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Response Strategies by Agro-Pastoral Farmers to Effects of Climate Variability in Laikipia West Sub-County, Kenya

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Authors' contributions

This work was done in collaboration between all authors. Authors MRM, GOO and CWR designed the study, while author MRM performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed literature searches. Authors GOO, CWR and LWN supervised and managed the research. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study assessed the effects of Climate variability on Agro-pastoral farmers' livelihoods and response strategies.
Study Design: The study employed a social survey research design, to examine household perceptions on climate variability and response strategies by agro-pastoral farmers to climate variability.
Place and Duration of Study: The study was conducted in Laikipia West region, between August 2015 and March 2016.
Methodology: A questionnaire was administered to 400 agro-pastoral farmers and interviews were held with 20 key informants from relevant institutions. Data was processed and analysed using descriptive statistics and chi-square test.
Results: The study findings revealed that, agro-pastoralists perceived that rainfall had decreased while temperatures had increased. The main response strategies employed by agro-pastoralists

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were: crop diversification, use of both organic and chemical fertilizers, planting drought tolerant crops and tree planting.

Conclusion: Agro-pastoral farmers in Laikipia West Sub-County are engaging in various response strategies to climate variability. There are fundamental changes in livelihoods such as crop diversification, rainwater harvesting, irrigation, mixed cropping, mixed farming, keeping of browsers and tree planting. However, currently there is promotion of drought tolerant crops, use of greenhouses, fallow cropping amongst others. There is need for integration of scientific and traditional ecological knowledge as well as climate smart agriculture for better adaptation to the effects of climate variability.

Keywords: Climate variability; response strategies; agro-pastoral farmers; coping; Laikipia West Sub-County.

1. INTRODUCTION

Climate variability and change is an environmental issue of global concern that pose serious threats in arid and semi-arid lands, to vulnerable and impoverished agro-pastoral communities. In developing countries, there are at least 40 million pastoralists/ agro-pastoralists who depend on natural grazing for their livelihood with most of them being subsistence oriented. Rapid increases in human and livestock populations during the last four decades, coupled with the diversion of grazing land to other land uses, have contributed to increasing grazing pressures, overgrazing and land degradation, particularly in ASALs. It is therefore common in these agro-pastoral systems to find conditions marked by drought, increasing livestock raids and theft, banditry and growing physical insecurity. This has resulted to loss of agro-pastoral resources [1].

The ASALs/rangelands of East Africa are facing unprecedented period of change. In 2009, interactive effects of climate variability/ uncertainty and land-use change had devastating effects on biodiversity and agro-pastoral livelihoods. Although climate variability and traditional adaptation strategies have since time in memorial, been part of agro-pastoral production systems, the convergence of increasing climate variability coupled with land-use change is eroding the resilience of ecosystems. The spatial scale and connectivity that underpins the inherent cultural and biological diversity is increasingly constrained and fragmented by climate and land-use. Landscapes are becoming increasingly isolated with constraints on system flows and movement of species threatening biodiversity and agro-pastoral livelihoods as well as ecosystem services provision. In addition, widespread poverty that limits adaptation capabilities makes many countries in sub-Saharan Africa more vulnerable to the impacts of projected climate variability and change [1]. Countries in East Africa are already among the most food insecure in the world and climate variability and change will aggravate dropping harvests [2].

Over 80% of Kenya is arid and semi-arid. 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. Agro-pastoral livelihoods in ASALs of developing countries are driven by other factors such as poor policy and governance issues, market forces, environmental degradation, population displacement, climate induced conflicts and diseases as well as characterized by rapid change other than, climate variability [3].

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. 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 [4].

Almost 18 million of Kenyans live below the poverty line [5], the majority of who reside in rural areas, with more than 90% relying on rain fed subsistence or smallholder farming and agro-pastoralism to survive. 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 and water availability) as which affects sustainability and subsequent viability. The threat that climate variability poses to these sectors has necessitated the assessment of the potential impacts of climate at various scales in these sectors in order to reduce vulnerability and secure livelihoods of those who depend on them [6]. Therefore, need to identify and strengthen the response strategies/ mechanisms of the agro-pastoral farmers.

