Pastoralists' Choice of Response Strategies to Climate Change and Variability in Semi-arid areas of Narok, Kenya

Kelvin John Kinuthia[a*]., Lenah Nakhone[b], and Shadrack Kinyua Inoti[a]
[a] Department of Natural Resources, Egerton University, PO Box 536-20115, Egerton, Kenya
[b] Department of Crops, Horticulture and Soils, Egerton University, PO Box 536-20115, Egerton, Kenya
[*] Corresponding author email: kelvinjkinuthia90@gmail.com, Phone: +254 724 649 101

D.O.I: 10.56201/ijaes.v8.no7.2022.pg39.50

Abstract

Crop farming and pastoralism are the main economic activities in the semi-arid lands of Narok County, Kenya. Like many semi-arid areas in the country, the region has been experiencing climate change and variability. This has caused the farmers and pastoralists to adopt various response strategies to the changing climate. This study aimed to document the strategies that the pastoralists had adopted for livestock production and the factors that influenced their decision. The study was conducted in all the four wards of Narok East in 2016. A cross-sectional survey research design was used, whereby 223 household heads were interviewed using a semi-structured questionnaire. Descriptive statistics were used to assess pastoralists' response strategies, while a multivariate probit model in conjunction with Principal Component Analysis was used to determine the factors that influence their choice of the response strategies. Results showed that herd reduction, transhumance, new breeds of livestock and fencing were the most widely adopted strategies. Results of the multivariate probit analysis showed that gender, level of education and age of the household head, total household size, receiving weather information and land tenure system were all significant factors in influencing a farmer's choice of response strategy. This study therefore recommends that farmers be empowered to access improved livestock breeds, education on climate change aspects and information on accurate and timely weather forecasts be availed to farmers.

Keywords: *Climate change, response strategy, livestock production, pastoralists*

Introduction

Climate change is a major threat to sustainable development (Kalungu et al., 2013). There is sufficient evidence to show that global climatic patterns have been changing, including; land and ocean surface temperatures have risen by 0.84°C to 1.10 °C between 1850 -2020, the number of warm nights and days has increased, the average Artic ice volume has decreased and sea level has risen (IPCC, 2021; Stocker et al., 2013). Extreme weather events such as droughts, storms and floods have also been on the increase (UNDP, 2015). Although climate change and variability impacts many economic sectors, agriculture is the most vulnerable (Antle, 2008).

Depending on the region and type of agriculture, climate change and variability is expected to cause changes in crop (Kinuthia et al., 2018) and livestock productivity (Antle, 2008). For livestock production, increasing global temperatures coupled with extreme weather events are expected to reduce the quantity and quality of animal feed, subject livestock to heat stress and increase the prevalence of certain livestock diseases (Godde et al., 2021). A warmer climate is predicted to increase food insecurity especially in Africa (Ngaira, 2007). A temperature increase of 1-3° C is hypothesized to cause a decrease in major crop yields in developing countries that are not properly equipped to adapt (Rosegrant et al., 2008). Droughts and storms are also expected to become more frequent and therefore contribute to lower productivity which may lead to human-wildlife conflicts over scarce resources (Kabubo-mariara et al., 2015).

The Government of Kenya acknowledges that climate change and variability and its effects are a common concern of all humankind and to the people of Kenya in particular (GoK, 2010). Agriculture is the biggest employer in Kenya, (about 82% of the population), the largest contributor to the GDP (30%) and the largest export sector with 70% of export earnings (Kabubo-Mariara et al., 2006). Of all this, livestock accounts for most of the agricultural capital stock at 53% and contributes 30% to the overall agricultural GDP (Republic of Kenya, 2021). Despite this great importance of agriculture, only 12% of the country is considered high potential, with the remaining 80% being considered as arid and semi-arid (Ojwang et al., 2010; Republic of Kenya, 2021).

Kenya's arid and semi-arid areas have been experiencing droughts and unpredictable rainfall patterns since 1960 (Ngaira, 2007). In the period between 1950 and 2007, Narok County experienced an overall decline in total rainfall amounts and a steady increase in mean temperature (Ojwang et al., 2010). The County has experienced increasing frequency and intensity of extreme weather events, including droughts and delayed onset of rains (which has seen the rivers and streams in the County experience receding water levels) (Mulenkei, 2015) and floods which have led to loss of human life and property (Kenya Meteorological Department, 2020).

