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*Original Article*

# Factors Influencing Farmers' Adaptations to Climate Change and Variability in Arid and Semi-Arid Lands of Kitui and Kajiado Counties, Kenya

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*Arid and Semi-Arid Lands, Adaptation Strategies, Climate Variability, Logistic Regression.*

## ABSTRACT

A study was conducted in the arid and semi-arid lands of Kitui and Kajiado counties to determine factors that influence farmers' adaptation to climate change and variability. Quantitative and qualitative approaches were applied in the study to gain insights into the adaptation strategies used by farmers to cope with climate change and variability and factors that influence their adoption. A mix of purposeful and multistage stratified random sampling methods were used to select households which formed the unit of analysis in the study. Results of the Chi-square test for independence indicated that there was an association between the adoption of different adaptation strategies to climate change and variability and the study sites ($p< 0.05$). In addition, scrutiny of the results of logistic regression analysis showed that gender, education level, farming experience, age, and county of the respondent significantly ($p<0.05$) influenced the adoption of adaptation strategies to climate variability and extremes in the study area. The study identified the need for increased agricultural extension training and sensitisation on climate change among farmers to ensure that feasible adaptation strategies are promoted and factors influencing their adoption are leveraged.

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## INTRODUCTION

Increasing human population and the concomitant rise in development activities along with climate change are predicted to have a major impact on water resources, with more frequent surface-water droughts, higher evaporation from lakes, reservoirs and wetlands, and more intense rainfall events with land flooding and 'flashy' streamflow. Increased evaporation and the risk of flooding and drought could adversely affect the security of the water supply, particularly surface water. Due to these pressures, as well as global population growth, demand for groundwater is likely to increase. Though the geographical distribution of these impacts is still subject to considerable uncertainty, they are likely to be more severe in the semi-arid climatic zones, where alluvial aquifers are mostly located, and they consequently increase the vulnerability of farmers to the changing environment (Kamau et al., 2020).

Against this background, farmers who are used to rain-fed farming systems are being pushed into the dryer, more marginal areas where they become increasingly vulnerable to drought and the unpredictability of weather patterns. For example, the population increase, coupled with the expansion of agriculture into arid lands, has affected the dynamics of pastoralism, where increased competition for natural resources has sparked escalated conflict in some areas (FAO, 2018). Furthermore, there has been a marked increase in the number of people dropping out of the nomadic livelihood, often moving into settled communities which are heavily reliant on food aid.

In the climate change scenario, which is precipitated by overall environmental changes, growth in agricultural production is a function of its resilience to climate change since this sector is highly vulnerable. The impact of climate change on agriculture is gaining currency as the IPCC (2007) and several other organisations predict the increasing changing trend of global climate change. Therefore, policy actions are required to reduce the vulnerability of the farmers to the changing climate. To this end, the climate policy literature suggests two policy options to deal with the inevitable impacts of climate change and variability, namely, mitigation and adaptation. While, traditionally, mitigation has received a higher priority, nowadays, adaptation is gaining worldwide interest because it responds quickly to climate change. The Government of Kenya (GoK) has also started to give it importance, along with mitigation, as is evident from Kenya's National Climate Change Action Plan (GoK, 2016).

According to Maddison (2006), an entity or system tends to adapt autonomously to climate change and variability, but not enough to offset losses from it as evidenced in the agriculture sector where farmers have adopted a myriad of adaptations but continue suffering losses season after season. Therefore, this calls for policy-driven or planned adaptation. In this context, the current study was conceived with the objective of assessing adaptation strategies to the changing environment practised by the farmers with a view to adducing information useful in shaping policy-driven adaptation.

## METHODOLOGY

### The Study Area

The study was conducted in the Kitui and Kajiado counties of Kenya (*Figure 1*). Tiva and Toroka river

 