2. METHODOLOGY

2.1 Study Area

The study area, Laikipia West sub-County lies within the latitudes 0°17' S and 0°45' N and longitudes 36°15' E and 37°20' E, occupying an area of approximately 9,666 Km^2. The County extends from the foot of Mt. Kenya to the north eastern base of Aberdare ranges. It stretches widely northwards and descends towards the Rift valley in the northwest with spectacular complex of fault- line volcanic ridges and escarpments. The altitude ranges from 1,600 m- 2,300 m above sea level on a dry land and semi-arid plateau. The county experiences moderate temperatures due to its altitude. Temperature minima and maxima are 6-14°C and 35°C respectively. The rainfall increases at higher elevation in the south and weakly tri-modal. The long rains occur in April-May, the continental or middle rains in August and November, and a pronounced dry season in January – March. The annual rainfall varies from 400-750 mm across the County, with higher values observed both at the foot of Mt. Kenya and Aberdare range. The County has five main livelihood zones namely: Mixed farming (35%), marginal mixed farming (43%), ranching, pastoral (9%) and formal employment (13%).

The main crops grown include wheat, maize, beans, potatoes and vegetables. Maize takes about 51per cent of the total planted area. Crop farming is mainly undertaken in the south western parts of the county due to favorable weather conditions. Efforts are now been put in place to promote the resistant crops such as millet, sorghum, sunflower and black beans (dolichos). There is an emerging trend of increased horticulture production both at large-scale and small-scale levels. This constitutes production of cut flowers, tomatoes, French beans, Aloe, chilies and water melons. There are also pockets of pineapple farms, orange trees and coffee bushes [7].

2.2 Data Collection Methods

A questionnaire was administered to the selected respondents (agro-pastoral farmers) to elicit the desired information. The research set an amicable environment for a comfortable engagement with the respondent by making the appropriate introduction including the purpose of the visit, the purpose of the study and then seek their permission to engage in the interview process. If, the respondent was literate and desires to fill the questionnaire, the researcher allowed this but also ensured that he/she was available to explain or clarify any question that was not clear to the respondent. The researcher was to recheck such a questionnaire and seek further clarification in places not properly filled. Such clarification was recorded by the researcher on the relevant sections in the questionnaire. The use of questionnaires enabled the respondents to be honest and remain anonymous in their responses [8]. Under normal circumstances, the researcher administered the questionnaires personally during the survey in a language in which the respondent was comfortable as the researcher did the recording of the answers. The use of this approach ensured direct contact between the researcher and respondent, a factor which facilitated elaboration of aspects that may have not been easily understood by the respondent. The procedure enabled the researcher ensure that the questionnaire was completed before leaving the respondent to minimize cases of incomplete questionnaires. A total of 400 households were surveyed.

Key informant interviews involved interviewing a selected group of individuals who were likely to provide needed information, ideas and insights on a particular subject. Key informants were selected because they had knowledge on the area of study that could be solicited by the interviewer. The 20 key informants were interviewed. It was essentially a qualitative interview which was conducted using interview guides that listed the topics and issues to be covered during a session. It was conducted in an informal atmosphere, resembling a conversation between acquaintances.

Key informants in this study were sought from the Ministry of Agriculture and Livestock, as well as Laikipia West community leaders. The interviewer subtly probed the informants to elicit information and take elaborate notes, which were later developed. In case, all relevant items were not covered in a session, the interviewer went back to the key informants. Key Informant Interviews were used to collect data on community and household preparedness in the recent climate variability. Key informant interviews complemented the survey research and targeted the division agriculture and Livestock officers.

2.3 Data Analysis

The computer based statistical package for social sciences (SPSS Version 20.0) was used for data analysis to yield descriptive and inferential statistics. Coding of questionnaires and observation schedules was done to enable data entry, cleaning and analysis. The collected data was analyzed using both quantitative and qualitative techniques. All the quantitative data collected was analyzed using the Statistical Package for Social Sciences (SPSS). Frequency counts, means and percentages were computed for all quantitative data, and results presented using frequency distributed tables, bar graphs and pie charts. All statistical tests were conducted at the 0.05 level of significance. Qualitative data were analyzed using qualitative techniques, which basically involves establishing the categories and themes, relationships/patterns and conclusions in line with the study objectives [9].

3. RESULTS AND DISCUSSION

3.1 Household Perceptions on Climate Variability

This study aimed at establishing the perceptions on climate variability (rainfall and temperature variability) in the study area. Through the Key informant interviews, the agricultural experts and farmers concurred that in the 1970's and 1980's, rainfall was more predictable and regular in season but this is not the case now. They stressed that decline in agricultural production was as a result of low and unpredictable rainfall, increased temperatures , failure to predict the on-set of rainy season using traditional indicators/indigenous knowledge and coupled with lack of information of the current soil fertility status in Laikipia west Sub-County.

