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Research in Biotechnology and Environmental Science. 2023; 2(3): 47-54.

DOI: 10.58803/rbes.v2i3.16

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Research in Biotechnology and Environmental Science

Original Article

Analysis of Coping Strategies Adopted by Smallscale Farmers due to Climate Change Hazards in Baringo County, Kenya

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ARTICLE INFO

Article History:
Received: 26/08/2023
Revised: 18/09/2023
Accepted: 21/09/2023
Published: 25/09/2023

Keywords:
Climate change
Coping strategy
Farmer perception
Logit regression model

ABSTRACT

Introduction: Climate change has adverse effects on food production, leading to detrimental consequences for food security, particularly in regions characterized as Arid and Semi-Arid Lands (ASALs). The focus of this study was to find out strategies used by small-scale farmers to cope with climate change hazard in Lembus-Perkerra Ward, Baringo County, ASAL region vulnerable to climatic hazards hence a suitable site for the study. In line with Sustainable Development Goal 2and 13, many researchers have been conducted on climate change but little has been documented in the study area on climate change coping strategies against its effects. Therefore, the objective of present study was to identify coping strategies that have been adapted by farmers within the study area and assess the farmers perception in regards to climate change.
Materials and Methods: A descriptive research design was adopted for this study, where 191 questionnaires were administered to household heads, and a Focus Group Discussion with key informants (2 agriculture officers) and five lead farmers from farmer groups were conducted to establish sufficient strategies corresponding to climate change situations.
Results: The findings showed strong positive influence at 5% levels of significance, between the selected variables (Age β1.34 P=0.003, Education level β=2.11 P=0.01, Access to climate info β =0.48 P=0.031,Access to extension services β=1.71 P=0.19 and Membership to farmer group β=1.02 P=0.008 shows positive significance to farmers' perception of climate change situations n. The gender of the household head and household size were insignificant in relation to farmers perception.
Conclusion: The results of this study hold considerable importance for both the Baringo County government and the Kenyan government with provide valuable insights for designing effective measures to address the challenges posed by climate change and for crafting policies that can protect local communities from its impacts.

1. Introduction

Climate change continues to pose a worldwide obstacle impacting human well-being, socio-economic endeavors, health, sustenance, and food stability[1]. Due to its effects, developing countries and poor smallholder farmers face increased vulnerability due to their insufficient ability to adapt[2]. Numerous countries, particularly those in Sub-Saharan Africa (SSA), prioritize agriculture as a means of ensuring an ample food supply for their populations, which is a critical factor in food security. Nevertheless, despite its considerable importance, agriculture remains susceptible to the potential consequences of climate variability and change, while the essential measures needed to bolster the sector in numerous developing nations continue to be deficient and delicate[3]. Hence, if climate variability and change are not effectively managed, it could lead to significant food insecurity, particularly impacting developing nations to a great extent[4,5]. According to Robinson (2020), regarding the IPCC assessment report, the anticipated rise in temperature to 1.5 degrees Celsius will place various developing countries at risk of climate-related challenges, impacting aspects such

► *Cite this paper as*: Cherono J, Siren JJ. Analysis of Coping Strategies Adopted by Smallscale Farmers due to Climate Change Hazards in Baringo County, Kenya. Research in Biotechnology and Environmental Science. 2023; 2(3): 47-54. DOI: 10.58803/rbes.v2i3.16

as health, livelihoods, food security, water supply, human security, and economic growth[6].

The high reliance of smallholder farmers on rain-fed agriculture leaves them exposed to the significant consequences of climate change, particularly in the context of high poverty levels[7]. In Kenya, climate change poses a credible threat to both food security and the economy, given its sensitivity to fluctuations in rainfall. The agricultural sector, which plays a pivotal role in Kenya's economic growth, contributes substantially to the country's GDP, both directly and indirectly[8]. Nevertheless, the sector's productivity has been compromised by evident manifestations of climate variability and change[9]. To effectively address these adverse effects, there is a pressing need to enhance the resilience of local farmers to climatic variations. This requires the adoption of strategies aimed at minimizing the impact on crops and subsistence while mitigating the root causes of climate change[5].