Farmers and pastoralists respond in different ways when faced with the impacts of climate change and variability. In Narok, pastoralists have always relied on nomadism, but due to land tenure changes, they are now resorting to livelihood diversification such as crop farming, mining and sugarcane planting (Mulenkei, 2015) as well as tourism enterprises (Inoti et al., 2022). Some studies have reported that household characteristics such as education level of household head, age of household head, gender of household head, family size and family income influence a farmer's choice of response strategy (Nti, 2012; Obayelu et al., 2014; Uddin et al., 2014). Other non-household factors such access to credit, extension services, information on climate change as well as observing climate change have also been reported as influencing a farmer's choice of response strategy (Komba & Muchapondwa, 2012; Nti, 2012; Obayelu et al., 2014).

The first objective of this study was to assess all the response strategies pastoralists take up to protect livestock production from the impacts of climate change and variability and determine which strategies are most widely adopted while the second was to determine the factors that influence their choice of the response strategies.

Materials and Methods

2.1 Study site

The study was conducted in Narok East Sub- County, Narok County Kenya. Narok County is located between latitudes 34°45'E and 36°00'E and longitudes 0°45'S and 2°00'S in the Great Rift Valley. Narok East Sub- County has four wards namely, Mosiro, Keekonyokie, Ildamat and Suswa. It has a population of 82,956 and a population density of 47 people per km^2 (Kenya National Bureau of Statistics {KNBS}, 2013). Higher human populations are found in the wetter areas, where agricultural and pastoralist activities take place (Obayelu et al., 2014). The main crops grown include horticultural crops, wheat, maize, barley, beans and Irish potatoes while livestock normally include cattle, goats, sheep and donkeys (SMART STAT Consultants Ltd., 2013).

Higher rainfall amounts are experienced in the north (2000/year) while the plains experience rainfall amounts as low as (500mm/year). Rainfall increases along a gradient from the dry plains in the southwest (500 mm/year) to wet highlands in the north (2000 mm/year), with higher rainfall amounts experienced in higher altitude areas. The region has two rainy seasons, with the first occurring between March and May and the second between November and December. The driest months are June and July while the annual temperature range is $12\text{-}28^0$ C (Ojwang et al., 2010).

2.2 Sampling Design

Narok East Sub-county was selected for the study so as to represent the semi-arid areas of Kenya. A cross-sectional survey research design was used. Pastoralists in the four Wards of Narok-East Sub-county constituted the population of the study. Each Ward contributed a representative sample of respondents, through the use of a multi-stage random sampling procedure. A household head, whether male or female, was the primary respondent of this study. From the multi-stage random sampling, a total of 223 household heads were selected for the interview, whereby a semi-structured questionnaire was used as the primary data collection tool.

2.3 Data Analysis

To assess the response strategies being used by the pastoralists of Narok East, descriptive statistic was used for the analysis. To determine the factors that influence a pastoralist's choice of response strategies, two analysis tools were used: Principal Component Analysis (PCA) and a multivariate probit model. The PCA was used to group correlated strategies into one component for easier analysis and interpretation of results. For this study, a total of four components were retained for analysis from the results of PCA (Table 1). The multivariate probit analysis was used to determine the factors that influence pastoralists' choice of response strategies to climate change and variability. The model is as specified below.

$$Y_{im}^{*} = \beta_m X_{im} + \varepsilon_{im}$$

Where Y_{im}^{*} (m = 1,….,k) represent the unobserved latent variable of adaptation strategies adopted by the i^{th} farmer (i = 1,…,n), k is the strategies adopted by the farmer. X_{im} is a 1 × k

vector of observed variables that affect the strategy adoption decision, the variables include the characteristics of the household head, awareness of climate change and variability, receiving weather information and the land tenure system.
The independent variables for this study were gender of household head, age of household head, total household size, noticing changes in mean annual rainfall, noticing change in mean annual temperature, noticing changes in the onset of rains, receiving weather information, level of education of household head and land tenure system.