This study sought opinion of respondents on whether there have been changes in mean temperature over the last 20 years in the study area. Majority (98.2%) of the respondents believed that the study area has been marked by significant changes in mean temperatures, however a few respondents (1.8%) did not believe that there has been any significant change in mean temperatures. This has resulted in increase in yield from beans growing, this was also as a result in decrease of frost (94.1%) as perceived by majority of the respondents.

Majority (98.7%) perceived that there were long term changes in mean annual rainfall in the last 20 years, only a few (1.3%) felt that that was not the case. Related studies in East Africa, report that persistence of below normal rainfall is a great risk to people's livelihood in Tharaka district in Kenya, where majority of people have been left vulnerable to hunger and famine [10].

Majority (98.2%; n=387) of the respondents felt there has been changes in the onset of long rains in the last 20 years and a few (1.8%; n=7) thought this was not the case. Similar observations have been reported by various scholars studying, for instance intra-seasonal factors, such as the timing of the onset of first rains affecting crop-planting regimes [11], length and distribution of period of rain during the growing season [12], and the effectiveness of the rains in each precipitation event [13], are the real criteria that affect the effectiveness and success of farming.

3.1.1 Observed changes in number of hot days, rainfall patterns, number of rain days and effects of climate variability on planting time

Majority (98.7%) of the agro-pastoral farmers perceived that there were long term changes in mean annual rainfall patterns in the last 20 years and the rest 1.3% believed that there were no long term changes. In a related study, [10] reported that persistence of below normal rainfall is a great risk to people's livelihood in Tharaka district in Kenya, where majority of people have been left vulnerable to hunger and famine. IPCC [14] reported that changes in rainfall amount and patterns also affect soil erosion rates and soil moisture, both of which are important for crop yields.

The distribution of the respondents opinion on observed changes in the number of hot days within the last 25 years was found to vary (Chi-square value = 134.061, P-value = 0.001) with majority of the respondents (86.8%) indicating that the incidence had increased in the study area (Table 1).

About 10.7% argued that it had declined, while only a few of them believed it had stayed the same (0.8%). These results agrees with [15], whom in their baseline household survey in Makueni, Kenya noted that the number of hot days had drastically increased as a result of climate change.

Majority (93.9%) of the agro-pastoral farmers felt that the number of rain days had significantly declined in the last 25 years, only a few (4.3%) felt that it had increased and the rest (0.5%) stated that it had stayed the same. The findings by [16] in the Limpopo Basin also corroborate these findings. He found out that 97% of the respondents in the study area observed changes in rainfall patterns over the past 20 years, and 81% noticed a decrease in the amount of rainfall or a shorter rainy season. The results of this study uphold the findings of a study conducted by [17] which revealed that wet regions are increasingly experiencing higher levels of precipitation, and arid areas are witnessing reduced levels and becoming drier. He attributed the precipitation patterns and variance to climate change and ocean currents [17].

Majority (96.2%) of the agro-pastoral farmers felt that it had become drier, while the rest 2.5% perceived that it had become wetter and 1.3% said there were no changes in the rainfall patterns in the last 25 years. Similar results were reported by [18,19] whereby a significant number of farmers in eleven African countries believed that temperatures had increased and that precipitation had declined.

Majority (79.4%) of the farmers planted late, while other farmers (69%) planted earlier and only a few (1.3%) planted at the same planting times. One of the key informants seconded this by stating that, “Before March-August, October-December were the normal rainy seasons but this has changed especially October-December, it only rains for 3 weeks. This has made it difficult to predict when to plant. These results are in agreement with that of [20], where the majority of farmers declared that rainfall onset has changed because they used to plant crops in October/November but nowadays they have to plant in December/January”.

Another key informant said that, “We have stopped practicing seasonal planting, because it is sometimes useless and does not pay off. We used to plant in March, and that would be it. Now we plant and plant again. We now waste time, money and energy on planting and land preparation”.

3.1.2 Household perceptions on indicators of climate variability

The agro-pastoralists in the study area’s perception on climate variability indicators included: Increased frequency of droughts, decreased rainfall amounts, extended dry spells and change in rainfall distribution as shown in Table 2.

The results in Table 2 imply that for most agro-pastoral farmers in Laikipia west sub-County, climate variability was a reality, characterized by extended dry spells with decreased rainfall amounts and increased frequency of droughts during the last 25 years.