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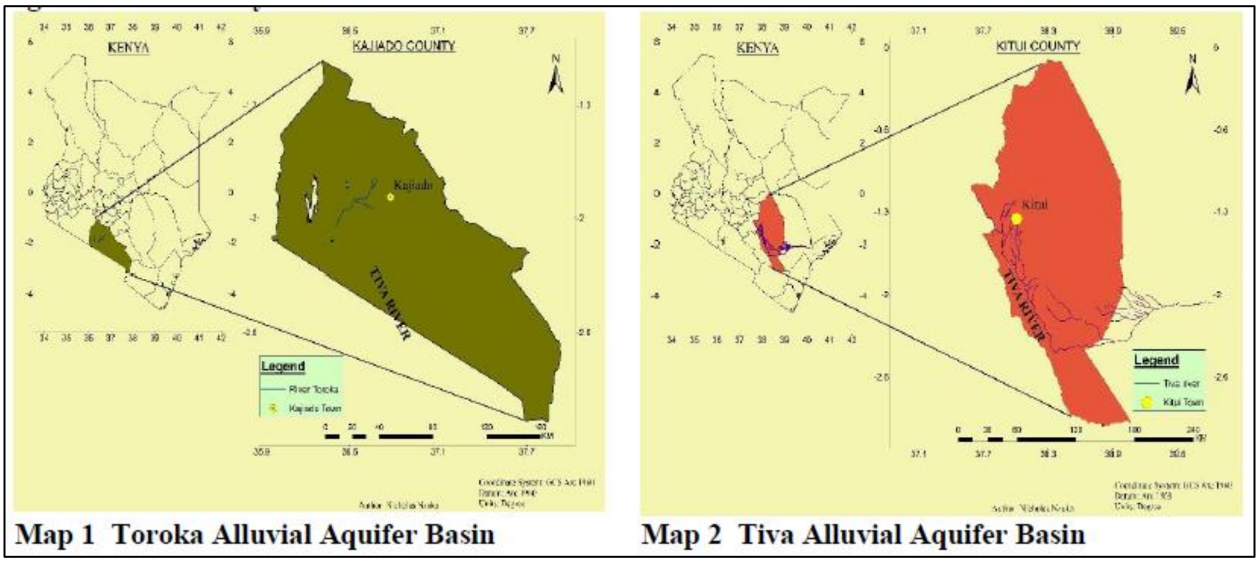
catchments formed the study sites for Kitui and Kajiando counties, respectively. The climate of the two study sites falls under two climatic zones, namely, arid and semi-arid, with most of the area being classified as arid (Government of Kitui, 2013 and Government of Kajiado, 2013). Both counties experience high temperatures throughout the year, ranging from 14 °C to 34 °C. The hot months are between September and October to January and February. The maximum mean annual temperature ranges between 26 °C and 34 °C whereas the minimum mean annual temperature ranges between 14 °C and 22 °C. July is the coldest month with temperatures falling to a low of 14 °C, while the month of September is normally the hottest with the temperature rising to a high of 34 °C (Government of Kitui, 2013 and Government of Kajiado, 2013).

The rainfall pattern is bi-modal with two rainy seasons annually. The long rains fall in the months of March to May. These are usually very erratic and unreliable. The short rains which form the second rainy season fall between October and December and are more reliable. The rest of the year is dry and the annual rainfall ranges between 250 mm-1050 mm per annum with 40% reliability for the long rains and 66% reliability for the short rains. Rainfall is highly unpredictable from year to year (Government of Kitui, 2013 and Government of Kajiado, 2013).

**Figure 1: Map of the study area**




### Research Design and Data Collection

In order to meet the data requirements of the objectives, both quantitative and qualitative data were collected in the lower and upper reaches of the two river catchments. Household interviews guided by interview schedules were conducted in the two study sites. In addition, researcher participant observation was done to collect more information from the field.

### Statistical Data Analysis

Analysis of the association between adaptation strategies to climate change and variability adopted by the farmers and the study sites was done by use of the chi-square test for independence. Logistic regression analysis was employed to determine factors that influence farmers' adaptation to climate change and variability. Dependent and explanatory variables used in the logistic regression analysis are shown in *Table 1*.

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**Table 1: Description of the explanatory variables used to predict farmers' adaptation to climate change and variability in arid and semi-arid lands of Kitui and Kajiado Counties, Kenya**

| Variable | Description | Expected relationship with the adaptation |
|---|---|---|
| $X_1$ | Education in years of the household head | + |
| $X_2$ | Gender of the household head (1=male; 0= female) | +/- |
| $X_3$ | Farming experience in years of the household head | + |
| $X_4$ | County of the respondent (1=Kajiado; 0= Kitui) | + |
| $X_5$ | Household size | +/- |

## RESULTS AND DISCUSSION

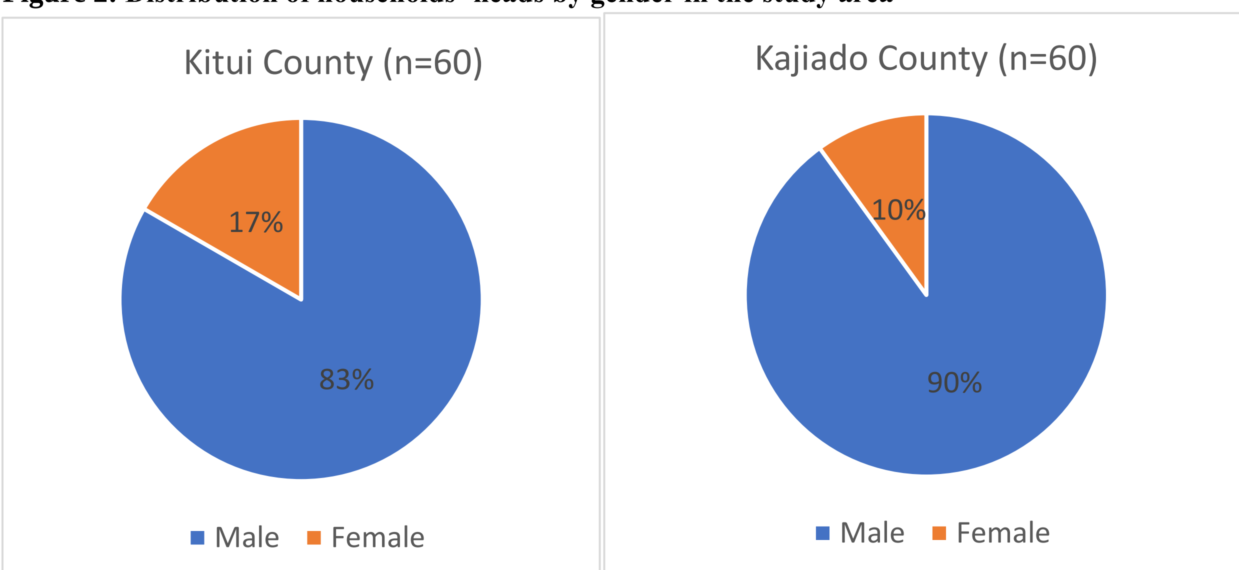
After the field data collection exercise, data were analysed using appropriate statistical software and results were presented as indicated below.