Results and Discussion

Livestock Response Strategies for Climate Change and Variability

A total of 10 livestock production strategies were identified, including herd reduction, herd increase, rearing new animals, zero grazing, using better breeds of animals, fencing off one's farm, using improved fodder, getting into alternative livelihoods, abandoning livestock keeping and engaging in transhumance. Results show that herd reduction, transhumance, fencing farms and getting new breeds of animals were the most preferred response strategies in descending order respectively (Figure 1), while increasing the herd size was the least adopted response strategy.

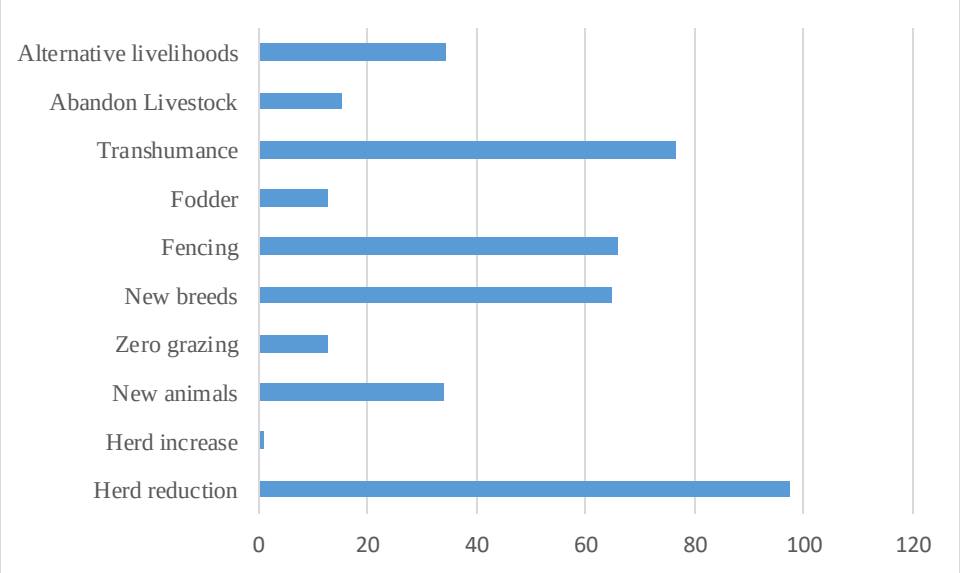

Figure 1: Percentage of farmers using each livestock production response strategy

The livestock production strategies adopted by farmers in Narok East were found to be similar to those adopted in Kajiado and Baringo Counties in Kenya (Kimani et al., 2014; Bobadoye et al., 2016). In Kajiado County, the Maasai pastoralists also practice migration, destocking, buying hay, diversifying herds, diversifying livelihoods, and adopting paddock grazing as the most utilised strategies (Bobadoye et al., 2016). Similarly in Baringo County, farmers also make use of livestock relocation, herd splitting, livestock diversification and destocking as major response strategies to climate change and variability (Kimani et al., 2014).

In Narok East, herd reduction is normally done by way of selling off some livestock during the times of drought or low rainfall. This is an effective response as it is easier to get enough pasture

and water for fewer animals. In this study, transhumance was reported to be one of the most popular response strategies by livestock owners. This is to be expected, as the dominant Maasai community in Narok East still practices transhumance as they move their livestock to places with greener pastures, water and market for their livestock (Bobadoye et al., 2016).

As reported earlier by Bodadoye et al. (2016), herd diversification in the way of getting better breeds of animals and new animals all together such as the Saiwal cattle and dairy goats is becoming more prevalent among the Maasai as they react differently to droughts and diseases. This study also reported similar results whereby getting better breeds of animals was one of the most adopted strategies. The reason for this is that the new breeds are more adapted to survive changing climate and are more productive compared to traditional breeds. Dairy goats for example, produce nutritious milk while consuming less forage than cattle (Bobadoye et al., 2016). Farmers who have larger farms where they do open grazing have also resorted to fencing off their farms. This is to discourage trespassing by other farmers who sometimes disregard land tenure rules and graze their livestock even in private land. Paddocking also helps farmers to control livestock movements within their farms leading to better and more efficient utilization of forage.

