



Effects of Perceived Climate Variability on Provisioning Ecosystem Services Among Agro-Pastoral Systems of Laikipia West Sub-County, Kenya

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Abstract— The impact of climate variability on societies around the world is increasingly evident. A vast majority of communities in Eastern Africa depend on agro-pastoralism for their livelihoods, however climate variability threatens a vast majority of these communities. Kenya is one of the most vulnerable countries and economic sectors and livelihoods frequently experience the manifestations of the problem. Climate variability therefore, affects provision of ecosystem services, especially those depended on by agro-pastoral farmers in Laikipia West sub-County, Kenya. This study determined the effects of perceived climate variability on provisioning ecosystem services (food supply/crop yield, livestock production and water availability) and response strategies employed by agro-pastoral farmers to mitigate risks in semi-arid Laikipia West sub-County. Both quantitative and qualitative data were collected through a combination of methods including: systematic quadrat sampling, key informant interviews and structured questionnaires. The study used multistage stratified sampling to select respondents and study sites; purposive sampling to select the study divisions and proportionate random sampling to select household respondents from each of the selected divisions. Four hundred agro-pastoral farmer households were selected through stratified random sampling. Statistical Package for Social Scientists (SPSS) was used for data analysis. To make reliable inferences from the data, all statistical tests were verified at $\alpha = 0.05$ level of significance. Results from the study indicated that majority of the agro-pastoral farmers kept poultry and browsers as they required less feed for survival during these times of climate variability and change. Climate variability resulted to decline in food supply/crop yields and water availability had increased yet its amount declined. Climate variability negatively affected provisioning ecosystem services like food supply/crop yield and water availability. The study recommends that, there is need for sensitization on climate smart agricultural practices that would increase food supply and enhance water availability sustainably.

Key Words—Perceived Climate Variability, Provisioning Ecosystem Services, Agro-Pastoral Systems, Laikipia West Sub-County, Kenya.

1. INTRODUCTION

Climate variability and change is one of the biggest issues facing the world today (IPCC, 2014). The impacts of climate change are prominent worldwide (Schneider *et al.*, 2007), especially in drylands, where its adverse effects are exacerbated by high rainfall variability (Kgosikoma & Batisane, 2014) coupled with high temperatures. Agriculture is the main economic activity that supports the livelihoods of millions of people in Africa. However, key challenges have emerged in the agricultural sector, climate variability being the most important. Drought in Africa affect about 220

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million people every year and it is projected that by 2020, yields from rain-fed crops could fall by 50 percent in some countries; while net revenues loss from crops could fall by 90 percent (Huho & Kosonei, 2014). The rampant food crisis that has been recently experienced in most sub-Saharan Africa countries are reminders of the continuing vulnerability of the region to the impacts of climate variability. This has been largely attributed to weak institutional capacity, limited engagement in environmental and adaptation issues, and a lack of validation of local knowledge (Adepoju & Obayelu, 2013). Climate variability has the potential to affect development activities in Africa and can hinder the achievement of the Sustainable Development Goal (SDG) no. 13, which focuses on enhancing the resilience of climate change. According to IPCC 5th assessment report, serious impacts are being felt by the poorest people majority of whom are marginalized and living developing countries (IPCC, 2014). This has led to

most of the population becoming vulnerable to effects of climate variability, which has negative effects on agricultural productivity, thus the need for farmers to devise adaptation measures (Omoyo *et al.*, 2015). Africa's population is projected to double by 2050, and globally food production will need to double in order to meet the needs of increasing urban populations. Urbanization is occurring rapidly in Sub-Saharan Africa (SSA), but large rural populations are projected for at least another generation (Lamboll *et al.*, 2011). In SSA, greater areas of land are typically under range lands and are marginal for agriculture. Such areas are increasingly unable to support rainfed agriculture, due to challenges posed by climate variability and increasing population. Climate variability is perceived as being the greatest threat to agricultural production and food security in sub-Saharan countries, it is emerging as a major threat on agriculture, food security and livelihood of millions of people in many places of the world (IPCC, 2014). Agro-pastoralists in most of the sub-Saharan countries have been affected by climate variability. This is caused by a combination of factors, which include widespread poverty, dependence on natural resources, over-dependence on rain-fed agriculture, conflicts and negligence from the government (Atinkut & Mebrat, 2016).