### Socio-Economic Characteristics of Households in Kitui and Kajiado Counties

#### *Gender*

A total of 120 respondents were sampled from Kitui and Kajiado Counties with equal numbers (n=60) from each of the two study sites. The results indicated that 83% and 90% of the respondents from Kitui and Kajiado Counties were males, respectively. Similarly, 17% and 10% of those respondents in Kitui and Kajiado Counties were females, respectively (*Figure 2*).

**Figure 2: Distribution of households' heads by gender in the study area**




#### *Age*

Results presented in *Table 2* indicated that the mean ages of the respondents in Kitui and Kajiado Counties were 51.50 years and 47.93 years, respectively. The minimum and maximum age of the respondents ranged from 23 to 70 years in Kitui County. In Kajiado County, the minimum and maximum age of the respondents ranged from 27 to 89 years.

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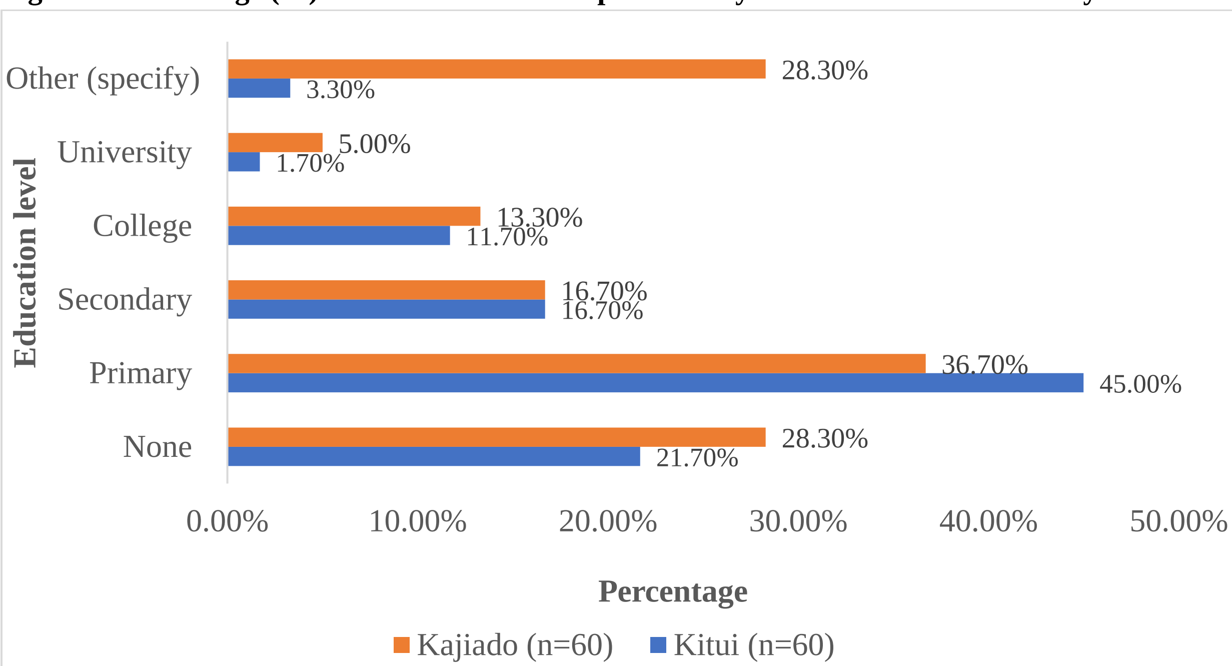
**Table 2: Age distribution of the respondents in the study area**

| Counties | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Kitui | 51.50 | 11.843 | 23 | 70 |
| Kajiado | 47.93 | 13.169 | 27 | 89 |

***Education Level***

Scrutiny of the results presented in *Figure 3* revealed that 28% of the respondents in Kajiado County had no formal education, while 36.70%, 16, 70%, 13.30%, and 5.00% had attained primary, secondary, college, and university education, respectively. The majority of the respondents from Kitui County (45.00%) had attained primary education, while 21.70% had no formal education, and 16.70%, 11.70%, and 1.70% had attained secondary college and university-level education, respectively. Further, results indicated that 28.30% and 3.30% of the respondents from Kajiado and Kitui Counties respectively had acquired other forms of education such as welding, carpentry, mechanics, hairdressing and beauty, among other artisan trainings.

**Figure 3: Percentage (%) distribution of the respondents by education level in the study area**




***Household Sizes***

The average household sizes in Kitui and Kajiado Counties were 7 and 8 individuals, respectively. Results presented in *Table 3* further indicated that the minimum household sizes in Kitui and Kajiado Counties were 2 and 3, respectively, while the maximum sizes ranged from 12 to 17 individuals.

