

Climate Variability and Livelihood Vulnerability of Maasai Pastoralists in Amboseli Ecosystem, Kajiado County, Kenya

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Abstract

The pastoral Maasai community living in Amboseli Ecosystem are facing serious challenges originating from climate variability. The ecosystem has been made fragile by climate related challenges causing household vulnerability. The aim of this study was to determine the effect of climate variability on livelihood vulnerability at the household level. The study used a mixed method, which focused on descriptive and correlational research designs. It targeted a population of 47, 058 residents from which a sample of 374 households was selected. Cluster and convenient sampling were used for quantitative and qualitative data respectively. A questionnaire with open and closed ended questions and with Likert scale format were used to collect quantitative data while interview schedules were used for qualitative data. In addition, secondary data were collected from different sources, including Kenya Meteorological Department and Kenya Wildlife Services. Descriptive statistics were used to analyze qualitative data while quantitative data were analyzed using inferential statistics. Results showed that climate variability is indeed causing livelihood vulnerability and therefore policy intervention is needed at the national and county levels. Majority of households were found to be moderately vulnerable with female headed households being most vulnerable. This study therefore recommends that adaptation strategies at the household level to community level should be put in place so as to reduce vulnerability such as crop farming, livestock diversification, small scale businesses and employment in addition there is need to empower women through education, offering of small loans and grants for businesses as well as involvement in decision making on matters pasture and water management.

Keywords: Climate Variability, Livelihood Vulnerability, Pastoralism, Household Vulnerability, Wildlife Ecosystem

Introduction

The fluctuation in climate patterns in Africa has had a harmful effect on the ability of people living in rural areas to make a living and presents a significant danger to the general health for rural populations according to the findings of Innocent (2017). Climate change and variability have a substantial impact on the lives of pastoralists in the Arid and Semi-Arid Lands (ASAL) regions of Africa, particularly in terms of the availability of food and water (Tover, L. (2022), WWF). KARI's research in 2021 by Kogo et al., (2021) uncovered significant climate-related challenges that dryland ecosystems encounter, directly affecting the well-being of local residents and the natural resources they rely on. According to the 2014 assessment from the IPCC, the pastoral regions in the Horn of Africa face the greatest danger of drought and negative impacts on their way of life owing to changes in rainfall patterns and increasing temperatures. Moreover, Morton's observations in 2010 emphasise that the ability of East African pastoralists to support themselves is deteriorating at a faster rate compared to other rural livelihoods.

The research conducted by Smith (2021) highlights that the cattle numbers in Kenya and other parts of Africa have considerably declined due to the detrimental effects of dehydration and degradation. Evidently, numerous pastoralist groups in Kenya are progressively transitioning from ancient pastoral farming to agro-pastoralism and alternative livelihood practices that need a settled lifestyle rather than a nomadic one. According to Abeje et al., (2019) livelihood vulnerability to climate variability and change is a function of how long a community has been exposed to adverse effects, the sensitivity of its production system, and its capacity to adapt Smith (2021) revealed that pastoralists may lose livestock if the environment continues to deteriorate. The objective of this investigation was to determine the effects of climate unpredictability on the occupations and daily transitions for Maasai people who live within semi-arid territory of Amboseli Ecosystem.

Materials and Methods

The study took place at the southern part of Kajiado County in Amboseli Ecosystem. The study area was subdivided into six sections named as group ranches for purposes of this study. Some are existing group ranches whereas some have since been converted into individual parcels of land. Kimana/Tikondo, Olgulului/Olararashi, Eselenkei, Mbirikani, Kuku, and Rombo). Amboseli Ecosystem is situated between longitudes 36° 0'E and 37°0'E and latitudes 1°0'S and 3 °0'S. It covers approximately 506,329 hectares with a population of 191,846 people and 47,058 households (KNBS, 2019). The residents of this area are mainly Maasai whose main source of livelihoods is Pastoralism.

Determination of the Sampling Size and Sampling frame

A formula by Kothari (2004) was used to determine the sample frame for each group ranch as follows:

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

Where P_i represents the proportion of population included in stratum i , N_1 –Population size of the strata, N is the total population of the study area, n represents the sample size.