The arid and semiarid lands (ASALs) require special attention, if Kenya is to achieve sustainable economic development. The ASALs cover more than 80% of the country's land mass and support about 70% of the national livestock population, valued at an estimated Kshs 70 billion (World Bank, 2010). ASALs are largely used for agro-pastoralism, extensive livestock production and wildlife. The economic impact of these climate change threats to the country is enormous. In the ASALs, there is widespread livestock and crop production risks due to climate variability. In many dry regions, most agricultural households are pastoralists or agro-pastoralists who struggle to cope with current climate variability. The vulnerability of agro-pastoral and pastoral communities to climate change is higher due to the synergic effect of inadequate health services, inadequate infrastructure, poverty, lack of alternative means of income, inadequate public awareness of disease risks and illiteracy (Chinasho *et al.*, 2017). These areas have naturally high reliance on climate-sensitive activities coupled by marginalization, regular food crises and water scarcity, rapid population growth and limited economic and institutional capacity to cope with climate variability (Diallo *et al.*, 2014).

Climate variability has come with a variety of changes in rainfall levels and distribution wind speeds, extreme weather events like droughts and floods (Van Dorland *et al.*, 2011), and emerging pests and diseases (African Technology Policy Studies Network [ATPS], 2013). Mitigating and adapting to climate variability requires collective action of different stakeholders to address the situation. Research shows that a variety of climate variability adaptation forms (operational, technical, and financial) have been taken by diverse stakeholders (farmers, climate variability agencies and organizations, and governments) at local, regional and international levels (Pradhan *et al.*, 2015). These stakeholders

have recognized the important role of agriculture in contribution to, and mitigation of climate variability. The concerns are on impacts and adaptations of climate variability on agricultural production and water availability because globally agriculture and water availability are strongly influenced by weather and climate. Climate variability is expected to impact on agriculture, potentially threatening established aspects of farming systems (Clark *et al.*, 2010). Climate variability will result in fundamental alterations to ecosystem structures and functions (Melese *et al.*, 2013).

Response is an urgent priority for farm households, to reduce the negative effects of climate variability because the livelihoods of many low-income households are likely, to suffer from declining food production (Ng'ang'a *et al.*, 2016). Diverse methods of mitigation have been adopted by pastoralists and agro-pastoralists including grazing management practices. Feed availability and seasonal fluctuations influence the appropriate method of response, which has an implication on the kind of property rights that can be attached to the resources (Beyene, 2016). Agro-pastoral farmers have diverse agricultural practices which include use of organic forestry (ATPS, 2013), use of local seeds which they believe are better adapted than exotic seeds, crop diversification, minimum tillage, mulching, collecting water in ponds and earth dams for irrigation, and changing their planting times based on rainfall forecasts (Pradhan *et al.*, 2015). However, agro-pastoral farmers are reactive dealing with short term challenges rather than being proactive to handle long term problems. This reactive behavior can be due to lack of information access and low understanding of mitigation and adaptation options. The ability of rural farmers to manage common systemic risks in the presence of more complex risks associated with climate variability definitely needs attention. In highly variable climates where any season can bring harsh conditions, farmers are generally reluctant to invest in more profitable technologies and practices (Hansen *et al.*, 2012). This lack of investment, combined with climate variability leading to unpredictable yields, is a major factor in keeping farmers trapped in poverty.

High population growth rate in Laikipia has caused negative effects on the socio-economic development and aggravated the poverty situation in the county. Increased pressure on available resources has often degenerated into conflicts between the agro-pastoral and pastoral community, large-scale ranching enterprises, smallholder farmers and wildlife. Low productivity due to small land holdings coupled with increased occurrence of droughts and extreme weather events has increased the severity of crop failure and land degradation. This has had a larger negative impact on the livelihoods of many local communities in the county (Laikipia CIDP, 2013).

Pastoral and agro-pastoral systems occupy about 40% of Africa's land mass with significant variations among countries. In Kenya, agro-pastoral and pastoral lands occupy over 84% of the country's land area, hosting approximately 10 million people and 70% of the national livestock population (FAO, 2009). Kenya's ASAL support

over 25% of the total human population and are mainly suited to extensive livestock production. However, climate change now threatens to eradicate the country's rich biodiversity (GoK, 2010).

Laikipia is one of the 47 counties in Kenya. It is a multi-ethnic tribal County which agro-pastoral and pastoral communities share with ranchers, farmers, horticulturalists and wildlife conservation areas (Laikipia CIDP, 2013). It includes extensive semi-arid lands as well as arable and urban areas. Pressures on water and land resources have increased greatly in recent years, with increased farming activities, rapid population growth, and periodic drought as well as climate variability (Laikipia CIDP, 2018).

Agro-pastoralism in Laikipia is a production system based on crop production and livestock (cattle, sheep, goats, donkeys and camels) rearing that is characterized by mobility in an ecologically fragile environment, high degree of flexibility and variability. It is managed through social organization based on traditionally authorized structures which is either territorial or clan in its jurisdiction (Laikipia CIDP, 2013). The key issues in its management are natural resources, and other political, social and economic issues associated with it. Livestock represent the major stores of wealth that utilize mobilized environment characterized by highly variable water resources and transient forage through mobility. In recent years mobility has been challenged as a result of land sedentarization and sub division (Laikipia CIDP, 2018). Even so, there is information sharing by different actors through early warning system, while meteorological department strives to provide sub county specific observatory information to farmers (MoALF, 2017).

