innovations than the other study sites. The two sites fall under Arid and Semi-Arid Lands (ASALs) that have a higher vulnerability to rainfall change and variability, and receive more attention from government and Non-Governmental Organizations than the other sites.

In regard to support given to smallholder farmers for adapting food security to rainfall change and variability, institutions supporting various innovations were identified and effectiveness of their support evaluated by the support recipients. Evaluation was based on timeliness of the support, availability and quality of extension services provided, capacity building, and sustainability of the innovation. The findings are presented in Table 7.

Innovation	Supporting Institution (NGOs-Non-Governmental Organizations; CBOs-Community-Based Organizations MoALDF-Ministry of Agriculture, livestock Development and Fisheries)	Effectiveness
Water harvesting and conservation	Ministry of Water & Irrigation (MOWI) NGOs CBOS	Very Effective Not Effective Not Effective
Value addition and preservation of cereals, root crops, fruits and vegetables	MOALDF Ministry of Health NGOs	Effective Not Effective Not Effective
Food shops and food hawking	County Government. (Issue licenses for food Trade and follow up on operations) Public Health Dept.	Very Effective Fairy Effective
Planting high yielding crop varieties	MoALDF) Research Institutions. NGOs	Very Effective Fairly Effective Not Effective
Planting drought tolerant crop varieties	MoALDF NGOs	Very Effective Fairly Effective
Agroforestry	MoALDF CBOs NGOs	Effective Fairly Effective Fairly Effective

Table 7: Common Adaptive Innovations for Food Security and Effectiveness of Supporting Institutions

Government institutions were reported to be more effective than NGOs and CBOs. This finding may be due to the well devolved and trained government personnel that are found almost in every part of the country, and are accessible by the smallholder farmers.

6. Conclusion and Recommendations

Smallholder farmers were aware of rainfall change and its indicators in Kenya. Some indicators were common while others were specific to the Agro-Ecological System. One of the common perceptions of the smallholder farmers was that the rainfall has decreased but the rainfall figures and trends revealed the contrary. In fact, upward trend in amounts was exhibited in all the sites except Kilifi at the Kenyan coast, which means that, what may be critical is the onset, cessation and duration. They also appreciated that rainfall change has resulted into decreased agricultural production leading to reduced food availability and affordability. However, every site had food categories required to meet dietary needs for an active and healthy life but the general perception was that, most of the foods were expensive. Rainfall change and variability therefore, affects food security in all Agro- ecological systems of Kenya, regardless of the agricultural potential. Consequently, some level malnourishment was reported for all gender categories, with women and children being the more affected during adverse seasons. In an attempt to adapt to rainfall, change and variability, smallholder farmers in all the sites had adopted innovations for food security, with support from Government, Non-Government and Community Organizations. Some of the innovations were common to all sites while others were specific. Evaluation of support given showed that Government institutions were more effective than NGOs and CBOs, perhaps due to the former's well devolved and trained personnel.

The researchers therefore make the following recommendations:

- The Ministry of Agriculture, livestock Development and Fisheries in Kenya should come up with a policy framework for integrating Climate change information into the extension messages for the farmers. This would ensure that smallholder farmers can get factual information on indicators of climatic change, to avoid faulty perceptions that may lead to adoption of inappropriate adaptation innovations and strategies.
- Climate Change content should be mainstreamed in the school curricula at all levels of education in in Kenya in order to sensitize majority of the Kenyan citizens on all aspects of climate change, including information on adaptation technology and options for optimal adaptation.
- Collaborative approach in supporting smallholder farmers should be encouraged to promote synergy and complementarity between support institutions. This is because Government institutions have the personnel and technical capacity but may lack materials, NGOs may have material support but lack adequate personnel while CBOs

have more access and control of local natural resources that can be factored in climate change education, such as land for farm demonstrations.
- Adaptation innovations for food security should have a gender focus paying attention to those that can provide women with incomes to buy food during adverse seasons.

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