Table 1: Sampling frame showing the sample size drawn from each group ranch

Group Ranch/Strata	N1	N	P1 = N1/N	n	n1 = P1* n
Olgululi-Ololarashi	4452	47058	0.0946	384	36
Eselenkei	1232	47058	0.0262	384	10
Imbirikani	6631	47058	0.1409	384	54
Kimana	9261	47058	0.1968	384	76
Kuku	11172	47058	0.2374	384	91
Rombo	14310	47058	0.3041	384	117
Total	47058				384

Data Collection and Statistical Data Analysis

Primary data was collected through semi structured questionnaires, which were administered to randomly selected Maasai pastoralists. Climate data was obtained from Kenya Meteorological Department. Satellite images were acquired from GIS and remote sensing. Data was collected during dry and wet seasons of both short rains (September, October and November) and long rain in March, April and May. Formal consent was sought from the respondents before participating in the data collection process. Collected primary data was cleaned and coded. It was further analysed using inferential statistics, ANOVA and regression analysis. Qualitative data was analysed through thematic analysis and PCA was used to analyse relationships between livelihood vulnerability indicators.

Results and Discussions

Households' Vulnerability to Climate Variability

As a result of the changing climatic conditions, Pastoralists have had to adopt to other sources of income. These alternative sources were investigated by the study. The main aim was to find out if such alternatives were reducing vulnerability at the household level. The responds gave the following as summarized in table 1.0 below. Structured questionnaire results showed that 85.6% of the households had alternative sources of income due to climate variability and only 14% of the responds indicated that they relied on their livestock only for family income.

Table 2: Alternative sources of household income (Yes- those who had alternative sources and No signified those without)

	Frequency	Percentage
Yes	310	85.6
No	52	14.4
Total	362	100.0

Source: Survey data (2022)

Household Vulnerability

This study utilized an integrated vulnerability strategy to create vulnerability indices for every family in Amboseli. The identical methodology was employed as advised by Madu (2018), and Tesso et al., (2018). This research made the assumption that families with more adaptive ability are less vulnerable to the effects of climate-induced pressures, thereby maintaining a consistent level of exposure.

The findings indicated 70.2% of households had experienced a notable rise in temperature fluctuations in area. 75.4.1% of the homes saw a reduction in rainfall, while 74.3% observed a consistent rise in drought conditions. 73.2% reported a reduction in floods, whereas 82.9% indicated a rise in animal illnesses. Majority 72.7% reported a decline in the accessibility of water for both livestock and household purposes. In periods of drought, there was a decline in both the supply of pasture and water. Resulting to a rise in food insecurity and malnutrition among children under the age of five, drought hindered the movement of both people and cattle populations, as well as impeding development endeavours. The aforementioned data indicate that Pastoralism, as a means of subsistence, is intricately linked to environmental services, including intricate systems of social, political, and economic structure. Furthermore, the Convention on Biological Diversity (2010) and Kareithi (2003) assert that pastoralists inhabit arid and semi-arid regions (ASALs), where their way of life and cultural practices revolve upon large cattle rearing.

The statement is substantiated by the results of focus group discussions conducted in the research region, which verified that the drought's consequences compelled individuals to travel significant distances in search of water and grazing land. As a result, this occasionally led to school-age children being absent from school or even permanently leaving school in certain cases. Furthermore, the respondents emphasized that human-wildlife conflict was a significant worry since they experienced cattle losses during interactions with wild predators. During the FGD at Kimana, a participant highlighted a significant livestock loss in 2009. This loss was attributed to the competition for pasture and water resources between domestic animals and wild animals. The economic impact of this event was severe, affecting numerous families, some of whom are still struggling to recover from the resulting hardships.

An intriguing point raised during the same FGD was that families whose members were gainfully employed due to their education were able to rebound from the 2009 drought. This is mostly due to their ability to buy essential necessities and simultaneously replenish their livestock following the conclusion of the drought period. The FGD's report on this drought experience highlighted the necessity of formal education.

Socio-Economic and Bio-Physical Vulnerability

Education had a crucial role in facilitating the youth's access to career opportunities. The results of this survey revealed that over 86% of the participants had received basic or elementary education, while the remaining individuals were illiterate. Lack of literacy diminishes a household's capacity to comprehend climate information and engage in diverse economic activities. The data on household size revealed that 66% of the individuals surveyed had a household size above five people, with 50.7% of the respondents stating that they had more than five dependents.