The majority of existing research has focused on climate change, but there has been limited attention given to exploring how farmers in Baringo County perceive and cope with these changes. Consequently, the current study sought to address this underexplored area, aiming to provide substantial evidence that can inform policy development. The ultimate goal was to strengthen farmers' ability to withstand climate-related challenges and identify practices that can be expanded and encouraged in similar ecological regions within the study area.

The agricultural industry has the capacity to play a role in both mitigating climate change and enhancing resilience through adaptation efforts. This sector is responsible for approximately 3.7% of worldwide greenhouse gas emissions (GHGs). Furthermore, it serves as a significant factor in deforestation activities, contributing an additional 7-14% to global greenhouse gas emissions[10].

In Baringo, the causes of climate change are primarily attributed to human activities, including deforestation, charcoal production, overgrazing, insufficient soil and water conservation practices, and extensive deforestation in both Baringo County and neighboring regions that serve as watersheds for the area[11]. The high reliance on rain-fed agriculture by small-scale farmers makes them highly susceptible to the profound impacts of climate change, as they lack adequate resources to adapt to adverse shocks, exacerbating issues related to food insecurity and global poverty. Local farmers continually adjust to climate variability by changing crop varieties, selecting different planting and harvesting dates, modifying land management practices, and adopting water-efficient techniques. Pepela et al. have suggested that national governments and development agencies play a crucial role in building farmers' capacity to cope with and adapt to a changing environment[12].

In line with Sustainable Development Goal 2 and 13, many researchers have been conducted on climate change but little has been documented in the study area on climate change coping strategies against its effects. Therefore, the objective of present study was to identify coping strategies that have been adapted by farmers within the study area and assess the farmers perception in regards to climate change.

2. Materials and Methods

2.1. Study area

Lembus-Perkerra ward is in Baringo county designated as ASAL area, occupies approximately 130.20 km^2 has a population of 15,871. Agriculture, including activities like beekeeping, livestock rearing, and crop farming, serves as the cornerstone of the local economy, offering a primary source of livelihood for 80% of the population while generating income and employment opportunities (Figure 1).