**Table 3: Households size in Kitui and Kajiado Counties**

| Counties | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Kitui | 7.10 | 2.215 | 2 | 12 |
| Kajiado | 8.47 | 3.568 | 3 | 17 |

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## Adaptation Strategies Adopted in Response to the Changing Climate

### *Water Conservation Measures Adopted by Households*

Study results presented in Table 4 revealed that the most adopted water conservation measures were roof water harvesting at 81.7% (41.8% in Kitui and 58.2% in Kajiado), dew harvesting at 63.3% (26.3% in Kitui and 73.7% in Kajiado) and traditional wells at 62.5% (29.3% in Kitui and 70.7% in Kajiado). Earth dams were adopted by 60% of total households (26.4% in Kitui and 73.6% in Kajiado), while hand-dug wells were adopted by 54.2% of total households (21.5% in Kitui and 78.5% in Kajiado). Water pans were also a common water conservation measure in the study areas adopted by 47.5% of total households (3.5% in Kitui and 96.5% in Kajiado). Further results in Table 4 showed that rock catchment and sand dams were adopted at equal rates (45.0% of total households), although the adoption rate was significantly higher in Kajiado than in Kitui. Similarly, sub-surface dams and natural depressions were adopted at equal rates (43.3% of total households), but the adoption rates were significantly higher in Kajiado than in Kitui. Scrutiny of the results of the chi-square test for independence showed statistically significant relationships between the Counties and the adoption of all the water conservation adaptation strategies ($p<0.05$). The rate of adoption of water conservation adaptation strategies was higher in Kajiado County compared to Kitui County.

The use of water harvesting and conservation structures as a popular adaptation strategy in the study area can be attributed to pronounced inter-seasonal and annual rainfall variability in arid and semi-arid areas. Similar studies by Ndungu and Bhardwaj (2015) and Mutunga et al. (2017) indicated that farmers adopt different strategies to harvest and conserve water to support their livelihoods in the face of the changing climate. The difference between Kitui and Kajiado Counties in the adoption of water harvesting and conservation structures can be ascribed to barriers to adaptations which include the high cost of adaptation, limited knowledge and lack of extension services, among others. Similar studies have found a strong positive relationship between the adoption of adaptation practices and wealth, education, knowledge, access to extension services, information sources and institutional credit, irrigation facilities and efficient and reliable weather (Ndungu & Bhardwaj, 2015; Juana et al., 2013).

**Table 4: Water conservation measures (%) adopted by households in the study areas**

| Water conservation adaptations | Kitui % (n=60) | Kajiado % (n=60) | Total % (n=120) | $X^2$ | P- |
|---|---|---|---|---|---|
| Rock catchment | 5.6 | 94.4 | 45.0 | 77.576 | 0.00** |
| Sand dams | 1.9 | 98.1 | 45.0 | 91.044 | 0.00** |
| Sub-surface dams | 1.9 | 98.1 | 43.3 | 84.842 | 0.00** |
| Farm ponds | 0.0 | 100 | 40.8 | 82.817 | 0.00** |
| Water pans | 3.5 | 96.5 | 47.5 | 93.868 | 0.00** |
| Earth dams | 26.4 | 73.6 | 60.0 | 40.139 | 0.00** |
| Natural depression | 1.9 | 98.1 | 43.3 | 84.842 | 0.00** |
| Roof water harvesting | 41.8 | 58.2 | 81.7 | 14.249 | 0.00** |
| Dew harvesting | 26.3 | 73.7 | 63.3 | 46.507 | 0.00** |
| Traditional wells | 29.3 | 70.7 | 62.5 | 34.169 | 0.00** |
| Hand-dug wells | 21.5 | 78.5 | 54.2 | 45.952 | 0.00** |

*Note: ** indicate significant at a 5% level of significance*

 

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***Crop Management Adaptation Strategies***

Results presented in Table 5 indicated that planting drought-resilient crops was the most practised crop management adaptation strategy with an adoption rate of 88.3% (48% in Kitui and 51.9% in Kajiado County). The adoption rate for the use of pesticides was 86.7% (47.1% in Kitui and 52.9% in Kajiado). Another common adaptation was the mixed crop-livestock system, whose adoption rate was 85.8% (47.6% in Kitui and 52.4% in Kajiado). Further, the results showed that 84.2% of farmers changed planting time (46.5% in Kitui and 53.5% in Kajiado) while 81.7% adapted by using improved crop variety (43.9% in Kitui and 56.1% in Kajiado). Other common adaptation strategies included the use of organic fertiliser 79.2% (45.2% in Kitui and 54.7% in Kajiado), crop diversification 78.3% (41.5% in Kitui and 58.5% in Kajiado), agroforestry 75% (38.9% in Kitui and 61.1% in Kajiado), irrigation and minimum tillage each with an adoption rate of 65.8% (32.9% in Kitui and 67.1% in Kajiado). As shown in Table 5, a considerable proportion of households had adopted water harvesting schemes 60% (26.4% in Kitui and 73.6% in Kajiado), integrated pest management 58.3% (21.4% in Kitui and 78.6% in Kajiado), water reusing 53.3% (15.6% in Kitui and 84.4% in Kajiado), and soil conservation techniques 52.5% (17.5% in Kitui and 82.5% in Kajiado). Among the least adopted adaptations were green-house farming and shifting from livestock keeping to crop growing, each at 47.5% (8.8% in Kitui and 86.7% in Kajiado), buying insurance at 48.3% (6.9% in Kitui and 93.1% in Kajiado), and use of chemical fertilisers 49.2% (8.5% in Kitui and 91.5% in Kajiado).