The gender of the household head is crucial for climate change adaptation. The survey revealed that 59% of the families were led by males, whereas 41% were led by females' Male family heads had greater levels

of education in comparison to female household heads. The findings suggested that homes led by women were more susceptible to climate-related pressures compared to households led by males. This is mostly due to the limited participation of women in community-level decision-making processes, particularly in areas related to pasture and water management. Furthermore, males seized any possible chance for alternate means of earning a living, while women stayed at home to attend to childcare responsibilities and do household tasks. The study revealed that the vulnerability of families is impacted by several factors, including the gender and education level of the household head, as well as the size of the family, particularly the number of dependent children. As the number of dependents increases, so does the amount of vulnerability.

Households should use revenue source diversity as an adaptive technique. The survey revealed that over 55.5% of households lacked additional sources of income and relied primarily on livestock as their primary source of earnings. Moreover, the survey results indicated that a small number of households engaged in both crop cultivation and animal rearing.

This study discovered that a significant majority of homes examined, specifically 78%, did not have any of their family members involved in formal work. A majority of the participants (82.1%) in the group ranches were found to employ more than two adaptation techniques as a means of managing and enhancing their livelihood in an environment that is undergoing fast change. The high unemployment rate among young people poses a significant challenge, highlighting the need for alternative livelihood options, particularly those that are environmentally focused. Examples of such options include beekeeping, establishing tree nurseries, setting up curio shops in strategic locations near Amboseli National Park, and engaging in bead making to cater to both local and international tourists.

The susceptibility of a household to climatic fluctuation is determined by environmental, economic, and biophysical variables. The findings of this study demonstrated that a significant proportion (86.7%) of households experienced sensitivity and exposure to climatic variability. Bobadoye et al. (2017) conducted a literature review which indicated that in order to effectively adapt to climate-related pressures, it is crucial to focus on household-level interventions. This is because the impacts of climatic variability and change are most strongly experienced at this level. Within the Amboseli Ecosystem, families experienced many significant hazards over the previous three decades, resulting in an elevated level of vulnerability.

A precise understanding of weather patterns and their potential effects on lifestyles was crucial for pastoralism as a means of production. Throughout this study, around 58% of the participants saw a rise in temperature and a decline in rainfall using conventional indicators while residing in the Amboseli Ecosystem. It was observed that this had an impact on their socioeconomic level as well as the purchasing power of the community.

The understanding of changes in crucial climatic factors by indigenous communities is significant, since it heightens the susceptibility of households to climate-related pressures, as stated in Ombogo's study of 2013. The factors used to assess the vulnerability of households were classified into three categories: social, economic, and environmental characteristics. Prior to doing the factor analysis (PCA), the data for each of the hypothesized variables underwent the Kaiser-Meyer-Olkin (KMO) Test. The purpose of the test was to assess the suitability of the data for conducting a factor analysis and to determine the availability and

validity of the desired measurements. The calculated statistic was an index measure that ranged from 0 to 1. The interpretation of the data was quite straightforward, as a number closer to 1 indicated a better outcome compared to a value closer to zero.

Table 3: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin measure of sampling adequacy		0.597
Bartlett's test of Sphericity	Approx. Chi-Square	685.855
	df	171
	Sig.	0.000

Thao et al., (2022) supports that factor analysis may be conducted if the Kaiser-Meyer-Olkin (KMO) value above 0.5 and the Bartlett's test result was below 0.1. The KMO measure of sample adequacy was observed to be 0.597, suggesting that the model was quite good. After verifying the suitability of the data for PCA, the vulnerability indicators that were found were subjected to analysis. A principal component analysis was performed on 14 indicator variables predicted to contribute to household vulnerability, including social, economic, and environmental aspects. The resulting impact scores are presented in Table 3.0. The analysis of social vulnerability factors revealed that the gender of the household head, degree of education, duration of residency, and the person responsible for livestock care had a beneficial impact on the vulnerability of households to climatic variability. Household sensitivity to climatic variability was negatively impacted by the age of the household head and the size of the family. The good traits enhanced resilience, but the negative attributes diminished it. The primary factors influencing household vulnerability were the degree of education, with a prevalence of 86%, and the gender of the household head, accounting for 59%. Additionally, family size had a significant role, contributing 50.7% to household vulnerability. Regarding the economic vulnerability variables, four factors were shown to positively impact household vulnerability, whereas two components had a negative impact. The size of the family's herd, the makeup of the herd, and the tactics used to adapt had a beneficial impact on the household's susceptibility at the household level. The formal employment of family members had a beneficial impact on lowering household vulnerability. Families that had bigger cattle herds and engaged in an extra income-generating activity exhibited superior resilience to climate shocks and pressures, in contrast to those that relied primarily on pastoralism. Households that had no alternative source of income and less livestock diversity had limited capacity for resilience against adverse climatic variation. The table displays the vulnerability level based on social, economic, and environmental parameters. The results above were obtained from the respondent's survey data.