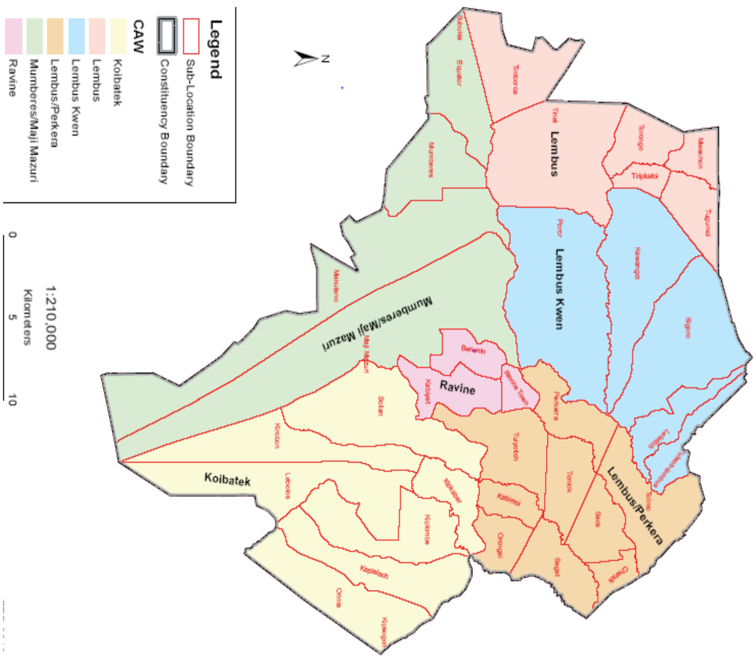

Figure 1. A Map showing a Study Area within Eldama-ravine Subcounty

2.2. Sampling methods and data collection

The study employed a simple random sampling method to choose the households under investigation. Data collection was carried out using structured questionnaires, which had been pre-tested on a selected group of households in the area before the main survey began (a pilot study). To gain a comprehensive understanding of the efforts made by various institutions to assist farmers, a Focus Group Discussion (FGD) was also conducted at the central location of Lembus-Perkerra ward. This discussion involved five lead farmers from farmer groups and two officials from the Ministry of Agriculture. A total of 191 households were sampled using Cochran's formula, distributed proportionally across five locations (Saos, Kabias, Kibimou, Kabimoi, and Toniok) based on their population sizes. The study was conducted between May and August 2020, during the COVID-19 pandemic.

2.3. Research design

The research employed a descriptive research design, which is suitable for capturing the characteristics or conditions of a specific phenomenon, essentially answering the question of "what exists." In this study, the descriptive research design was utilized to provide a comprehensive overview of the adaptation strategies adopted by smallholder farmers. This design incorporates the use of both primary and secondary sources of data.

2.4 Data analysis

The SPSS software version 20 and excel was used to analyze data and descriptive analysis was presented in tables and figures. Factors influencing socio-economic variables farmer, perceptions were analyzed in a logistic regression model framework where analysis of variance with β coefficients of explanatory variables and odd ratios predicts the influence of farmers' perception to climate change. The reliability of the questionnaire was tested in Cronbach's alpha test after the pilot study and a value of 0.714, hence there was consistency of the questionnaire.

3. Results and Discussion

3.1. Objective 1: Smallholder farmers' perception of climate variability and change

The sampled respondents gave their testimonials on the severity impacts of climate change as they perceive it as very hazardous as illustrated in Figure 2.

In order to assess coping strategies for climate change, it is imperative to have a clear comprehension of how farmers perceive climate changes[15]. Farmers in this study made comparisons between present-day weather conditions and those from a decade ago, pinpointing indicators of climate variability and change within their region. The variables that were analyzed included fluctuations in temperature, the distribution of rainfall, the timing of rainfall onset, and the correlation of these changes with human activities.(Figure 3).

The findings show that 90% of farmers observed a reduction in rainfall over a period, while only 1% and 9% reported an increase or stability in rainfall levels, respectively (Figure 1). This decrease in rainfall is evident through diminished precipitation amounts and the presence of unpredictable and inconsistent rain patterns. These outcomes are consistent with the research conducted by Belay et al., which also reported that farmers in various areas of Kenya had similarly noticed a decline in rainfall over time[16].

81.3% of the respondents, observed a rise in temperatures over the years while 12% believed the rainfall has moderately decreased and 6.7% explained