Table 1. Household perceptions on climate variability

Observed changes	Categories	Freq.	Percent	Chi-square	df	P-value
Number of hot days	Stayed the same	3	0.8	134.061	2	.000
	Increased	342	86.8			
	Declined	42	10.7			
Rainfall patterns	Drier	379	96.2	176.780	2	.000
	Wetter	10	2.5			
	No change	5	1.3			
Number of rain days	Stayed the same	2	0.5	169.273	2	.000
	Increased	17	4.3			
	Declined	370	93.9			
Effect of climate variability on planting time	Stayed the same	5	1.3	103.000	2	.000
	Earlier	69	17.5			
	Later	313	79.4			

Table 2. Household perceptions on indicators of climate variability

Climate variability trends/indicators	Frequency (F)	%
Extended dry spells	338	85.5
Windstorms	90	22.9
Increase in growing periods	25	93.6
Decrease in growing periods	135	34.4
Increase in rainfall amounts	25	6.4
Decrease in rainfall amounts	359	91.3
Change in rainfall distribution	178	54.7
Increased frequency of floods	13	3.3
Decreased frequency of floods	67	16.8
Frequent drought	245	62.1
Increase in frost	23	5.9

Majority of the agro-pastoral farmers had experienced a number of indicators of climate variability during the past 25 years. The experienced climatic variations, as shown in Table 2 included increased frequency of droughts (62.1), extended dry spells (85.5%) and decreased rainfall amounts as the major climate variability indicators (91.3%).

Following droughts, decreased rainfall amounts and increased temperatures, the agro-pastoral farmers also reported increased incidences of pests and diseases (78.1%) as well as crop and livestock losses. This was also raised by one of the key informants: In 1984 and 2009, we lost our livestock and we did not harvest from our crops. In 2014, we did not harvest any maize and if some farmers did they harvested very few number of bags.

Another key informant seconded this by stating that: They used to experience drought at least after 10 years but now they have 3 years of good harvest but on the 4th year they experience severe drought. The findings by [16] in the Limpopo Basin also corroborate these findings. He found out that 97% of the respondents in the study area observed changes in rainfall patterns over the past 20 years, and 81% noticed a decrease in the amount of rainfall or a shorter rainy season. The results of this study uphold the findings of a study conducted by which revealed that wet regions are increasingly experiencing higher levels of precipitation, and arid areas are witnessing reduced levels and becoming drier. [17] attributed the precipitation patterns and variance to climate change and ocean currents.

A study by [21], concluded that the impacts of climate variability are manifested by floods, droughts, erratic rains and extreme events. They revealed that famine resulting from either floods or drought has become increasingly common since the mid-1990s and is undermining food security. Climate variability and change are likely to intensify drought and increase potential vulnerability of the communities to future climate change especially in the semi-arid regions, where crop production and livestock keeping are critically important to food security and rural livelihoods.

3.2 Response Strategies to Effects of Climate Variability

3.2.1 Diversification of crops

An investigation was carried out in order to establish whether the agro-pastoralists used diversification as a response strategy to low yields or crop failure. On analyzing this item, results showed that 85% of the respondents practiced this response strategy (Fig. 1). This showed that the agro-pastoralists had indigenous knowledge that a diversified portfolio of crop products would ensure that farmers do not suffer complete ruin when the climate is unpredictable. The respondents mentioned maize, Irish potatoes, and beans as the main crops they grow together. Diversification of crops is intended to give a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to lessen risk related to climate variability and change [22]. Indigenous crops in one area or improved varieties of the same may not always prove to be suitable in other areas though the areas may appear to be ecologically the same. For instance, [23] cites a case in Ethiopia where higher yielding sorghum varieties were introduced to increase income and food security for farmers and rural communities. When weather and other conditions were favorable, the modern varieties proved a success. However, in some areas complete crop failures were observed, whereas local varieties, with a higher variance of traits, were less susceptible to the frequent droughts. The loss of an entire crop was considered by the farming community as more than offset by the lower, average yields of the local variety that performed also under more extreme conditions. According to the Convention on Biological Diversity (CBD), in some places there will be acceleration in the loss of the genetic and cultural diversity already occurring in agriculture as a result of global climate change. This loss will also be evident in crops and domestic animals. A 2.5℃ rise in global temperature would determine major losses: Between 20 and 30 per cent of all plant and animal species could face a high risk of extinction. Ecosystems and species display a wide range of vulnerabilities to climate variability and change, depending on the imminence of exposure to ecosystem-specific critical thresholds. Local and rare breeds of plant/crop species could be lost as a result of the impact of climate variability. Biodiversity loss has global health implications and many of the anticipated health risks driven by climate variability will be attributable to a loss of genetic diversity [24].

3.2.2 Use of fertilizer/manure

Soil fertility was expected to be a key factor in crop production. On analysis the results showed that 83.5% of the respondents used either chemical fertilizer or manure as a response strategy to climate variability (Fig. 1). This high percentage may explain that the response strategy was popular and acceptable by the community.