Agro-pastoralism helps in circumventing natural resource degradation trends and poverty. However, over the past three decades agro-pastoral farmers have been faced with enormous problems as a result of extremes of climate variability and land use change. This has posed serious challenges to the provisioning ecosystem services (food supply/crop yield, agro-biodiversity maintenance and water availability) as which affect sustainability and subsequent viability.

Climate variability is one of the greatest challenges to having healthy ecosystems and their service provision in ASALs of Kenya. It is also clear that climate variability and increasing probability of extreme climatic events will pose new challenges to the resilience of agro-pastoral community livelihoods and agro-ecosystems in Laikipia West sub-County. Despite the expected balance provided by the ecosystem, combinations of factors - including climate variability and change have put constraint on provisioning ecosystem services. This has put a strain on the livelihood of the agro-pastoral farmers. In an effort to address the challenge posed by climate variability, development agencies including the Kenyan government are supporting climate change adaptation programmes. Very often though, these initiatives have focused on communities in ASALs - with a lesser focus on the ecosystem as whole. In addition, little is known about how the agro-pastoral farmers respond

to the effects of climate variability and the effects of climate variability on food supply/crop yield, water availability and agro-biodiversity maintenance in Laikipia West sub-County. This study sought to determine the effects of climate variability on food supply, livestock kept and water availability in Laikipia West sub-County.

2. RESEARCH METHODOLOGY

This study was conducted in Laikipia West sub-County which is located to the north-west of Mount Kenya.

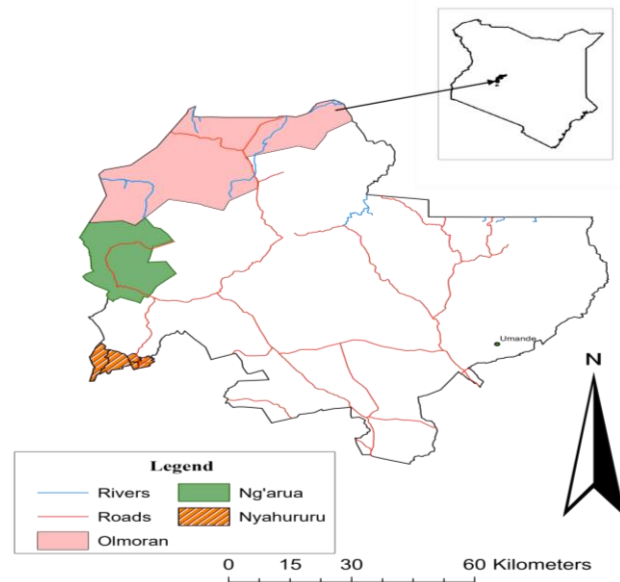


Figure 3. 1 Map of the study area showing the three wards that were surveyed.

Source: World Resource Center (2013)

Laikipia West sub-County has a population of 224,431 and 55,705 households (KNBS, 2009). The study used a multi-stage sampling technique. Laikipia County was selected purposefully because of its vulnerability to climate variability and majority of the people are agro-pastoral farmers as shown by the livelihood zones map of Laikipia County (FAO, 2009). Stratified random sampling was used to obtain the sample from 3 wards: Igwamiti, Olmororan and Githiga. For uniformity purposes, proportionate stratified sampling method was used to ensure all the divisions are represented in the study. The population data were obtained from the area agricultural offices in the three selected wards as 19,219 farm households. The key informants in this study were sought from the Ministry of Agriculture Livestock, Forestry Department as well as Laikipia West community leaders; 5 from each of these sectors (agriculture, livestock, forestry and community leaders) were interviewed.

The sample size was determined using the following formula by Bowley's (1977) quoted in Nzelibe (1999) proportion sample formula assuming a 95% confidence interval as shown:

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

Where; S_{total} = total sample size of all respondents
 N = total population of farming households in Laikipia west sub-county (19219)

1 = constant

e = level of significance (confidence interval of 95%)

Hence replacing the values into the formula gives

$$S_{total} = \frac{19219}{1+19219(0.05)^2} = 391.844$$

$$S_{total} \approx 392$$

Table 1: Total and sampled households according to Wards in Laikipia West sub-County

Laikipia Wards	West	Total households	Sampled Households
Githiga		11,581	240
Igwamiti		4,683	98
Olmoran		2,955	62
Total		19,219	400

Source (KNBS, 2009)

A total of 400 households were interviewed but after data cleaning only 394 households' data was analyzed. The 20 key informants were interviewed based on their field of specialization. Primary data was collected by interview method using semi-structured questionnaires and key informant interviews. Pre-testing was done to ensure that the questionnaire and the key informant interview guide were reliable and necessary adjustments made. The result of the pre-test indicated a reliability coefficient of 0.9 for the whole instrument using the Guttman split-half reliability index. The questionnaire was found to be a reliable instrument for collecting data in the field (Howitt & Cramer, 2003). The computer-based statistical package for social sciences (SPSS Version 20.0) was used for data analysis to yield descriptive and inferential statistics.