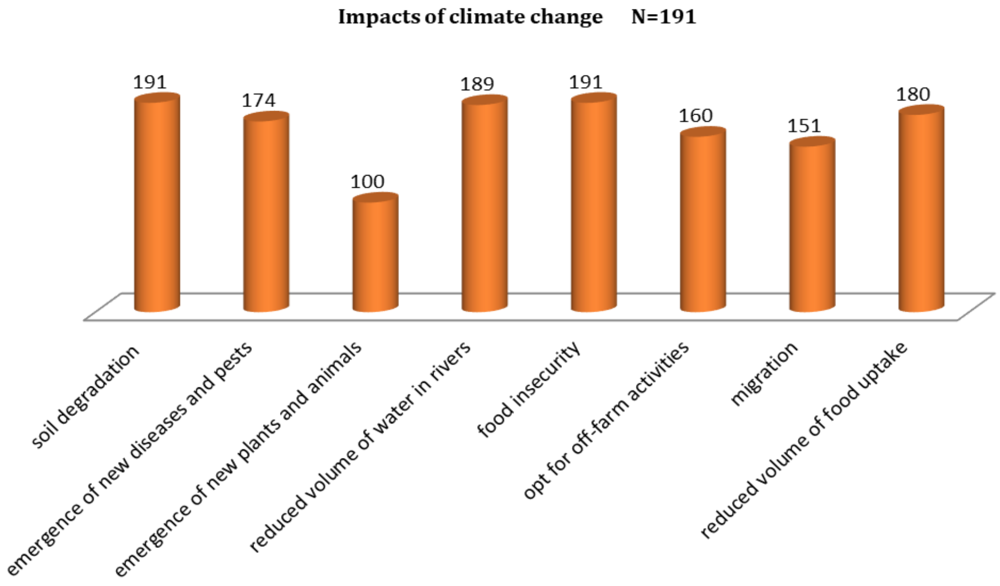

Figure 2. Farmers perception on impacts of climate change

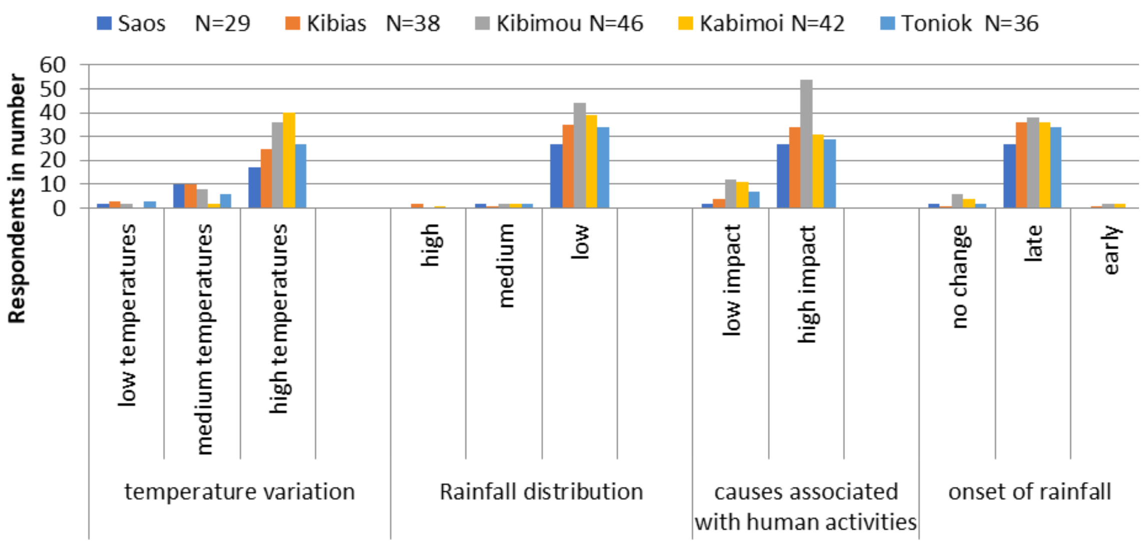

Figure 3. Farmer perception for climate variability

that there have been low temperatures over 10 years. The findings are consistent with those of[17]. High temperatures have a detrimental impact on dairy production as it leads to poor body condition and even death of animals hence loss of income. These impacts will soar higher according to the projection illustrated in Figure 4.

Farmers' perception of the increased temperatures mirrored the factual climatic data projected by kcsap (Secondary data). Livelihoods aspects greatly impacted by the climate change events were high as recorded by 90.29% while 9.71% recorded low impact (Figure 3). The associated human activities include charcoal burning, brick making, sand harvesting, deforestation among others.

Onset of rains also was another variable to be measured and 89% of the sampled household explained that onset of rainfall has delayed over years. The changes in the onset of rainfall have disrupted the traditional seasonal calendar followed by farmers, which was already perceived to be short. farmers participating in the Focus Group (FGD) Clarified, "since the 1990s, there had been a rise in temperatures and a decrease in rainfall amounts". These changes, as indicated in the study's results, had an adverse impact on agricultural productivity and contributed to food insecurity. The farmers also pointed out that the seasonal planting schedule had shifted from December-January and July-August to March-May and September-November, respectively (Figure 4).