From the key informants' interview, it was noted that the soil fertility status of Laikipia County was not known and therefore, the agricultural extension officers and experts were not sure on whether they were giving out the right fertilizers to the farmers.

From the social survey, it came out that the agro-pastoralists perceived soil fertility in terms of the soil colour (67.4%), crop yield (94.1%), weed growth (46.8%), colour of crop (53.4%), and crop growth rate (51.7%). They employ different indicators of knowing whether the soil is fertile or not. The major indicator mentioned by agro-pastoralists is amount of crop yield (94.1%). A variety of soil fertility management techniques practiced by agro-pastoralists in the study area include: application of farmyard manure, mixed cropping, planting leguminous crops, very few agro-pastoralists practiced fallow cropping (12.7%) and opening of new fields (1.0%) (Table 5). The reasons given by the community on why they used the strategy concur with the scientific definition of soil fertility as the status of a soil with respect to its ability to supply elements essential for plant growth without a toxic concentration of any element to enhance productivity (Deenik, 2005).

3.2.3 Irrigation

The study intended to find out whether, irrigation was practiced as a response strategy to low rainfall. The proportion of respondents reporting this practice was relatively small (37.8%) showing that irrigation was not a common practice in the study area (Table 3). This may have been so because some of the respondents relied on rain water for irrigation use yet rainfall amounts had decreased and only a few (23.2%) relied on borehole water for irrigation use. The majority of crops grown under irrigation are: tomatoes, cabbages, arrow roots, kales amongst others. There is an emerging trend of increased horticulture production both at large-scale and small-scale levels. This constitutes production of cut flowers, tomatoes, French beans, Aloe, chilies and water melons [7].

Table 3. Response Strategy to low rainfall

Response strategy	F	%
Irrigation	149	37.8%
Livestock production	203	51.5%
Migration	1	0.3%
Open up larger fields	2	0.5%
Use of greenhouses	2	0.5%
Water management practices	162	41.1%

A study in Manyoni and Shinyanga Rural Districts of Tanzania; showed that irrigation or wetland cultivation was practiced close to wetlands as a means of reducing the impacts of drought and high temperatures in the soil since wetlands are relatively cooler and moisture than upper fields. However, poorly developed irrigation facilities limit this practice to only small plots. The proportion of respondents reporting this practice was relatively low (18.8%), indicating that irrigation is not common practice in these areas. In some places, especially in these dryland areas, even wetland cultivation may not be reliable in ensuring sustainable livelihoods especially if they dry up early in the season [25].

3.2.4 Livestock production

During low rainfall, majority (51.5%) of the respondents resulted to livestock production as response strategy due to its lower demand on water availability (Table 3). While, such a practice has guaranteed a livelihood for the respective households in times of low rainfall and crop failure due to unreliable climatic conditions, they have also been a cause of environmental degradation through overgrazing. Farmers experience shows, however, that as a result of climate variability and its impact on availability of water and pasture, many agro-pastoral farmers now put an emphasis on small stocks whose water and fodder requirements are less, as expressed by 36.0% of the respondents decreasing cattle stocks and only 10.2% decreasing goat stocks as well as 6.8% sheep stocks in the study area.

3.2.5 Migration

Migration was practiced by minority (0.3%) of the respondents, therefore in Laikipia West Sub-County, mobility as a response strategy was almost non-existent (Table 3). The low mobility can be attributed to land tenure system, with individual land ownership with title deeds. With this kind of land ownership, there is limited mobility and much confinement.