Table 4: Social, Economic and Environmental Indicators and Their Effect on Vulnerability Level

Hypothesized variables	Percentage	Influence on vulnerability
Social vulnerability variables		
Gender of the respondent-HH: Male-headed	59.1	+
Age of the respondent HH head: 50+ years	36.2	-
Level of education of the respondent	86.2	+

HH size: more than 9 persons	50.7	-
Experiences in the area: less than 5 years	34.1	+
Person responsible to take care of animals: Both	23.5	+
Economic vulnerability variable		
Alternative source of income	44.5	-
Herd size: More than 20 livestock	28.3	+
Herd structure: no of cattle	62.8	+
HH employed: no member of HH employed	78.1	+
HH Adaptation strategies: Those with more than 2 adaptation strategies other than pastoralism	82.1	+
Livestock diversity: less than 3 livestock species	45.4	-
Environmental vulnerability variable		
Climate change: experiencing change	86.7	+
Temperature: experiencing increase	57.9	+
Drought: noticed increasing events	6.4	+
Flood: noticed change	7.1	+
Wind: noticed unusual change	12.6	+

Source: Author (2022)

The Data collected from the respondents also indicated that all climate-related factors had a beneficial impact on household susceptibility as indicated by the environmental vulnerability indicators. The primary factor contributing to household vulnerability was climatic variability, accounting for 86.7% of the effect, followed by a temperature increase of 58%. Additional variables. The susceptibility of households was little affected by factors such as wind, land floods, and the frequency of drought episodes. Although the impacts of individual climate variables may be minor, the combined exposure to all of them might diminish family resilience.

PCA facilitated the representation of multidimensional data by condensing it into a reduced number of variables, known as summary indices, for the purpose of identifying patterns, discontinuities, groupings, and exceptional values. It revealed the connections between observations and variables, as well as the relationships among the variables. The factor scores (weights) from the initial principal component analysis had good correlations with most of the indicators discovered under adaptive ability, exposure, and sensitivity. When exposure and sensitivity are kept equal, a negative index indicates that the household has a comparatively weaker adaptive capacity compared to a home with a positive index value, and vice versa.

Within the Olgulului-Ololarashi group ranch, located adjacent to Amboseli National Park, women were actively involved in the creation of bead crafts as a supplementary means of generating cash. The ladies demonstrated ingenuity and crafted exquisite merchandise and decorations, which they marketed to tourists frequenting Amboseli National Park and the adjacent tourist settlements. In addition, they established social collectives aimed at enhancing the financial capabilities of their members, such as "merry-go-round," "Tuinuane" (a Swahili term denoting mutual upliftment), and various forms of social support organizations. These groups provided economic empowerment to household members by facilitating their access to financial loans.

The vulnerability index was calculated using indications of adaptive capability, which showed a positive correlation with the first principal component analysis, as well as indicators of sensitivity and exposure, which showed a negative correlation. The variables examined encompassed the gender of the household leader, educational attainment, and possession of livestock. Nevertheless, the research took into account all factors in terms of exposure and sensitivity. Adaptive capability is seen as a beneficial aspect in reducing vulnerability. Exposure and sensitivity have a detrimental impact on reducing vulnerability. A higher factor score indicates greater significance of the variable and a stronger contribution to the household's vulnerability.