3.2. Objective 2: Factors influencing smallholder farmers' perception of climate change

Inferential statistics was applied using logit regression analysis to test hypothesis and to draw the conclusions showing the effect of selected variables on farmer perception to climate change as represented in Table 1.

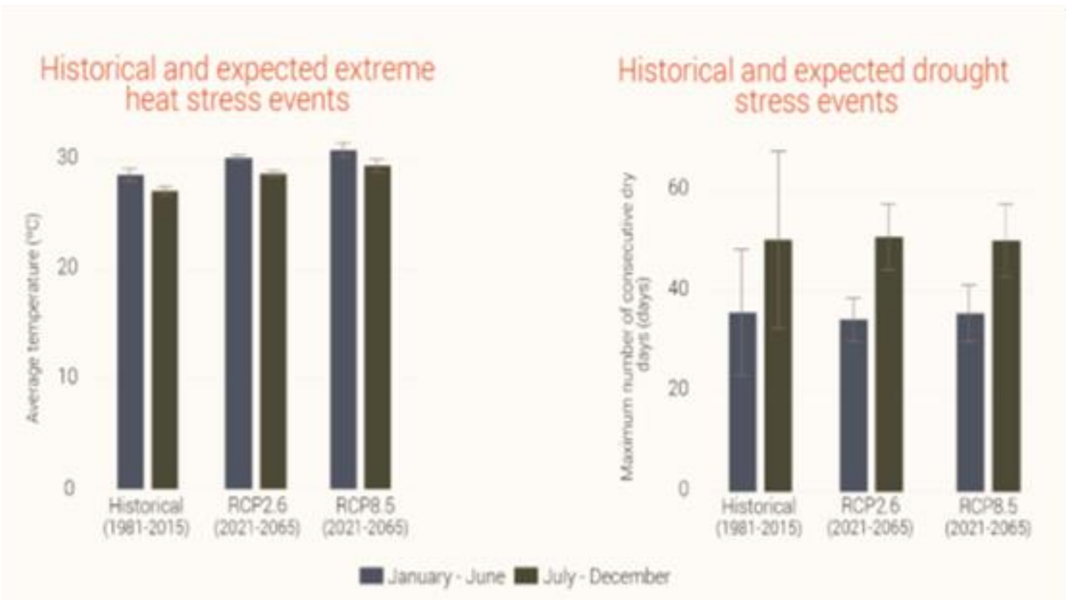

Figure 4. Source: Kenya climate smart agriculture report on heat stress events and projections

$Z_i (1, 0) = \beta_0+\beta_1X_1+ \beta_2X_2+ \beta_3X_3+ \beta_4X_4+ \beta_5X_5...+\beta_nX_n + e$

Where, z_i the probability that a farmer perceive climate change (high temperatures, low rainfall Figure 2). X represents the explanatory variables; *e* denotes the base of natural logarithms, which is approximately equal to 2.718. β_0 is the intercept term (constant), $\beta_1 ... \beta_n$ are the coefficients of the explanatory variables and $X_1....X_n$ are the corresponding vectors of regression. The coefficients reflect the effect of individual explanatory variables on its *odd ratios.* Therefore, taking the predictor variables of the study,

Farmer perception= $\beta_0+\beta_1$(Gen)+B_2(Age)+B_3(Edu)+ B_4(Hhsize)+B_5(access to climate info) +B_6(access to extension)+ β_7 (M.Social group) + *e (2.718 constant)*

Among the 191 households surveyed, 38.6% were headed by males, while 61.4% were headed by females. The notable higher percentage of female respondents can be attributed to the fact that a significant number of men had relocated to urban areas in search of additional income opportunities outside of farming. From the study findings (Table 1), the influence of gender of the household head and the household size were insignificant.

Age was found to have a significant influence on farmer perception on climate change β= 0.82 p= 0.003. This shows that as the age of a farmer increases, it increases the likelihood of perceiving climate changes, low rainfall and increase in temperature by 1.85odds. This could be contributed by the increase in knowledge awareness and experiences.