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of Respondents

3.1.1 Age and Gender Distribution of the Respondents

All age groups in this survey were found to be active and participating in agro-pastoral farming/agro-pastoralism. The /maximum age of the agro-pastoral farmers was 97 years, while the minimum was found to be 24 years. The mean age of an agro-pastoral farmer in Laikipia west sub-County was found to be 51.05 years. This is contrary to the average age of a Kenyan farmer which is put at 57 years (Momanyi *et al.*, 2012). Results of this study reveal that almost all the age groups participated i/n the study as shown in Table 2: persons aged over 55years (32.2%), 46-55years (28.9%) and 36-45 years (28.2%) constituted the majority of sampled households. Engagement of this category in agro-pastoralism demonstrated that the involvement of younger people (10.66%) in farming was increasing. This can be attributed to the rising levels of overall unemployment in Kenya, which was reported at 12.7% in the year 2006 (KNBS, 2009) and at 40% in the year 2009 (Krishnamurthy & Dejan, 2009).

A total of 394 households were interviewed of whom 63.9% were male and 36.1% female respondents. Men were more

than the women in all the sampled wards (Igwamiti, Githiga and Olmoran) probably because, traditionally they are the heads of the households and only in their absence do women head the households on a part-time basis.

Table 2: Age distribution of the respondents in Laikipia West

Ward	Gender	18-24	25-35	36-45	46-55	Over 55	Total
Igwamiti	Male	1	13	39	45	42	140
	Female	0	8	34	29	24	95
	Total	1	21	73	74	66	235
Githiga	Male	2	8	20	16	17	63
	Female	0	3	6	8	13	30
	Total	2	11	26	24	30	93
Olmoran	Male	0	3	10	12	23	48
	Female	0	4	2	4	8	17
	Total	0	7	12	16	31	65
Total	Freq.	3	39	111	114	127	394
	Percent	0.8%	9.9%	28.2%	28.9%	32.2%	100%

Female headed households were not common. Temesgen *et al.* (2014) found that male-headed households adapt more readily to climate because they have more access to improved technology, information on climate, credit and extension services than female headed household. A study by Campbell *et al.* (2002) on household livelihoods in semi-arid areas has shown similar results of both male and female gender involvement in farming activities as a response to meeting livelihood needs occasioned by the harsh environment in ASALs. The study by Rao *et al.* (2011) have also shown that males and females equally participate in farming with differences only in the farming activities they are engaged in. Farming activities that are manually demanding for example: irrigation, land preparation and spraying are dominated by males; while females handle activities requiring precision like sorting, planting, picking, grading and packaging.

3.1.2 Marital Status and Family Sizes

In terms of marital status of the agro-pastoral farmers interviewed in Laikipia West sub-County, 281 out of 394 (71.6%) were married while 42 out of 394 (10.7%) were single, 61 out of 394 (15.5%) widowed and 9 out of 394 (2.3%) were divorced as shown in Table 3. The results are in agreement with Kenya Demographic and Health Survey (2003) that describes Kenya as a marrying society and that almost everyone had done so by age 40-44 (Kenya Demographic and Health Survey, 2003).

The mean number of family members over 18 years of age per household in Laikipia West sub-County was 2.63 persons, while for family members under 18 years of age per household was 2.19 persons. Therefore, the mean number of family members per household was 4.82 persons. However, the average family size for Kenya is 4.4 compared with the average for less developed countries of 2.17 while, for Sub-Saharan Africa, it is 5.6 based on average number of surviving children per woman (female over 15 years) (Haupt & Kane, 2002).

Table 3: Marital status of Respondents in Laikipia West

Marital status	Igwaremiti		Githiga		Olmoran		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Married	166	70.2	65	69.9	51	78.5	282	71.6
Single	30	12.8	11	11.8	1	1.5	42	10.7
Divorced	7	3	1	1.1	1	1.5	9	2.3
Widowed	33	14	16	17.2	12	18.5	61	15.5
Total	236	100	93	100	65	100	394	100.0

3.1.3 Education Levels of the Respondents

A descriptive analysis of the education level of the respondents in the study area was summarized in frequency distribution as shown in Table 4. Results of this study showed that majority (49.5%) of the respondents had primary school education. As the level of education increased, the number of respondents with such qualifications decreased accordingly with 34.0% having secondary education, 8.9% having attained tertiary education and only 2.5% university education. Education is a significant income diversification strategy that is critical to climate variability and change adaptation. These results imply that majority of the dairy farmers may lack adequate

formal education which is a prerequisite to better modern farming technologies. In addition to this, the level of education of the household head can influence the kind of decision that may be made on behalf of the entire household with regard to farming technologies. More educated farmers are likely to make better decisions as well as quickly adopt new technologies in farming as compared to their less educated counterparts. The results showed that significantly more males than females had tertiary and university education. These low levels of education can be attributed to high dropout at primary level especially for girls (Glennerster *et al.*, 2011).