The households were categorized into three groups based on the vulnerability index: Households that were in a vulnerable condition but nevertheless had the ability to manage were relatively less susceptible. Households classified as moderately sensitive need immediate yet temporary aid in the event of climate-induced shocks and pressures. Highly vulnerable homes were on the brink of irreparable circumstances. The examination of these vulnerability categories revealed that 34% of the homes examined in this study were classified as moderately susceptible, indicating the majority. These families had an index ranging from -1.00 to 1.00. The homes with lower vulnerability levels ranged from 1.1 to 3.0 on the vulnerability index and accounted for 29% of the households included in the sample. On the other hand, the households with higher vulnerability levels had an index ranging from -0.9 to -3.0 and formed 27% of the total households sampled, as indicated in Table

Table 5: Factor score for the first principal component analysis

Factors	Factor Score
Social vulnerability variables	
Gender of the respondent-HH: Male-headed	0.229
Age of the respondent HH head: 50+ years	-0.258
Level of education of the respondent	-0.029
HH size: more than 9 persons	-0.298
Experiences in the area: less than 5 years	0.0395
Person responsible to take care of animals: Both	-0.316
Economic vulnerability variable	
Alternative source of income	-0.04414
Herd size: More than 20 livestock	0.19573
Herd structure: no of cattle	
Access to remittances: no cash transfers	-0.341
HH employed: no member of HH employed	0.294
HH Adaptation strategies: Those with more than 2 adaptation strategies other than pastoralism	0.101
Livestock diversity: less than 3 livestock species	-0.159
Environmental vulnerability variable	
Climate change: experiencing change	0.048
Temperature: experiencing increase	0.095
Drought: noticed increasing events	0.101
Flood: noticed change	-0.428

Abbreviations: Households (HH)

Female-led families were determined to be more susceptible than households led by males. This may be attributed to the patriarchal character of the Maasai community. Female participation in decision-making within this group is minimal. Widowed women had significant disadvantages since males held the primary authority in determining the options for alternate means of supporting themselves. In some locations, the transfer of property upon death did not occur automatically. Furthermore, land ownership is exclusively held by men, unless in highly exceptional cases. Occasionally, the eldest sons assumed the duty of managing their houses. Relatives of departed husbands had the authority to approve livestock management choices in widower households. Reduced availability of adaptive methods was observed to correlate with increased household vulnerability. There is a decrease in the number of adaption techniques at the household level. The following is a depiction of home susceptibility based on each group ranch.

Regression analysis revealed that several dimensions of pastoralists' livelihoods, particularly socio-economic, environmental, and biophysical dimensions, were undergoing significant transformations. The demographic makeup of families was starting to shift due to an increase in susceptibility. The study observed that the social makeup of households varied across several aspects, with the socioeconomic factor having the most influence. It was also determined that alterations in temperature and precipitation patterns did really impact livelihoods. This can be ascribed to a substantial decline in cattle output. The milk output, for instance, saw a significant decline, leading to vulnerability as it was a staple item in many homes. However, in contrast to other animal products, milk proved to be a lucrative source of revenue since it could be readily sold by women to adjacent urban areas, allowing them to get cash for other essential needs. A decrease in milk production thus resulted in reduced earnings and heightened susceptibility.

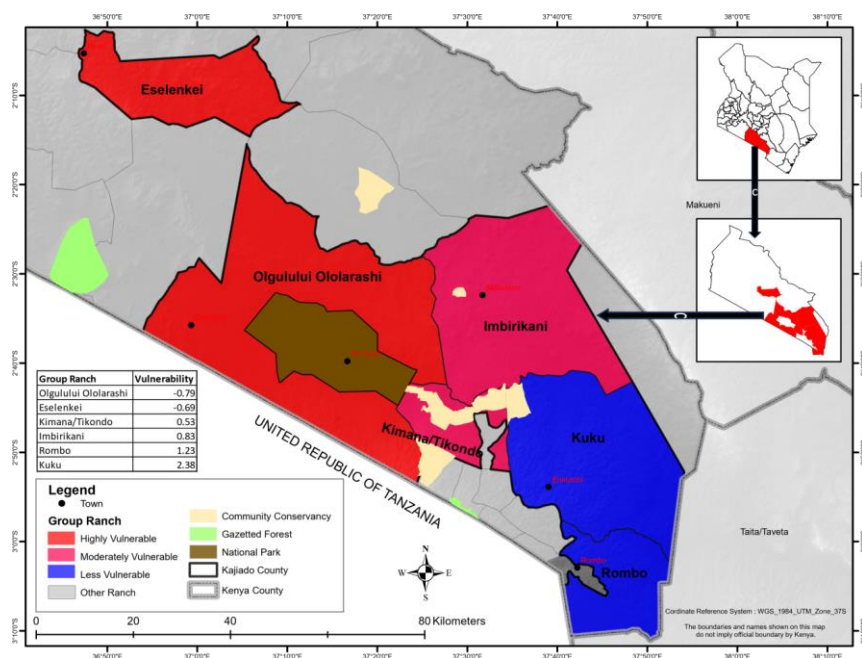


Figure 1: Household Vulnerability Map Per Group Ranch

An observable decrease in the number of animals in the herd was seen as a result of the increasing scarcity of both pasture and water. This can be ascribed to decreased animal reproductive output caused by