Scrutiny of Chi-square test results presented in Table 5 revealed statistically significant relationships between counties and adoption of crop diversification ($X^2$=12.57, p<0.05), shifting from livestock keeping to crop growing ($X^2$=73.82, p<0.05), water harvesting schemes ($X^2$=40.14, p<0.05), soil conservation techniques ($X^2$=56.17, p<0.05), buying insurance ($X^2$=83.43, p<0.05), irrigation ($X^2$=27.00, p<0.05), use of chemical fertilisers ($X^2$=80.06, p<0.05), minimum tillage ($X^2$=27.00, p<0.05), agroforestry ($X^2$=17.78, p<0.05), integrated pest management ($X^2$=54.86, p<0.05) and use of green hose farming ($X^2$=73.82, p<0.05). Further, the results showed that the adoption of mixed crop-livestock systems, planting drought-resilient crops, changing planting times and use of pesticides were not significantly associated with counties (p>0.5). From Table 5, it is evident that the levels of adoption for all the crop management adaptation strategies were higher in Kajiado compared to Kitui County.

Crop management strategies are popular adaptive investments adopted by farmers to counter rising temperatures caused by the changing climate. Consequently, the high percentage of farmers in the current study who have adopted different crop management strategies can be explained by the increasing temperature variability in arid and semi-arid areas. Studies on climate change show that arid and semi-arid lands are experiencing unprecedented high temperatures (IPCC, 2021). In addition, a study carried out by Kamau et al. (2020) in arid and semi-arid lands of Kitui County, Kenya, indicated that farmers had autonomously adopted different climate-smart crop management strategies to adapt to the rising temperatures.

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**Table 5: Crop management adaptation strategies (%) adopted by households in the study areas in response to the changing climate**

| Adaptations | Kitui % (n=60) | Kajiado % (n=60) | Total % (n=120) | $X^2$ | P- |
|---|---|---|---|---|---|
| Shift from livestock keeping to crop farming | 8.8 | 86.7 | 47.5 | 73.818 | 0.00** |
| Mixed crop-livestock system | 47.6 | 52.4 | 85.8 | 1.713 | 0.19 |
| Crop diversification | 41.5 | 58.5 | 78.3 | 12.570 | 0.00** |
| Plant drought-resilient crops | 48.1 | 51.9 | 88.3 | 1.294 | 0.26 |
| Build a water-harvesting scheme | 26.4 | 73.6 | 60.0 | 40.139 | 0.00** |
| Practice reuse of water | 15.6 | 84.4 | 53.3 | 64.821 | 0.00** |
| Changing planting time | 46.5 | 53.5 | 84.2 | 3.064 | 0.08 |
| Soil conservation techniques | 17.5 | 82.5 | 52.5 | 56.174 | 0.00** |
| Buy insurance | 6.9 | 93.1 | 48.3 | 883.426 | 0.00** |
| Irrigation | 32.9 | 67.1 | 65.8 | 27.008 | 0.00** |
| Use of chemical fertilisers | 8.5 | 91.5 | 49.2 | 80.056 | 0.00** |
| Use of organic fertilisers | 45.3 | 54.7 | 79.2 | 4.093 | 0.06 |
| Minimum tillage | 32.9 | 67.1 | 65.8 | 27.008 | 0.00** |
| Improved crop variety | 43.9 | 56.1 | 81.7 | 8.015 | 0.01** |
| Use of pesticides | 47.1 | 52.9 | 86.7 | 2.596 | 0.12 |
| Agroforestry | 38.9 | 61.1 | 75.0 | 17.778 | 0.00** |
| Integrated pest management | 21.4 | 78.6 | 58.3 | 54.857 | 0.00** |
| Greenhouse farming | 8.8 | 86.7 | 47.5 | 73.818 | 0.00** |

*Note: ** indicate significant at a 5% level of significance*

***Livestock Production Adaptation Strategies***

Scrutiny of results presented in table 6 revealed that seeking services from veterinary officers was the highest adopted livestock production adaptation strategy 70% (29.8 in Kitui and 70.2% in Kajiado). Finding off-farm jobs was adopted by 62.5% of households (28% in Kitui and 72 in Kajiado) while reducing the number of livestock was practised by 45% of households (37% in Kitui and 63% in Kajiado). Livestock diversification and moving herds from one place to another were also common with adoption rates of 34.2% (58.5% in Kitui and 41.5% in Kajiado) and 29.2% (11.4% in Kitui and 88.6% in Kajiado), respectively. Land leasing was also a common adaptation strategy adopted by 22.5% of households (29.6 in Kitui and 70.4% in Kajiado). In contrast, only a few households adopted migration to urban areas 8.3% (20% in Kitui and 80% in Kajiado) and shifting from crop farming to livestock keeping 5.8% (57.1% in Kitui and 42.9% in Kajiado) as adaptation strategies for livestock management.