Table 4: Education level of respondents in Laikipia West sub-County.

Level of education	Igwaremiti		Githiga		Olmoran		Totals	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Informal	2	0.9	8	8.6	10	15.4	20	5.1
Primary	112	46.8	48	51.6	35	53.8	195	49.5
Secondary	97	41.6	25	26.9	12	18.5	134	34.0
Tertiary	20	8.6	8	8.6	7	10.8	35	8.9
University	5	2.1	4	4.3	1	1.5	10	2.5
Total	236	100	93	100	65	100	394	100.0

3.1.4 Land Tenure and Size

Land tenure plays an important role in agricultural production. Majority (87.1%) of the agro-pastoral farmers are individual land owners with title deeds, while individual land owners without title deeds were 3.0% and a few owned community land (0.5%) and family owned land (8.4%). Results of landholding size presented in Table 5 shows that the average size of total cultivated land owned by the agro-pastoral farmers was 4.4 acres with farmers having the smallest size of land owning 0.5 acres and the largest owning 50 acres. This is in agreement with the findings of Jayne *et al.* (2003) who noted that the average landholdings in the small farm sector ranges between 5 and 7 acres in Kenya. The larger proportion of respondents (84.3%) had farms measuring below 5 acres (Table 5). Agro-

pastoral farmers in the sub-county need to maximally invest on the available land to increase production because land for expansion is limited. This finding is supported by Ogola *et al.* (2011) that small land size is an indication that intensive farming is the only option to enhance production.

Demands on the land for economic development and pressures from a burgeoning population are leading to an influx of "immigrant" farmers into the arid and semi-arid lands of Kenya (Jayne & Muyanga, 2012). In Laikipia West sub-County, this influx of farmers from neighboring high potential counties is leading to more land fragmentation and declining household farm sizes (Laikipia CIDP, 2013).

Table 5: Land holding size

Land size	Igwaremiti		Githiga		Olmoran		Totals	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Below 5	201	85.2	81	87.1	50	76.9	332	84.3
6-10	25	10.6	10	10.8	14	21.5	49	12.4
11-15	1	0.4	2	2.2	0	0	3	0.8
16-20	2	0.8	0	0	0	0	2	0.5
Above 20	7	3	0	0	1	1.5	8	2.0
Total	236	100	93	100	65	100	394	100.0

Mean = 4.4027, Standard deviation = 4.556, Min = 0.25, Max = 50.00, Range = 49.75

3.2 Effects of Climate Variability on Provisioning Ecosystem Services (Food Supply, Livestock Production and Water Availability)

3.2.1 Effects of Climate Variability on Food Supply

The study intended to find out the effects of climate variability. The results of data analysis showed that crop

yield had declined in the last 20 years as indicated in Table 6.

Table 6: Crop yield changes in the last 20 years

Changes in crop yield	Wards	Frequency	Percent (%)
Improved	Igwamiti	22	9.3
	Githiga	2.0	2.2
	Olmoran	1.0	1.5
	Total	25	6.3
Remained the same	Igwamiti	3	1.3
	Githiga	0	0.0
	Olmoran	0	0.0
	Total	3	0.8
Declined	Igwamiti	208.0	88.1
	Githiga	91.0	97.8
	Olmoran	64	98.5
	Total	363.0	92.1

Table 7: Causes of changes in crop yield

Causes	Ward	Frequency	Percent (%)
Soil fertility	Igwamiti	92	39.0
	Githiga	18	19.4
	Olmoran	40	61.5
	Total	150	38.1
Rainfall	Igwamiti	85.0	36.0
	Githiga	28.0	30.1
	Olmoran	42	64.6
	Total	155.0	39.3
Drought	Igwamiti	156	66.1
	Githiga	83.0	89.2
	Olmoran	55.0	84.6
	Total	294	74.6
Pests and diseases	Igwamiti	153.0	64.8
	Githiga	52.0	55.9
	Olmoran	49.0	75.4
	Total	254.0	64.5