As the farmers of Narok East become more educated and land use in the region changes, more farmers are turning to modern methods of livestock production and are also exploring alternative livelihoods. Modern techniques that were observed in Narok East include the use of improved fodder and practicing zero grazing. These strategies are however not as common since most of the community still follows traditional strategies. In the neighbouring Kajiado County, Maasai women were reported to be engaging in business and tourism related activities which greatly improved their livelihoods (Inoti et al., 2022). While this is an area with great potential to shield households from the impacts of climate change and variability, it is greatly underutilized in pastoral communities including those in Narok East. This should be a key focus for policy makers and non-governmental organisations while driving their climate change adaptation agenda.

In extreme cases of drought, some farmers reported to having stopped livestock keeping altogether. These same farmers would then get back to it when conditions became more conducive. Considering that most extreme weather events normally lead to loss of livestock, the least preferred response strategy was reported as increasing the herd size.

Factors affecting farmers' choice of livestock production strategies

Before running the multivariate probit model, Principal Component Analysis was carried out. All components with an eigenvalue of >1 were retained for analysis in accordance with Kaiser's criterion (Constantin, 2014). A total of four components were therefore identified and named. They were designated as non-traditional strategies, herd management strategies, lifestyle change and traditional strategies, with each component having at least two response strategies under it (Table 1).

Table 1: Livestock production strategies under each component

Component	Variables in component
Comp1- Non-traditional	• New farm animals • Zero grazing • Improved fodder
Comp2- Herd management	• Reduce herd size • Increase herd size
Comp3-Lifestyle change	• Abandon livestock keeping • Seeking alternative livelihoods • Fencing farms
Comp4- traditional strategies	• Transhumance • New breeds

The factors that were found to be significant in influencing a farmer's choice of livestock response strategy were gender, age and level of education of household head, total household size, receiving weather information and land tenure system. Perceiving/noticing changes in climate patterns was found not to be significantly influencing the decision to take up any livestock production strategy.

Household characteristics

The results show that a household with a male household head was more likely to engage in transhumance or to get new breeds of animals at 5% significance level. The current findings corroborates with those of Ndamani and Watanabe (2016), who also found that male farmers are more likely to engage in certain adaptation practices compared to female farmers. In Ethiopia's Gondar region, it was reported that male headed households were more likely to engage in transhumance as an adaptation strategy compared to female headed households (Atinkut and Mebrat, 2016).

The findings of this study also agrees with the cultural norm where traditionally, female household heads are expected to stay at home and be care-givers, as the men go out to find pasture for the livestock. Furthermore, as noted earlier by Bobadoye et al. (2016), the Maasai community is patriarchal in nature, which means that female household heads may not have the same opportunity as male household heads to access information on climate change and variability thereby hindering them from choosing certain strategies. This therefore explains why they are less likely to get new breeds.

Table 2: Factors affecting farmers' choice of livestock production strategies

	Non-traditional		Herd management		Lifestyle change		Traditional	
Independent Variable	**Coef.**	**Std. Err**	**Coef.**	**Std. Err**	**Coef.**	**Std. Err**	**Coef.**	**Std. Err**
Gender	0.190	0.428	0.844	0.758	-0.347	0.486	0.871	0.404[b]
Age	-0.019	0.014	-0.1	0.043[b]	-0.043	0.014[c]	-0.009	0.012
Household size	0.005	0.0.014	-0.01	0.035	0.012	0.018	-0.026	0.013[b]
Mean annual rain change	0.552	0.531	0.680	0.787	-0.411	0.656	-0.713	0.7
Rain onset change	0.130	0.403	1.135	0.744	0.203	0.451	-0.032	0.457
Weather info	1.123	0.340[c]	-1.584	0.1.208	0.847	0.28[c]	0.302	0.273
Primary education	0.102	0.264	-0.728	0.618	0.49	0.281[a]	-0.181	0.27
Secondary education	0.483	0.246[a]	0.325	0.795	1.033	0.331[c]	0.185	0.279
Tertiary education	2.217	0.582[c]	0.59	1.133	6.139	184.764	0.872	0.532
No title deed	0.211	0.220	4.189	346.906	0.303	0.246	0.24	0.236
Family land	-0228	0.452	-0.678	0.796	-0.574	0.532	-0.516	0.425
Communal land	-2.128	0.957[b]	4.3	587.685	-0.817	0.599	-0.519	0.418
_cons	-1.510	1.079	6.045	3.125	1.9	1.194	1.084	1.143
Observations			223					
Log Likelihood			-324.19771					
Wald $\chi 2$			118.56					
Prob > $\chi 2$			0.0000					

Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: chi^2 (6) = 13.233 Prob > chi^2 = 0.0395 [a], [b], [c]= significant at 10%, 5% and 1% significance level respectively.

The age of the household head was found to be a significant variable for two of the components. A household with an older household head was less likely to adopt herd management practices at 5% significance level. A household with an older household head was also found to be less likely to engage in lifestyle change strategies at 1% significance level. Other studies have found similar results whereby older farmers were less likely to use certain adaptation practices (Atinkut and Mebrat, 2016; Ndamani and Watanabe, 2016). According to Atinkut and Mebrat (2016), older farmers were less likely to take up the more labour-intensive livestock production strategy of seasonal migration. In Narok East, the unwillingness of older farmers to reduce their herd size can be attributed to the culture of the Maasai where owning more livestock is considered prestigious. Older farmers are also generally less educated, hence their inability to change their lifestyles.

The total household size was another independent variable that was significant for one of the components. The study found that households with a larger household size were less likely to engage in transhumance or to buy new breeds of animals at 5% level. This finding can be explained using some economic principles. Both of the strategies require significant financial investments. A family with more members would therefore rather spend the money on more basic needs such as food and education rather than on improving their animal breeds.

The level of education of the household head was found to be a significant explanatory variable for two of the components. Household heads who had attained secondary education were more likely to engage in non-traditional strategies than those who had informal education at 10% level. Those who had attained tertiary education were more likely to use non-traditional strategies compared to those who had no formal education at 1% significance level. Household heads who had gone up to primary school were more likely to engage in lifestyle change strategies compared to those with informal education. Furthermore, those who had gone up to secondary school were more likely to use lifestyle change strategies than those who had no formal education at 1% significance level. Similar findings have been reported by several earlier studies (Deressa et al., 2010; Mabe et al., 2014; Uddin et al., 2014; Abid et al., 2015; Ndamani and Watanabe, 2016). These findings are to be expected, as more educated people are more exposed and empowered to try their hand on other careers other than just farming. Interestingly, attaining tertiary education was found not to be a significant variable when it came to the same lifestyle change strategies.

Receiving weather information

Receiving weather information was a significant variable for two of the components. Farmers who receive weather information were found to be more likely adopt the non-traditional coping strategies at 1% significance level. Those farmers who received weather information were also found to be more likely to choose lifestyle change strategies at 1% significance level.

Other studies have found similar results whereby access to climate information had a positive impact on adaptation. One of the studies conducted in Ethiopia among sheep and goat farmers found that farmers who received climate information were more likely to use crossbred animals, engage in home feeding and do marketing during extreme weather events (Feleke et al., 2016). The Maasai pastoralists in Kajiado County also reported that receiving reliable and timely climatic information would enable them choose the appropriate response strategy (Bobadoye *et al.*, 2016). In Nothern Ghana, farmers who received weather information were more likely to engage in destocking (Mabe et al., 2014). It is therefore to be expected that farmers who are more informed about climate change and variability are more likely to adopt zero grazing, use improved fodder, use new farm animals, fence their farms and look for alternative livelihoods.

Land tenure system

When it came to the issue of land tenure system, only one of the categories was significant for only one of the components. Farmers who used communal land for their livestock were found to be less likely to engage in non-traditional strategies compared to those who had title deeds for their farms at 5% significance level.