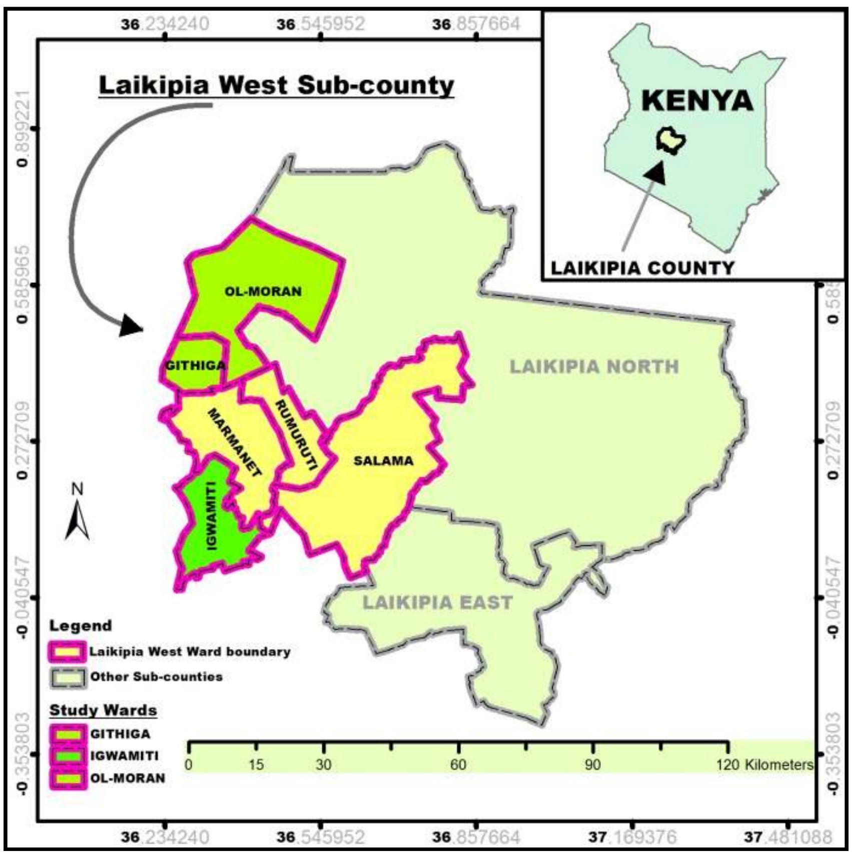

Fig. 1. Map of the Study area showing the three surveyed sites

Table 4. Response strategy to late onset of rains and few number of rain days

Late onset of rains	Response strategy	F	%
	Change of crop variety practices	264	67.0%
	Harvest and store water practices	227	57.6%
Few number of rain days	Water management practices	163	41.4%
	Short season crops practices	225	57.1%

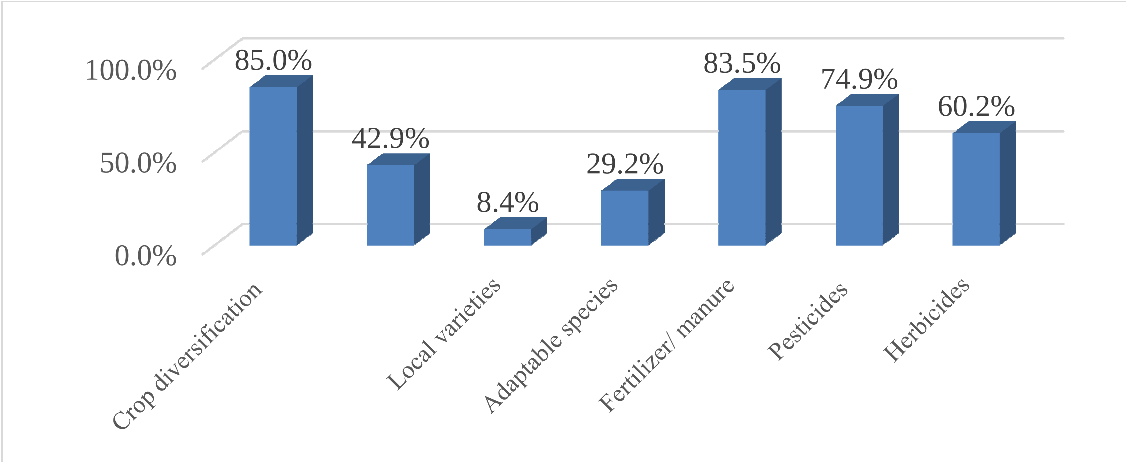

Fig. 2. Agro-pastoral farmers' response strategy to low yields/crop failure

3.2.6 Harvest and store water practices

This study investigated whether, rain water harvesting was used as a response strategy during the late onset of rains. The results after analysis showed that only 57.6% of the respondents used the strategy (Table 4). This average practice could be linked to the findings on land ownership which showed that majority of the respondents in the study area owned land privately. While [26] observes that the potential of rain water harvesting in providing water supplementation to increase crop yield and reduce the risk of crop failure is very high.

Agricultural water management is one of the best bets for adapting agricultural production to climate variability and change. Water management can be improved through a diversity of options such as shallow wells, boreholes and rainwater storage. Nonetheless, the ecological effects of these options need to be investigated [27].