inadequate nutrition. In contrast, calves born during drought conditions had a very low likelihood of survival. Conversely, a decrease in animal products led to a rise in market prices due to limited availability, resulting in increased demand. The dry season led to a decrease in the affordability of items, resulting in increased vulnerability. The null hypothesis, which stated that climatic variability and change did not contribute to vulnerability at the household level, was proven.

Conclusion

The livestock sector and pastoralism are hardest hit by climatic variability and stress. It was apparent that livelihood vulnerability among pastoral households were rapidly increasing due to high dependence on livestock as the main source of livelihood. Respondents in the study area identified climate-induced social and economic impacts as: rise in poverty levels, malnutrition among children below the age of five, increase in school dropouts as boys and young men would help out during migration and early marriages driven by the need to acquire wealth in the form of cows especially when families lost livestock due to famine/drought. Households in the Amboseli Ecosystem adopted to some strategies in order to cope with climate variability. The adaptive strategies were diverse and were largely influenced by financial capacity of the household. The strategies included crop farming, small business enterprise, employment, tourism and bead making. These strategies reduced vulnerability to climate stress, but they were not sufficient to shield households during periods of severe drought. As a result, women respondents called for empowerment by improving their financial capacity through self-help groups that enable them to gain financial independence and access to loans to start up small business enterprises, which improve income and reduce vulnerability at the household level.

Recommendations

The County Meteorological Office should create awareness of climate variability and establish an early warning system to enable pastoralists prepare for climate related disasters in the Amboseli Ecosystem and across the sub-County. There should be livestock diversification, downsizing of livestock herds from the household level across the six group ranches. There should be water harvesting during rainfall seasons to enable the community cope with drought occurrences hence improving livelihoods

Declarations

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Author Contributions

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References

- Abeje, M. T., Tsunekawa, A., Haregeweyn, N., Nigussie, Z., Adgo, E., Ayalew, Z., ... & Masunaga, T. (2019). Communities' livelihood vulnerability to climate variability in Ethiopia. *Sustainability*, 11(22), 6302.
- Bobadoye, A., Ogara, W., Ouma, G., & Onono, J. (2017). Assessing vulnerability of Maasai pastoralist in Kenya to climate change and variability.
- Convention on Biological Diversity (2010)
- Innocent, N. O. (2017). *Farmers' perceptions On the Effects of Climate Variability on Dairy Farming in Masaba North, Nyamira County, Kenya* (Doctoral Dissertation, Kenyatta University).
- IPCC. (2014). Climate change 2014: Impacts, adaptation and vulnerability. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge: Cambridge University Press
- Kenya National Bureau of Statistics (KNBS) (2019). Kenya population and housing census. Kenya National Bureau of Statistics, Nairobi
- Kogo, B. K., Kumar, L., & Koech, R. (2021). Climate change and variability in Kenya: a review of impacts on agriculture and food security. *Environment, Development and Sustainability*, 23(1), 23-43.
- Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.
- Madu, I. A. (2012). Spatial vulnerability of rural households to climate change in Nigeria: Implication for internal security. *Working paper No. 2*.
- Ombogo, M. O. (2013). *The Impact of Climate Variability on Pastoralism: forage dynamics and trends in cattle population in Kajiado county*. Nairobi.
- Thao, N. T. P., Van Tan, N., & Tuyet, M. T. A. (2022). KMO and Bartlett's Test for Components of Workers' Working Motivation and Loyalty at Enterprises in Dong Nai Province of Vietnam. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, 13(10), 1-13.
- Smith, A. B. (2021). Pastoralism in Africa. In *Oxford Research Encyclopedia of African History*.
- Tover, L. (2022). Solving the Climate Crisis? WWF's and La Via Campesina's Work on Mitigating Climate Change Through a Gramscian Lens