Analysis of Chi-square test results showed statistically significant relationships between the adoption of land leasing ($X^2$=5.78, $p<0.05$), reducing the number of livestock ($X^2$=6.60, $p<0.05$), migration to urban areas ($X^2$=3.93, $p<0.05$), finding off-farm jobs ($X^2$=38.72, $p<0.05$), seeking support from veterinary officers ($X^2$=45.87, $p<0.05$), and moving herd from one place to another ($X^2$=29.41, $p<0.05$). The results indicated that only livestock diversification and shifting from crop farming to livestock keeping were not significantly associated with counties ($p>0.5$). In addition, results in Table 6 designated that the levels of adoption of livestock management adaptation strategies were higher in Kajiado compared to Kitui County except for livestock diversification and shifting from crop to livestock keeping where the adoption was higher in Kitui County.

Livestock production is a major livelihood in the arid and semi-arid lands of Kenya. In Kajiado County, livestock keeping is the main livelihood strategy, while in Kitui County, farmers mainly

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practice small-scale crop farming. This explains the higher levels of adoption of livestock management adaptation strategies in Kajiado County as compared to Kitui County. These adaptation strategies are adopted to cope with rising temperatures and varying rainfall in the face of changing climate. The current trend of results is in agreement with the findings of Ndungu and Bhardwaj (2015) and Mutunga et al. (2017) who reported that livestock farmers in arid and semi-arid areas had adopted a number of strategies including reducing the numbers and moving from one place to another in search of water and pastures among others to cope with drought.

**Table 6: Livestock production adaptation strategies (%) adopted by households in the study areas in response to the changing climate**

| Adaptations | Kitui % (n=60) | Kajiado % (n=60) | Total % (n=120) | $X^2$ | P- |
|---|---|---|---|---|---|
| Shifting from crop to livestock production | 57.1 | 42.9 | 5.8 | 0.152 | 0.70 |
| Reducing the number of livestock | 37.0 | 63.0 | 45.0 | 6.599 | 0.01** |
| Livestock diversification | 58.5 | 41.5 | 34.2 | 1.815 | 0.18 |
| Migration to urban areas | 20.0 | 80.0 | 8.3 | 3.927 | 0.05** |
| Finding off-farm jobs | 28.0 | 72.0 | 62.5 | 38.720 | 0.00** |
| Land leasing | 29.6 | 70.4 | 22.5 | 5.783 | 0.02** |
| Seeking support from veterinary officers | 29.8 | 70.2 | 70.0 | 45.873 | 0.00** |
| Moving herd from one place to another | 11.4 | 88.6 | 29.2 | 29.405 | 0.00** |

*Note: ** indicate significant at a 5% level of significance*

***Improved Livestock and Napier Grass Breeds***

*Table 7* presents the results of the adoption of improved livestock and Napier grass breeds. Concerning the adoption of improved livestock, the results indicated that Galla and Friesian had the highest adoption rates at 55% (20% in Kitui and 90% in Kajiado) and 19.2% (38.3% in both Kitui and Kajiado), respectively. Saanen was adopted at 3.3% (1.7% in Kitui and 5.0% in Kajiado), while Jersey was adopted in Kitui at 3.3%. In addition, Toggenburg and Alpine were adopted only in Kitui County, each at 1.7%. Further, Chi-square test results revealed a strong statistically significant relationship between the adoption of the Galla breed and counties (($X^2$=59.39, $p<0.05$). The results showed no significant association between the adoption of Saanen, Toggenburg, Alpine, Friesian and Jersey with the counties ($p>0.5$). Regarding Napier grass breeds, the study results indicated that the Bana breed was adopted only in Kitui by 1.75% of households, while Clone 13 was adopted only in Kajiado by 15% of households. The results revealed a statistically significant relationship between the adoption of Clone 13 and the counties where adoption was only in Kajiado County.

Livestock improvement and diversification is a major livelihood strategy adopted by farmers in arid and semi-arid areas to adapt to drought. As noted earlier, farmers in Kajiado County are predominantly livestock keepers as compared to those in Kitui County who mostly practice crop farming. This explains the low adoption of improved livestock breeds by Kitui farmers as compared to their Kajiado counterparts. Quandt (2021) reported that livestock diversification is increasingly being adopted by livestock keepers in arid and semi-arid areas to adapt to the changing climate.

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**Table 7: Improved livestock and Napier grass breeds**

| Adaptations | Kitui % (n=60) | Kajiado % (n=60) | Total % (n=120) | $X^2$ | P- |
|---|---|---|---|---|---|
| Saanen | 1.7 | 5.0 | 3.3 | 1.034 | 0.31 |
| Toggenburg | 1.7 | 0.0 | 0.8 | 1.008 | 0.32 |
| Alpine | 1.7 | 0.0 | 0.8 | 1.008 | 0.32 |
| Galla | 20.0 | 90.0 | 55.0 | 59.394 | 0.00** |
| Friesian | 38.3 | 38.3 | 19.2 | 28.454 | 0.32 |
| Jersey | 3.3 | 0.0 | 1.7 | 2.034 | 0.15 |
| Bana Napier grass | 1.7 | 0.0 | 0.8 | 1.008 | 0.32 |
| Clone 13 | 0.0 | 15.0 | 7.5 | 9.730 | 0.00** |