Majority (92.1%) of the respondents experienced decline in crop yields in the last 20 years. Respondents reported that the main causes of decline in crop yields/food supply in Laikipia west Sub-County were drought (74.6%), pests and diseases (64.5%), rainfall (39.3%) and soil fertility status (38.1%) as shown in Table 7. Farmers perceived that there has been an increase in pests and disease due to increase in temperatures for instance, stalk borers (*Calidea dregii*) and Maize *Lethal necrosis* disease. According to the key informants in 2014, many farmers had almost total failure on maize yields as a result of drought and the maize *Lethal necrosis* disease. The IPCC reported that, an increase in average temperature will adversely affect crops, especially in semi-arid regions, where already heat is a limiting factor of production (IPCC, 2007). Increased temperature also increase evaporation rates of soil and water bodies as well as evapotranspiration rate of plants, and increase chances of severe drought. It means that with warmer temperatures plants require more water.

Given the over-dependence on rain-fed agriculture by a majority of farmers living in rural areas, climate variability has been one of the major limiting factors of agriculture production, thus resulting in food insecurity. Droughts and floods have been reported to cause failure and damage to crops and livestock - leading to chronic food shortages (Liwenga *et al.*, 2007). Studies conducted by Rosenzweig *et al.* (2002) revealed that changes in rainfall patterns and amounts have led to loss of crops and reduced livestock production in the United States. As the planet warms up, rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent. This will result in poor and unpredictable yields, thereby making farmers more vulnerable, particularly in Africa (UNFCCC, 2007).

The two most important climatic elements determining the localization and occurrence of pests and diseases appear to

be temperature and moisture. In general, pests and disease vectors do better when the temperature is high under conditions of optimum water supply. Climate variability and change may increase the incidence of pests and diseases. FAO (2007) reported that changing temperatures and rainfall in drought-prone areas are likely to shift populations of insect pests and other vectors and change the incidence of existing vector-borne diseases in both humans and crops.

3.2.2 Effects of Climate Variability on Water Availability

The study sought to find out if there were changes in water quality and quantity as well as distance to the water source over the last 20 years. Majority (62.6%) of the respondents in Laikipia West sub-County felt that there were changes in both water quality and quantity over the last 20 years, however a few (32.4%) felt there were no changes as shown in Table 8.

Table 8: Changes in water quality and quantity over the last 20 years

Ward	Frequency	Percent (%)
Igwamiti	145	61.7
Githiga	55	66.3
Olmoran	59	90.8
Total	259	62.6

Most of the agro-pastoral farmers in all the wards in Laikipia West sub-County agreed that the distance to the water source had declined. However, with regards to water amounts only respondents in Githiga ward (63.8%) felt that it had increased, the others in Igwamiti and Olmoran wards felt that water amounts had declined (53.1% and 61.4% respectively) as shown in Table 9. This was because many agro-pastoral farmers in Githiga ward had access to borehole water as compared to Olmoran and Igwamiti wards. Responding to water scarcity stress and the threat of declines in crop yields require farm level intervention such as rainwater harvesting and establishing small-scale water reservoirs on farmlands (Osman-Elasha, 2010).

Table 9: Changes in distance to water source and water amounts over the last 20 years

Nature of changes	Ward	Response	Freq.	Percent	Chi-square	df	P-value
Distance to water source	Igwamiti	Declined	129	87.8	196.286a	2	.000
		Remained the same	6	4.1			
		Increased	12	8.2			
	Githiga	Declined	48	78.7	57.082a	2	.000
		Remained the same	9	14.8			
		Increased	4	6.6			
	Olmoran	Declined	29	47.5	24.820a	2	.000
		Remained the same	2	3.3			
		Increased	30	49.2			
	Total	Declined	206	78.6	231.086a	2	.000
		Remained the same	17	6.5			
		Increased	46	17.6			
Water amount	Igwamiti	Declined	78	53.1	50.245a	2	.000
		Remained the same	10	6.8			
		Increased	59	40.1			
	Githiga	Declined	13	22.4	24.862a	2	.000
		Remained the same	8	13.8			
		Increased	37	63.8			
	Olmoran	Declined	35	61.4	28.737a	2	.000
		Remained the same	2	3.5			
		Increased	20	35.1			
	Total	Declined	126	48.1	78.443a	2	.000
		Remained the same	20	7.6			
		Increased	116	44.3			
	Total		262	100.0	61.153a	2	.000

Table 10: Changes in water availability in the last 20 years

Changes in water availability	Categories	F	%	Chi-square	Df	P-value
Changes in amount of water	Declined	146	33.7	92.170	2	0.000
	Remained the same	20	5.3			
	Increased	116	31.0			
Changes in the distance to water source	Declined	219	54.1	253.809	2	0.000
	Remained the same	17	4.5			
	Increased	46	12.1			

Results of this study showed that, the amount of water available has declined as perceived by 33.7% of the respondents in Laikipia West sub-County as shown in Table 10. This may be due to the decrease in the amount of rainfall as stated by majority of the respondents. However, majority (54.1%) of the respondents perceived that the distance to the water source had declined. This may have been due to majority (77.2%) of the agro-pastoral farmers having access to borehole water.