3.2.7 Short season crops practices

The growing season, which is the period of each year when crops can be grown, was expected to be an important coping strategy in order to take advantage of the decreasing rains when available. The study revealed that growing of short season crops was used by 57.1% of the respondents (Table 4). During the questionnaire administration and key informant interviews; maize, kales and tomatoes were mentioned as the crops of choice used under this strategy. Further probing on maize seed used revealed that the type of seeds used were the improved varieties but not the "traditional/ local" varieties and similarly for the other crops. This could therefore be said to be a popular coping strategy. According to [28], the growing season is usually determined in agriculture by the climate, elevation and crop selection. Temperature, rainfall, location and daylight hours (photoperiod), may all be critical environmental factors. In hot climates, such as the study area, the growing season is limited by the availability of water, with little growth in the dry season. It is often possible to greatly extend the growing season in hot climates by irrigation. However, it was expected that the option of taking advantage of the rainy season. A short season is considered to be anything below 110 days and any crop that matures within such a period is considered a short season crop. The Convention on Biological Diversity [24] gives about 7,000 as the plant species that have been cultivated for food since agriculture began about 12,000 years ago. This number of species has been reducing overtime courtesy of plant breeding efforts and currently only about 15 species supply about 90% of human food. The crops referred to as traditional are among these remaining species. The term traditional varieties should therefore be understood to mean those varieties adopted since the colonial period but not hybrid (improved) varieties rather than varieties originating from the area.

3.2.8 Keeping of browsers in the herds

It was expected that agro-pastoralists would adjust their herds in terms of species to take advantage of a specific species capacity to utilize available resources. Species refer to types such as cattle, sheep or goats. Fig. 2 shows that 47% used this as a response strategy because they were more resilient to droughts and secondly they have a higher reproduction rate (average gestation period for shoats is 150 days) than that of cattle (average gestation period for cattle is 280 days). Thus, browsers replaced the lost herds during severe and extreme droughts quicker than cattle.

Table 5. Response strategy to Infertile soils

Response strategy	F	%
Fallow cropping	50	12.7%
Opening new field	4	1.0%

Farm lands in Laikipia West Sub-County are really left fallow as shown by few of the agro-pastoral farmers (12.7% and 1.0%) practicing fallow cropping and opening up new fields

Pastoralists are changing their species composition from grazers (cattle and sheep), to browsers (camels and goats) to reduce risk and insure against natural as well as human-made shocks. They continue to argue that camels and goats easily adapt themselves to changes in pasture [29]. The number of shoat has been increasing at a higher rate than cattle in Laikipia County in general. Between 1999 and 2001 for instance, [30] observed that the overall rise in livestock numbers by 4.1 percent in the county was caused by increased number of browsers since cattle population declined by 26.9 percent. Similar trends have been observed among the pastoralists in Sub-Saharan Africa [31]. For instance, the Borana pastoralists in Ethiopia have reduced the number of cattle while at the same time increasing the shoat population in their herds [32]. While increase in livestock numbers causes overgrazing, the feeding behavior of shoats accelerates the loss of vegetation cover. The ecological impact of the overgrazing is loss of biodiversity.

Table 6. Response strategy to poor crops

Response strategy	F	%
Changing enterprise	111	28.2%
Drought tolerant varieties	183	46.4%
Intercropping	255	64.7%

3.2.9 Planting of drought tolerant crop varieties

The results of this study showed that almost half of the respondents (42.9%) were planting drought tolerant crops such as: sorghum, cassava, millet, and maize varieties as a response to crop failure. The results are in agreement with [7], that efforts are now being put in place to promote the drought resistant crops such as millet, sorghum, sunflower and black beans (dolichos). Other studies show that in the recent years agricultural experts and food agencies like World Food Program (WFP) have raised the issue on the need for Kenya to shift focus from crops like maize and beans to drought tolerant crops [33]. A study by [34] in Mbeere South District indicated that faced with increasingly unreliable rains, farmers in this area have started growing drought-tolerant crops to meet their food and subsistence needs instead of the staple maize. Farmers in other marginal areas of Kenya are also adopting these drought tolerant crops albeit slowly.

3.2.10 Mixed cropping

When this strategy was analyzed results showed that 74.6% of the respondents have used this as a response strategy to decline in crop yields (Table 7). Note that the percent compares very closely with the percentage of those who have practiced crop diversification as a response strategy. This may mean that those who practiced mixed cropping did so as they practiced diversification.