***Trees Adopted for Livestock Production (Fodder and Medicine)***

Results presented in *Table 8* on the adoption of acacia trees indicated that *Acacia mellifera* (oiti, muthiia) was adopted by the majority of households, 93.3% (86.7% in Kitu and 100% in Kajiado). *Acacia xanthophoea* (olerai, kimweya) was the second most adopted acacia species in the study areas having been planted by 68.3% of households (29.3% in Kitui and 70.7% in Kajiado). The results showed that *Acacia tortilis* (oltepesi, mulaa), *Acacia drepanoobium* (oluai, lunga), and *Acacia commiphora* (osilalei) were adopted at equal rates of 50.8% with only 1.7% in Kitui and 98.4% in Kajiado County. Similarly, *Lannea schweinfurthii* (orpande), *Fucus sycomorys* (orgaboli) and *Acacia ancistroclada* (oljurai) were adopted at equal levels of 50% with only 1.7% in Kitui and 98.3% in Kajiado County for the three species. Notably, *Balanites aegptiaca* (olngosua) and *Ziziphus mucronate* were adopted only in Kajiado County at the rate of 100%. Equally, *Balanites glabra* (osaragi) and *Dalbergia melanoxylon* (oltiaseka) were adopted only in Kajiado County at the rates of 96.7% and 91.7%, respectively. On the other hand, *Acacia seyal* (kisewa), *Acacia polyacantha* (kivovoa), *Acacia brevispica* (mukuswi), *Acacia elatior* (munina) and *Acacia gerradii* (muthi) were adopted only in Kitui County at the rates of 36.7%, 33.3%, 40%, 66.7% and 41.7%, respectively. Further, the study results indicated that *Acacia lahai* was the least adopted species at 3.3% in Kitui and 1.7% in Kajiado County. Results of the Chi-square test showed statistically significant relationships between the adoption of all acacia species ($p<0.5$) except for *Acacia lahai* ($p>0.5$).

Studies show that Acacia species are popular as livestock fodder in arid and semi-arid areas. The fodder production, particularly from *Acacia mellifera* in arid and semi-arid areas has been documented by a number of authors (Pretty, 2003; Chema et al., 2002). This explains the high adoption of these species by livestock farmers in Kajiado County. The current study findings are also corroborated by Mudzengi et al. (2020) who indicated that indigenous browse species such as Acacia remain a significant source of abundant and persistent animal feeds in arid and semi-arid areas, especially during drought.

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**Table 8: Acacia trees adopted for livestock production (fodder and medicine)**

| Acacia trees adaptations | Kitui % (n=60) | Kajiado % (n=60) | Total % (n=120) | $X^2$ | P- |
|---|---|---|---|---|---|
| *Acacia tortilis* (oltepesi, mulaa) | 1.7 | 98.4 | 50.8 | 116.066 | 0.00** |
| *Acacia drepanoobium* (oluai, lunga) | 1.7 | 98.4 | 50.8 | 116.066 | 0.00** |
| *Acacia xanthophoea* (olerai, kimweya) | 29.3 | 70.7 | 68.3 | 44.519 | 0.00** |
| *Acacia commiphora* (osilalei) | 1.7 | 98.4 | 50.8 | 116.006 | 0.00** |
| *Acacia mellifera* (oiti, muthiia) | 86.7 | 100.0 | 93.3 | 8.571 | 0.00** |
| *Balanites aegptiaca* (olngosua) | 0.0 | 100.0 | 50.0 | 120.000 | 0.00** |
| *Ziziphus mucronata* (oloilaei) | 0.0 | 100.0 | 50.0 | 120.000 | 0.00** |
| *Cordial monoica* (oseki) | 1.7 | 96.7 | 49.2 | 108.330 | 0.00** |
| *Acacia senegal* (olderekesi, king'ole) | 1.7 | 98.3 | 50.0 | 112.133 | 0.00** |
| *Ficus thorningii* (oreteti) | 1.7 | 95.0 | 48.3 | 104.650 | 0.00** |
| *Cordial sinensis* (oldoroko) | 1.8 | 91.7 | 46.7 | 97.634 | 0.00** |
| *Olea europaea* (oloirien) | 1.8 | 93.3 | 47.5 | 101.086 | 0.00** |
| *Balanites glabra* (osaragi) | 0.0 | 96.7 | 48.3 | 112.258 | 0.00** |
| *Lannea schweinfurthii* (orpande) | 1.7 | 98.3 | 50.0 | 112.133 | 0.00** |
| *Fucus sycomorys* (orgaboli) | 1.7 | 98.3 | 50.0 | 112.133 | 0.00** |
| *Acacia ancistroclada* (oljurai) | 1.7 | 98.3 | 50.0 | 112.133 | 0.00** |
| *Dalbergia melanoxylon* (oltiaseka) | 0.0 | 91.7 | 45.9 | 101.338 | 0.00** |
| *Acacia seyal* (kisewa) | 36.7 | 0.0 | 18.5 | 26.540 | 0.00** |
| *Acacia polyacantha* (kivovoa) | 33.3 | 0.0 | 16.8 | 23.640 | 0.00** |
| *Acacia brevispica* (mukuswi) | 40.0 | 0.0 | 20.2 | 29.562 | 0.00** |
| *Acacia elatior* (munina) | 66.7 | 0.0 | 33.6 | 59.249 | 0.00** |
| *Acacia gerradii* (muthi) | 41.7 | 0.0 | 20.0 | 31.121 | 0.00** |
| *Acacia lahai* | 3.3 | 1.7 | 2.5 | 0.325 | 0.57 |