According to IPCC (2019) rainfall changes and variations significantly affect agriculture and the availability of water for socioeconomic activities including water for domestic use, crop and livestock production, particularly in arid and semi-arid areas in developing countries. Decreased rainfall, for example, is likely to reduce the water available for crops and livestock, the key economic activities of most rural populations in developing countries where rain-fed agriculture is dominant. Globally, however, the potential for food production is projected to increase with increases in local average temperatures ranging from one to three degrees centigrade. Above this temperature range, however, food production is projected to decrease. At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease even with small local temperature increases (1 to 2°C), which will increase the risk of hunger.

4. CONCLUSIONS AND RECOMMENDATIONS

Majority of the agro-pastoral farmers kept poultry and browsers as they required less feed for survival during these times of climate variability and change. The study concluded that climate variability resulted to decline in food supply/crop yields and water availability had increased yet its amount declined. Climate variability negatively affected provisioning ecosystem services like food supply/crop yield and water availability. The study recommends that, there is need for sensitization on climate smart agricultural practices that would increase food supply and enhance water availability sustainably.

5. REFERENCES

- Adepoju, A. O. & Obayelu, O. A. (2013). Livelihood diversification and welfare of rural households in Ondo State, Nigeria. *Journal of Development and Agricultural Economics*, 5(12), 482-489.
- African Technology Policy Studies Network, ATPS. (2013). Farmers' Response and Adaptation Strategies to Climate Change in Mafeteng District, Lesotho [Tsepo Stephen Tiisetso Sekaleli, Karabo Sebusi], *ATPS working paper*, 74.
- African Technology Policy Studies Network, ATPS. (2013). *Indigenous rain water harvesting practices for climate adaptation and food security in dry areas: The Case of Bahi District*. ATPS Research Paper No. 22.
- Atinkut, B. & Mebrat, A. (2016) Determinants of farmers choice of adaptation to climate variability in Dera woreda, south Gondar zone, Ethiopia. *Environmental Systems Research*, 5(1), 1-8.
- Beyene, F. (2016) Land use change and determinants of land management: experience of pastoral and agro-pastoral herders in eastern Ethiopia. *Journal of Arid Environments*, 125, 56-63.
- Campbell, B. M., Jeffrey, S., Kozanayi, W., Luckert, M., Mutamba, M., & Zindi, C. (2002). *Household livelihoods in semi-arid regions: Options and constraints*.
- Chinasho A., Yaya, D., & Tessema, S. (2017). The adaptation and mitigation strategies for climate change in pastoral communities of Ethiopia. *American Journal of Environmental Protection*, 6(3), 69-77.
- Clark, R., Gornall, J., Betts, R., Burke, E., Gornall, J., & Camp, J. (2010). *Implications of climate change for agricultural productivity in the early twenty-first century*. UK: Met Office Hadley Centre, FitzRoy Road Exeter, Devon EX1 3PB.
- Diallo, I., Bain, C.L., Gaye, A.T., Moufouma-Okia, W., Niang, C., Dieng, M.D. & Graham R (2014) Simulation of the West African monsoon onset using the HadGEM3-RA regional climate model. *Climate Dynamics*, 43(3), 575-594.
- FAO (2009). *Review of evidence on drylands pastoral systems and climate change: implications and opportunities for mitigation and adaptation*. Land and Water Division Discussion Paper, Rome: FAO.
- FAO. (2007). *Adaptation to Climate Change in Agriculture, Forestry and Fisheries: Perspective, framework and priorities*. Italy, Rome: Interdepartmental Working Group on Climate Change.
- Glennerster, R., Kremer, M., Mbiti, I., & Takavarasha, K. (2011). *Access and quality in the Kenyan education system: A review of the progress, challenges and potential solutions*. <http://www.povertyactionlab.org/publication/access-and-quality-kenyan-education-system>.
- GoK. (2010). *National Climate Change Response Strategy: Ministry of Environment and Mineral Resources*. Nairobi, Kenya: Government of Kenya.
- Hansen, J., Sato, M., & Ruedy, R. (2012). Perception of climate change. *Proceedings of the National Academy of Sciences*, 109(37), E2415-E2423.
- Haupt, A. & Kane, T. T. (2002). *The Population reference bureau: World data sheet*. Washington, DC: Population Reference Bureau.
- Howitt, D. & Cramer, D. (2003). *A guide to computing statistics with SPSS 11 for windows*. Pearson Education Limited, England, Great Britain.
- Huho, J. M. & Kosonei, R. C. (2014). Understanding Extreme Climatic Events for Economic Development in Kenya. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 8(2), 14-24.
- IPCC (2014). *Climate change 2014: synthesis report*. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change: 151.
- IPCC (2019). *The IPCC's Special Report on Climate Change and Land: What's in it for Africa?*
- Jayne, T. S., & Muyanga, M. (2012). Land constraints in Kenya's densely populated rural areas:

implications for food policy and institutional reform. *Food Security*, 4(3), 399-421.

e0129487.