Out of all the households included in the sample, 53% had completed secondary school education, 10.1% had completed primary school, 14.2% had received education at the college or university level, 2% had no formal education, and 20.7% had dropped out of school at some point. The regression findings showed that respondents who have attained higher education level with β=2.11 p=0.015 increases the likelihood of perceiving general climate change, a decrease in rainfall and an increase in temperature by 2.12 odds. Educated farmers have the capacity to receive, interpret, and identify changes in their surroundings and understand information that is pertinent for making accurate decisions related to climate change[18]. A study by Siren et al. also found that level of education influences 'perception of soil and water conservation technologies in West Pokot County[19].

The study findings showed that access to weather and climate information with β=0.48, p=0.031 odd ratio of 2.28 increases the likelihood of perceiving climate changes, a decrease in rainfall and an increase in temperature. The access to climate information increases farmer's awareness and knowledge of the variations in rainfall and temperature, and this informs their response strategies such as what crop varieties to plant, time to plant[2].

Access to agricultural extension services β=1.71; P<0.019 and an odd ratio of 2.29, recorded positive significant effect increases the likelihood of perceiving climate changes, decrease in rainfall and increase According to Caffaro et al. farmers' perception was among the drivers of farmers' intention to adopt technological strategies in Italy[20].

Belonging to a social group is positively associated with farmers' perceptions of coping strategies, as it allows them to exchange and access information on climate, innovations, and other pertinent knowledge that can improve their resilience. Among the respondents surveyed, 92.4% were part of a social group, while 7.6% were not affiliated with any social group. These social groups included entities like "Chama," social groups, or farmer associations. From regression analysis, membership to farmer group (β=1.00; P<0.008) recorded positive significant effect explained increase in likelihood of perceiving climate changes, a decrease in rainfall and an increase in temperature by 3.94. These findings correlate with results by Cherono et al. where it was observed that membership to farmer groups had a greater significance in participation on soil erosion management in West Pokot[21]. From the FGD, membership to social group positively influences the access to extension services, farmer training, pooling the resources together and credit access. The existing farmer groups in the area are as shown in Figure 5.

The Kenya climate Smart agriculture project supports the existing farmer groups by issuing drought resistant crop varieties e.g millet, sorghum, melon seeds, indigenous chicks, livestock feeds and disease management practices. "Hence, coming up together has been beneficial" one of the respondent explained.

Table 1. Factors influencing farmer perception on climate change

Variable	B	p value	Odd ratio
GEN (X_1)	0.82	0.87	2.27
AGE (X_2)	1.34	0.003*	1.85
EDU (X_3)	2.11	0.015*	2.12
Hh size(X_4)	2.36	0.65	3.24
Weather info (X_5)	0.48	0.031	2.28
EXT (X_6)	1.71	0.019	2.36
MEMBR (X_7)	1.00	0.008*	3.94
CONSTANT	9.24	0	0

Significant level is defined at 5%. Dependent variables are dummy variables measuring climate change perceptions

3.3. Objective 3: Climate change coping strategies adopted by smallholder farmers

Coping strategies and enhanced adaptive capacity of farmers are crucial in addressing climate variability and change. Figure 6, shows the strategies identified during the study.

3.3.1. Decrease in crop quantity grown/ livestock kept

Findings of this study recorded a sample of 112 households reported a decrease in the quantity of the major food crop grown and number of livestock kept by small holder farmers. Most farmers reported that this could have been attributed by a fear of losses from the risks and uncertainties such as droughts, landslides, pests and