Table 7. Response Strategy to Loss of biodiversity

Response strategy	F	%
Tree planting	332	84.3%
Mixed cropping	294	74.6%
Pasture reseeding	16	4.1%
Mixed farming	280	71.1%

Mixed cropping in modern science is also known as inter-cropping or co-cultivation. It is a type of agriculture that involves planting two or more crop types simultaneously in the same field [35]. In general, the theory is that planting multiple crops at once will allow the crops to coexist either symbiotically or non-competitively together. Possible benefits of mixed cropping are to balance input and outgo of soil nutrients, to keep down weeds and insect pests, to resist climate extremes (wet, dry, hot, cold), to suppress plant diseases, to increase overall productivity and to use scarce resources to the fullest degree. While modern science refers to it as a theory, to the agro-pastoral farmers in the study area, it is a practice. When farmers employ multiple cropping or polyculture systems, they can adapt to local conditions, and sustainably

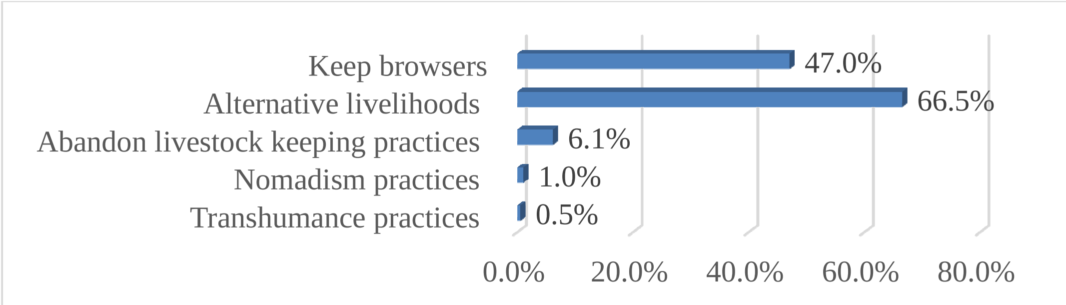

Fig. 3. Response Strategy to Increased droughts

manage harsh environments and meet their subsistence needs without depending on mechanization, chemical fertilizers, pesticides or other technologies of modern agricultural science. Indigenous farmers tend to combine various production systems as part of a typical household resource management scheme. The practice of multiple cropping systems enables agro-pastoral farmers to achieve several production and conservation objectives simultaneously. Furthermore, polycultures exhibit greater yield stability and less productivity declines during a drought than in the case of monocultures. These types of ecological studies suggest that more diverse plant communities are more tolerant to disturbance and more resilient to environmental perturbations [36].

According to a study in Manyoni District of Tanzania [20], mixed cropping was commonly practiced where cereals (maize, sorghum), legumes (beans) and nuts (groundnuts) are grown together. From discussions with farmers, it was noted that they have wide field knowledge on advantages of mixing crops with varying attributes in terms of maturity period (e.g. maize and beans), drought tolerance (maize and sorghum), input requirements (cereals and legumes) and end uses of the product (e.g. maize as food and sunflower for cash). The study revealed that farmers diversify crop types as a way of spreading risks on the farm [37,38]. Crop diversification can serve as insurance against rainfall variability.

3.2.11 Mixed farming

Mixed farming was employed as a response strategy to loss of biodiversity by majority (71.1%) of the agro-pastoral farmers (Table 7).

3.2.12 Tree planting

Majority (83.5%) of the respondents practiced tree planting as a response strategy to loss of biodiversity (Table 7). The agro-pastoralists and key informants stated that majority of the trees were being planted now unlike in the past when there was a lot of deforestation. This agrees with the study findings that the vegetation quality had declined as well the vegetation structure.

3.2.13 Other response strategies

Other response strategies used by the agro-pastoral farmers were IPM principles (9.9%), opening up of new fields (3.0%), nomadism practices (1.0%), transhumance (0.5%), and use of greenhouses (0.5%). These practices were not done by majority of the respondents.

4. CONCLUSION

The agro-pastoral farmers of Laikipia West Sub-County have a lot of indigenous knowledge on how communities respond and cope to climate variability. This was evident because, majority of the agro-pastoral farmers practiced several response strategies to cope with the effects of climate variability such as: Crop diversification, keeping of browsers, mixed cropping, harvesting and storage of water practices, irrigation, amongst others. Few of the agro-pastoral farmers planted drought tolerant crop varieties and the use of greenhouses. Majority of the agro-pastoral farmers also kept poultry and browsers as they required less feed for survival during these times of climate variability and change. The study recommends that, farmers should use indigenous livestock and crop species as they are more adopted to the effects of climate variability.

The study also recommends that, the wealth of traditional knowledge on adaptation and coping that farmers have, should form a foundation for designing agricultural innovation systems to deal with impacts of climate change and variability. Further, development initiatives at community level in semi-arid areas should put more emphasis on planting drought tolerant crops and provide funding for use of greenhouses.

There is also need for integration of both indigenous knowledge and scientific knowledge for better adaptation to climate variability and change.

COMPETING INTERESTS

Authors agree that no competing interests exist.

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