Farmers who use communal land for their livestock were found to be less likely to engage in zero grazing, use improved fodder or get new farm animals. This is to be expected as communal land tenure does not give the farmers the freedom to use the land as per their individual preferences, but they instead have to follow the already agreed resolutions. Also, as reported by Mwase et al. (2015), some climate change adaption strategies are difficult to use under communal land tenure, since the lack of security deters farmers from making certain investments.

Conclusion

Livestock production strategies such as herd reduction, transhumance, fencing farms and getting new breeds of animals were found to be the most widely adopted by pastoralists. This shows that although many pastoralists still rely on the ancient fix of moving their livestock to where there is better pasture, more and more pastoralists are beginning to embrace modern solutions. On the other hand, herd increase was found to be the least adopted strategy.

On the other hand, socio-demographic factors such as gender, age and level of education of the household head, total household size, receiving weather information and land tenure system were all significant factors in influencing a farmer's choice of response strategy. Perceiving changes in climatic conditions was however found not to be a significant factor.

Recommendations

1. The County government of Narok, by conducting regular and comprehensive seminars and workshops should therefore work to inform and educate pastoralists on climate change and variability and its impact on their livelihoods.

2. The national government, through the Ministry of Agriculture should also give incentives to the pastoralists to access better breeds of animals that can produce more milk or more meat.

3. Accurate and timely weather forecasts should also be given to the farmers to enable them plan effectively and protect themselves.

4. Both National and Local Governments should assist local communities to diversify their livelihood activities and therefore reduce their reliance on rain-fed pastoralism.

Acknowledgements
The authors acknowledge the financial support of the National Research Fund (formerly NACOSTI) for funding this project. The authors would also like to acknowledge the help of Narok East Sub- County government for assisting in mobilizing the community for the research and providing important logistical information.

Conflict of interest
The authors wish to state that there is no conflict of interest as pertains to the current paper

References

Abid, M., Scheffran, J., Schneider, U. A., & Ashfaq, M. (2015). Farmers ' perceptions of and adaptation strategies to climate change and their determinants : the case of Punjab province , Pakistan. *Earth System Dynamics*, *6*, 225–243. https://doi.org/10.5194/esd-6-225-2015

Antle, J. M. (2008). Climate change and agriculture: Economic impacts. *Choices*, *23*(1), 9–11.

Atinkut, B., & Mebrat, A. (2016). Determinants of farmers choice of adaptation to climate variability in Dera woreda , south Gondar zone , Ethiopia. *Environmental Systems Research*, *5*(6), 1–8. https://doi.org/10.1186/s40068-015-0046-x

Bobadoye, A. O., Ogara, W. O., Ouma, G. O., & Onono, J. O. (2016). Assessing climate change adaptation strategies among rural Maasai pastoralist in Kenya. *American Journal of Rural Development*, *4*(6), 120–128. https://doi.org/10.12691/ajrd-4-6-1

Constantin, C. (2014). Principal component analysis - A powerful tool in computing marketing information. *Economic Sciences*, *7*(2), 25–30.

Deressa, T. T., Ringler, C., & Hassan, R. M. (2010). *Factors affecting the choices of coping strategies for climate extremes: The case of farmers in the Nile basin of Ethiopia* (Issue August).

Feleke, F. B., Berhe, M., Gebru, G., & Hoag, D. (2016). Determinants of adaptation choices to climate change by sheep and goat farmers in Nothern Ethiopia: the case of Southern and Central Tigray, Ethiopia. *Springerplus*, *5*(1), 1692.

Godde, C. M., Croz, D. M., Mayberry, D. E., Thornton, P. K., & Herrero, M. (2021). Impacts of climate change on the livestock food supply chain ; a review of the evidence. *Global Food Security*, *28*(1), 100488. https://doi.org/10.1016/j.gfs.2020.100488

Government of Kenya [GoK]. (2010). *National climate change response strategy* (Issue April). Government Press.

Inoti, S. K., Mutinda, M. N., & Ogonda, J. H. (2022). Livelihood diversification influence on socioeconomic wellbeing of Maasai women in. *International Journal of Frontiers in Life Science Research*, *3*(1), 9–16.