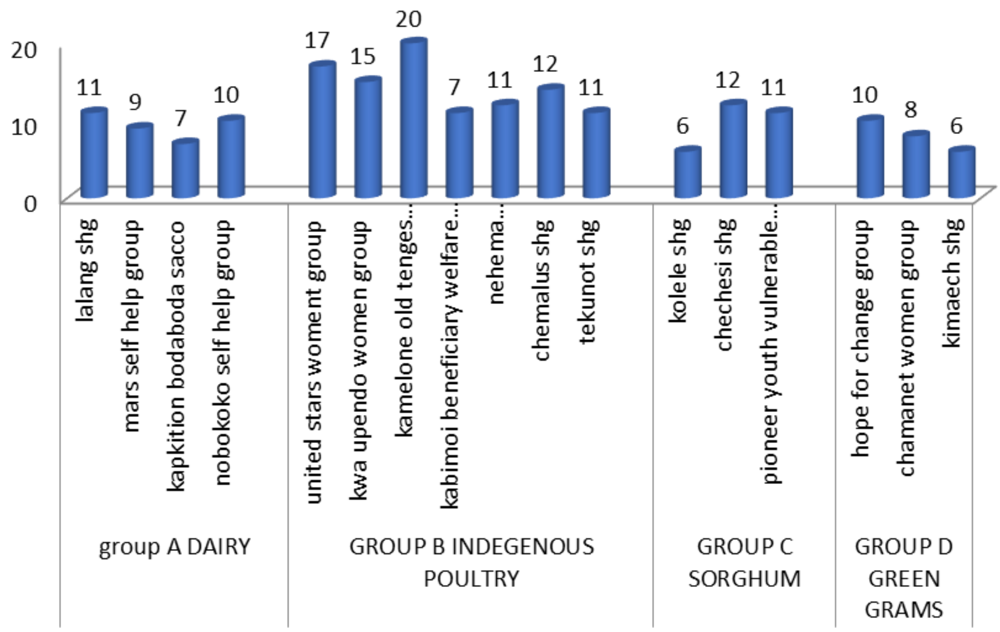

Figure 5. The existing farmer groups in the study area

diseases. Adiel, also reported a fear of the fore-mentioned risks and uncertainties in the study on climate variability risk perception on rain-fed agricultural practices among small-scale farmers in Embu County, Kenya[22]. Emergence of Tuta Absoluta pests that affected Perkerra Irrigation Scheme since 2001 and nearby areas have forced farmers to reduce the quantity of crops grown[23]. During the Focus Group Discussion (FGD), the majority of farmers mentioned a consistent decline in the cultivation of essential food crops on their farms. They also reported shifts in their livelihood patterns, the disappearance of certain plant species, rising food prices, and other related impacts.

3.3.2. Crop Diversification

To ensure a continuous supply of food in the homesteads, 187 of the sampled households opted for crop diversification to improve food security and nutrition as they farm fruits like mango, melon, pawpaw among others, and different crops of different nutritive values. Farmers participating in the FGD explained that, in response to reduced crop production, they practice mixed cropping, which involves cultivating multiple crops simultaneously. This approach helps safeguard them in the event of a failure in one of the crops.

3.3.3. Change in crop variety

The results show that 154 respondents have altered the types of crops they cultivate as an adaptation strategy to address the shifting climate conditions. These respondents clarified that they have transitioned to planting drought-tolerant crop varieties like millet, sorghum, watermelon, pumpkins, and others. These findings align with research findings from farmers in semi-arid and sub-humid regions of Kenya who have also abandoned certain crops due to poor yields associated with limited rainfall and have opted for early-maturing and drought-resistant crop varieties instead.

3.3.4. Change of planting time adaptation practices

In this research, 102 respondents make some changes their planting time in response to alterations in temperature and variations in rainfall. Many of these farmers transitioned to planting their crops after the onset of rainfall when they were confident that there was sufficient soil moisture to support growth. According to the respondents in the FGD, farmers typically plant between December and February before the long rainy season begins, while in the short rainy season, they opt for planting between September and October.

3.3.5. Change in land use adaptation strategies

In order to boost farmers' ability to withstand challenges posed by climate change, 182 respondents described their adoption of improved land-use practices.