<https://doi.org/10.1371/journal.pone.0129487>

- Jayne, T. S., Yamano, T., Weber, M., Tschirley, D., Benfica, R., Chapoto, A., & B. Zulu. (2003) Smallholder income and land distribution in Africa: Implications for poverty reduction strategies. *Food Policy*, 28(3), 253-275.
- Kangalawe, R.Y.M., & Lyimo, J.G. (2013). *Climate change, adaptive strategies and rural livelihoods in semi-arid Tanzania*. Tanzania: Institute of Resources Assessment, University of Dar es Salaam.
- Kgosikoma, O.E. and Batisane, N. (2014). Livestock population dynamics and pastoral communities' adaptation to rainfall variability in communal lands of Kgalagadi South, Botswana. *Pastoralism: Research, Policy and Practice*, 4(1), 19-20.
- KNBS (2009). *The Kenya population and housing census*. Kenya National Bureau of Statistics. Nairobi: Government Printer.
- Krishnamurthy, S., & Dejan, V. (2009). *The global public relations handbook revised edition*, 329. New York: Routledge Publishers.
- Lamboll, R., Nelson, V. & Nathaniels, N. (2011). *Emerging Approaches for Responding to Climate Change in African Agricultural Advisory Services: Challenges, opportunities and recommendations for an AFAAS climate response strategy*. African Forum for Agricultural Advisory Services, Kampala.
- Liwenga, E. T., Kangalawe, R. Y. M., Lyimo, J. G., Majule, A. E., & Ngana, J. O. (2007). *Research protocols for assessing the impact of climate change and variability in rural Tanzania: Water, food systems, vulnerability and adaptation*. START/PACOM, African Global Change Research.
- Melese G., Munyae M., & Mulinge. (2013). *Impacts of climate change and variability on pastoralist women in sub Saharan Africa*. Kampala, Uganda: African Books Collection Limited.
- MoALF (2017). *Climate Risk Profile for Laikipia County. Kenya County Climate Risk Profile Series*. Nairobi: Ministry of Agriculture Livestock and Fishing.
- Ng'ang'a S, Van Wijk MT, Rufno MC, Giller KE (2016) Adaptation of agriculture to climate change in semi-arid Borena, Ethiopia. *Reg Environ Change*, 16(8):2317-2330.
- Ogola, O., Milton, W., Ayieko, A., Orawa, O., & Kimani, W. (2011). Analysis of fertilizer use in potato production in Nakuru District, Kenya. *Africa Journal of Agriculture*, 6 (16), 3672-3677.
- Omoyo, N.N., Wakhungu, J. & Oteng'i, S. (2015). Effects of climate variability on maize yield in the arid and semi-arid lands of lower eastern Kenya. *Agriculture and Food Security*, 4(1),8-17. <https://doi.org/10.1186/s40066-015-0028-2>
- Osman-Elasha, B. (2010). *Climate change adaptation: Options and good practices for the Arab region*.
- Pradhan P, Fischer G, van Velthuisen H, Reusser DE, Kropp JP (2015) Closing Yield Gaps: How Sustainable Can We Be? *PLoS ONE* 10(6):
- Rao, K. P. C., Ndegwa, W. G., Kizito, K., & Oyoo, A. (2011). Climate variability and change: Farmer perceptions and understanding of intra-seasonal variability in rainfall and associated risk in semi-arid Kenya. *Experimental agriculture*, 47(2), 267-291.
- Rosenzweig, C. E., Tubiello, F., Goldberg, R., Mills, E., & Bloomfield, J. (2002). Increased crop damage in the U.S. from excess precipitation under climate change. *Global Environmental Change*, 12, 197-202.
- Temesgen, D., Yehualashet, H., & Rajan, D. S. (2014). Climate change adaptations of smallholder farmers in South Eastern Ethiopia. *Journal of Agricultural Extension and Rural Development*, 6(11), 354-366.
- UNFCCC (2007). *Climate change: Impacts, vulnerabilities and adaptation in developing countries*. Bonn, Germany: United Nations Framework Convention on Climate Change.
- Van Dorland, R.B., Jansen, K., van der Sandt, B., Van Hove, C., Jacobs, C., & Swart, R. (2011). Staat van het klimaat 2010: Actueel onderzoek en beleid nader verklaard. Netherlands: PCCC, de Bil, Wageningen.