IPCC. (2021). *Climate change 2021 the physical science basis summary for policymakers*.

Kabubo-mariara, J., & Kabara, M. (2015). *Climate change and food security in Kenya* (No. 15; 5).

Kabubo-mariara, J., & Karanja, F. K. (2006). *The economic impact of climate change on Kenyan crop agriculture : A Ricardian approach*.

Kalungu, J. W., Filho, W. L., & Harris, D. (2013). Smallholder Farmers ' Perception of the Impacts of Climate Change and Variability on Rain-fed Agricultural Practices in Semi-arid and Sub-humid Regions of Kenya. *Journal of Environment and Earth Science*, *3*(7), 129–141.

Kenya Meteorological Department. (2020). *Extreme weather events in Kenya between 2011 and*

2020.

Kenya National Bureau of Statistics {KNBS}. (2013). *Exploring Kenya's inequality: Pulling apart or pooling together?*

Kimani, E. W., Ogendi, G. M., & Makenzi, P. M. (2014). An evaluation of climate change indigenous coping and adaptation strategies for sustainable agro-Pastoral based Livelihoods in Baringo County, Kenya. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT), 8*(8), 38–58.

Kinuthia, K. J., Inoti, S. K., & Nakhone, L. (2018). Factors influencing farmer ' s choice of crop production response strategies to climate change and variability. *Journal of Natural Resources and Development*, *8*, 69–77.

Komba, C., & Muchapondwa, E. (2012). *Adaptation to climate change by smallholder farmers in Tanzania* (No. 299; Issue July).

Mabe, F. N., Sienso, G., & Donkoh, S. (2014). Determinants of choice of climate change adaptation strategies in Northern Ghana. *Research in Applied Economics*, *6*(4). https://doi.org/10.5296/rae.v6i4.6121

Mulenkei, L. (2015). *Promoting climate change adaptation for natural resource dependent communities in Narok on best practices in energy and livestock indigenous information network*.

Ndamani, F., & Watanabe, T. (2016). Determinants of farmers' adaptation to climate change: A micro level analysis in Ghana. *Scientia Agricola*, *73*(3), 1–7.

Ngaira, J. K. W. (2007). Impact of climate change on agriculture in Africa by 2030. *Scientific Research and Essays*, *2*(7), 238–243.

Nti, F. K. (2012). *Climate change vulnerability and coping mechanisms among farming communities in Nothern Ghana*. Kansas State University.

Obayelu, O. A., Adepoju, A. O., & Idowu, T. (2014). Factors influencing farmers ' choices of adaptation to climate change in Ekiti State , Nigeria. *Journal of Agriculture and Environment for International Development - JAEID*, *108*(1), 3–16. https://doi.org/10.12895/jaeid.20141.140

Ojwang, G. O., Agatsiva, J., & Situma, C. (2010). *Analysis of climate change and variability risks in the smallholder sector: Case studies of the Laikipia and Narok Districts representing major agro-ecological zones in Kenya* (No. 41).

Republic of Kenya. (2021). *Range management and pastoralism strategy 2021-2031*. https://www.iyrp.info/sites/iyrp.org/files/Kenya Range Management %2B Pastoralism Strategy 2021-31.pdf

Rosegrant, M. W., Ewing, M., Yohe, G., Burton, I., Huq, S., & Valmonte-santos, R. (2008). *Climate change and agriculture: threats and opportunities*.

SMART STAT Consultants Ltd. (2013). *Report of SMART nutrition survey Narok County,*

Kenya (Issue July).

Stocker, T. F., Qin, D., Plattner, G., Tignor, M. M. B., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V., & Midgley, P. M. (2013). *Climate change 2013: The physical science basis: Summary for policymakers*.

Uddin, M., Bokelmann, W., & Entsminger, J. (2014). Factors Affecting Farmers' Adaptation Strategies to Environmental Degradation and Climate Change Effects: A Farm Level Study in Bangladesh. *Climate*, *2*(4), 223–241. https://doi.org/10.3390/cli2040223

United Nations Development Programme [UNDP]. (2015). *Sustainable development goals*. Sustainable Development Goals.