*Note: ** indicate significant at a 5% level of significance*

**Factors Determining Farmers' Adoption of Adaptation Strategies to Climate Change and Variability**

Results of logistic regression to test the effects of level of education, gender, farming experience and gender of the household head and household size on farmers' adaptation to climate change and variability indicated that the five-predictor model provided a statistically significant improvement over the constant-only model. The Nagelkerke $R^2$ indicated that the model accounted for 88 % of the total variance. Further, scrutiny of the results indicated that the level of education, gender, farming experience, gender and county of the household head significantly predicted the farmers' adaptation to climate change and variability (*Table 9*).

It is evident that there is a positive relationship between farmers' adaptation strategies to climate change and variability and the level of education of household heads, with the odds of farmers adopting increasing by a factor of 1.25, for every unit increase in the level of education (coefficient = 0.22; odds ratio = 1.25). This implies that a higher level of education leads to an increase in the probability of adopting new technologies. It increases one's ability to receive, decode, and understand information relevant to making innovative decisions. The role of education in enhancing the adaptive capacity of farmers has been reported in other studies (Ndungu & Bhardwaj, 2015; Mutunga et al., 2018; Kamau et al., 2020; Acquah-de & Onumah, 2011).

In addition, a close examination of the results showed that there was a positive relationship between farmers' adoption of adaptation strategies

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and the gender of the household head with the odds of male-headed households adopting increasing by 1.92 times as compared to female-headed households (coefficient= 0.64; odds ratio= 1.92). This indicated that the gender of the household head has an influence on farmers' decision to adopt adaptation practices. Similar findings have been reported by Okonya et al. (2013), Ndungu and Bhardwaj (2015) and Kamau et al. (2020). In most developing countries, women have lesser access to critical resources like land, cash, and labour which undermines their ability to carry out labour-intensive agricultural innovations.

However, in some other cases, female-headed households could more likely take up climate change adaptation strategies. This is possible in situations where men are based in towns and much of the agricultural work is done by the women. Thus, in this case, women have more farming experience and information on various management practices and how to change them based on available information on climatic conditions and other factors such as markets and food needs of the households.

The farming experience got a positive coefficient and an odds ratio of 35.55, implying that the odds of the farmer adapting increase by a factor of 35.55 for every unit increase in farming experience. In other words, farmers' adaptation to climate change and variability is contingent upon years of farming and the adaptation increases with an increase in farming experience. This is because experienced farmers have better knowledge and information on changes in climatic conditions and crop and livestock management practices. Studies indicate that experienced farmers have an increased likelihood of using portfolio diversification, changing planting dates and changing the amount of land under production (Nhemachana & Hassan, 2007; Ndungu & Bhardwaj, 2015; Mutunga et al., 2018).

Further scrutiny of the results indicated that the odds of farmers adapting to climate change and variability increased by 1.90 if one belonged to Kajiado County. The difference in capacity to adapt between the two study areas can be ascribed to factors such as access to extension services and credit. Other factors include the high cost of adaptation, lack of knowledge and technology, among others. The results are in consonance with the findings of other studies (Ndungu & Bhardwaj, 2015; Juana et al., 2013; Mutunga et al., 2018; Kamau et al., 2020).

Household size registered a coefficient of -0.34 and an odds ratio of 0.31, implying that the odds of farmer adapting decrease by a factor of 0.31 for every unit increase in household size. This may be explained by the fact that households with many family members might have diverted part of their labour force to off-farm activities in an attempt to earn income to ease the consumption pressure imposed by large family sizes. Similar findings have also been reported by Ndungu and Bhardwaj (2015) and Tizale (2007). However, in other cases and as also reported by Tekelwold et al. (2006), household size acts as a proxy for labour availability and influences the adoption of new technologies by reducing the availability of labour constraints.

**Table 9: Determinants of farmers' adaptation to climate change in Kitui and Kajiado Counties of Kenya**

| Explanatory variable | Estimated coefficient | Odds ratio | P. value |
|---|---|---|---|
| Education level | 0.22 | 1.25 | 0.00*** |
| Gender | 0.64 | 1.92 | 0.02** |
| Farming experience | 3.50 | 35.55 | 0.00*** |
| County of the respondent | 0.21 | 1.90 | 0.01** |
| Household size | -0.34 | 0.68 | 0.31 |

*Note: ***, ** indicates significant at 1% and 5% levels of significance, respectively*

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## CONCLUSION

Changing climate situations have brought forth new problems and questions the solutions to which have been generated by combining farmers' ingenuity and their trial-and-error efforts like shifting to new crops and their varieties, reducing the number of livestock, and using rainwater harvesting technologies, among others. However, factors such as the education of the household head, farming experience, gender and household size influenced farmers' adaptive capacity and hence these need to be addressed in the study area.

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