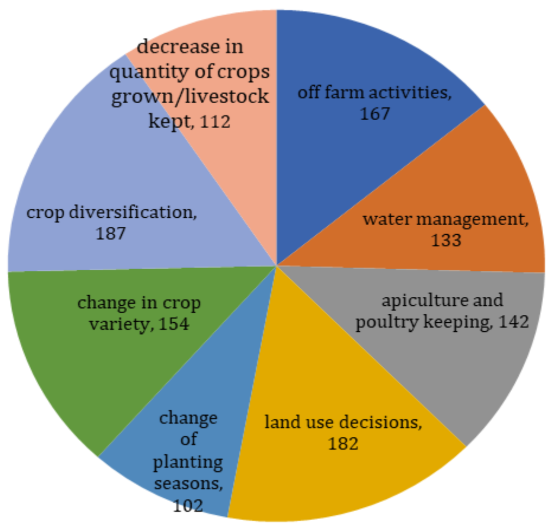

Figure 6. Farmers' frequency on their Coping Strategies

These farmers engaged in either crop rotation or mixed cropping to enhance soil fertility and overall productivity, recognizing that different crops have varying nutrient requirements that can benefit each other when cultivated together. Including legumes like beans to aid in nitrogen fixation, which contributes to improved soil fertility. Some households also implemented soil conservation techniques such as minimal tillage, mulching, and terracing on their farms.

3.3.6. Apiculture and poultry farming

142 sampled farmers have resorted to bee keeping as they explained that the activity is not affected by climatic variation unlike farming activities. 78% of the sampled household also rear indigenous and improved chicken. Indigenous or local chicken is an important source of food, income, and employment. Worm infestation and diseases including New Castle Disease, Coccidiosis, and fowl typhoid are among the challenges they experience in this venture.

3.3.7. Water management

The reduction of water volume in the rivers was also noted. 133 of sampled households use irrigation systems, mulching to improve water retention, water harvesting during the drought seasons. This depicted that farmers have partly shifted from over-reliance of rain-fed agriculture.

3.3.8. Off –farm activities

From result findings, it was recorded that 167 respondents have opted for other off-farm activities such as boda-boda businesses, brick making, sisal weaving, sand harvesting, selling firewood, charcoal burning among others. Farmers from FGD also explained that these strategies have helped them resilient to climate change hazards since they get income. Although, some of these activities were reported to have negatively impacted the environment.

4. Conclusion

Farmers' recognition of rising temperatures and declining rainfall, leading to reduced agricultural productivity, is closely tied to their education levels, access to climate information, and engagement with agricultural services and farmer groups. Small-scale farmers have responded to these challenges by adopting adaptive measures like crop diversification, reduced crop/livestock quantities, altered planting times, mixed cropping, and changing crop varieties. These strategies are explicitly aimed at bolstering their resilience against climate fluctuations. To further enhance resilience and reduce vulnerability, it is recommended that government and non-governmental organizations conduct climate change training, provide support for mitigation and coping, and offer critical inputs such as disease-resistant and drought-tolerant seeds as part of local development efforts. Additionally, fostering effective connections and collaboration among farmers, researchers, extension officers, and meteorologists is crucial for aligning knowledge and coping strategies.

Declarations

Competing interests

There was no conflict of interest.

Authors' contribution

Janeth Cherono designed the study methodology, performed the statistical data analysis, the literature reviews.

Janet Jebet Siren guided on data analysis and interpretation of results findings, literature searches and previews. All the authors read, substantially revised and approved the final manuscript.

Funding

The authors received no financial support for the publication of this article.

Ethical considerations

The authors checked for plagiarism and consented to the publishing of the article. The authors have also checked the article for data fabrication, double publication, and redundancy.

Acknowledgments

Most sincere gratitude to MR. Makau S. Lawrence and Mureithi James, Baringo Ministry of Agriculture office for the Ethical Research acceptance,enumerators, farmers from Perkerra Ward who contributed greatly to the success of this research study.

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