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Livelihood Vulnerability of the Gabra Agropastoralists to Climate Variability and Change in Marsabit County, Kenya

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Abstract

The livelihoods of pastoralist communities in Kenya are largely climate sensitive due to their dependence on natural resources. This is despite their minimal contribution to global greenhouse gas emissions. This study aimed to assess the livelihood vulnerability of pastoralists who mainly depend on livestock, crops and natural resources to climate variability and variability. This study adopted survey design whereby semi-structured questionnaires were used to collect data from 398 randomly selected pastoralists from the Gabra community in North Horr, Moyale, North Marsabit, Sololo, Loiyangalani, Marsabit Central, Marsabit South sub-Counties of Marsabit County. In order to assess the degree of livelihood vulnerability between the different sub-counties, the study used livelihood vulnerability index. This study used focus group discussions to substantiate study results. According to the results, Gabra communities are highly vulnerable to climate change and vulnerability: Moyale (0.317), Loiyangalani (0.282), Marsabit South (0.168), Marsabit Central (0.247), Marsabit North (0.337), Sololo (0.246) and, North Horr (0.337). similar results were obtained using livelihood vulnerability index-intergovernmental panel on climate change: Moyale (0.063), Loiyangalani (0.065), Marsabit South (0.078), Marsabit Central (0.032), Marsabit North (0.076), Sololo (0.094) and, North Horr (0.076). The high sensitivity scores for all the sub-counties may be attributed to limited access to potable water in the study area. Strategies that minimize households' degree of sensitivity and enhance their adaptive capacity should be promoted. There is need to seek increased adoption of climate-smart

technologies by the Gabra community. Household income can also be diversified establishment of alternative livelihoods.

Key words: Climate change, climate-smart technologies, composite index approach, intergovernmental panel on climate change and, livelihood vulnerability index.

Introduction

Climate change and its impacts on livelihoods is a key concern to many communities in developing countries. The wellbeing of marginalized communities is threatened by climate shocks such as droughts, heavy precipitation, floods and heat waves and tropical cyclones ((IPCC, 2021; Tofu, 2024). In arid and semi-arid areas (ASALs), severe drought causes significant disruption to natural ecosystems, biodiversity, water supply and agricultural production. Many communities in sub-Saharan Africa commonly practice agropastoral systems, which combine cultivation of crop and rearing of livestock (FAO,2021). The communities that practice agropastoral systems derive economic benefits (e.g., primary source of income, food security, asset and wealth storage and employment); socio-cultural (e.g., cultural identity, social status and prestige and social capital) and environmental benefits (e.g., sustainable land use and biodiversity preservation).

The attainment of Sustainable Development Goal (SDG) on eradicating poverty (SDG1) and on food security (SDG2) has been a big challenge in many developing countries in sub-Saharan Africa (Biswas et al., 2021). The situation in most ASALs has been exacerbated by climate variability and change. Ecosystem degradation, alteration of hydrological cycle, poor agricultural yields and reduced food supply have forced communities to adopt maladaptation practices, such as overstocking and charcoal burning, thus worsening the situation (Mahmood et al., 2021). Therefore, climate variability and change poses uneven and severe threats to many communities in ASALs of the sub-Saharan Africa.

Agro-pastoralists in ASALs of Kenya are dependent on ecological services thus making them highly dependent on the rainfall and temperature patterns (Mahmood et al., 2021; Shah et al., 2020). Therefore, the livelihood of agropastoral communities is an integral part of climate change induced vulnerability and risk. However, there has been limited research on livelihood security despite the challenged posed by climate variability and change (Blackmore et al., 2021). Marsabit County has been experiencing increased variability, intensity and frequency of climate variability and change (Gudere et al., 2022). This has adversely affected the livelihoods, local economies, cultural assets, public health and wellbeing, environmental assets and ecosystem services (IPCC, 2021). Therefore, there is a need to assess the livelihood vulnerabilities of agro-pastoral communities in Marsabit County. This is important in understanding the susceptibility of agro-pastoralist communities to climate change induced disasters. The study guides in developing interventions, strategies and policies to enhance livelihoods of the agro-pastoralist in Marsabit County.

Methodology

Study Area Description

Marsabit County is located in Kenya's in the middle part of northern Kenya and it is an arid and semi-arid area (ASAL) area covering over 70,961.2 square kilometres. The county is defined by latitude 2.33333 and longitude 37.9833. Marsabit county borders Ethiopia to the North, Lake Turkana to the West, Samburu County to the South, Wajir and Isiolo counties to the East.

Large areas of Marsabit county comprise broad plains that rises from 300 to 900 meters above sea level and which gently slopes to the South West. The plains are surrounded to the West and North by hills and mountain ranges, with a number of hills having volcanic cones and calderas. Mt. Kulal in the North West is the highest and stand at 2,235m in altitude followed by Ol Donyo Ranges in the South West at 2,066m above sea level, then Mt. Marsabit in the central part of the county at 1,865m in altitude and Hurri Hills in the North East 1,685m above sea level. The Sololo-Moyale escarpment in the North East and the Chalbi Desert are some of the county's prominent topographical features. The Chalbi Desert has an area of 948 Square Kilometres, is located at an elevation of 435m to 500m, and is distinguished by an extensive physical depression; a feature that suggest that Chalbi could have been an ancient lake which dried up. The depression is located within the Great Rift Valley and is separated from Lake Turkana by a small ridge which rises 65 to 100 meters Lake Turkana.

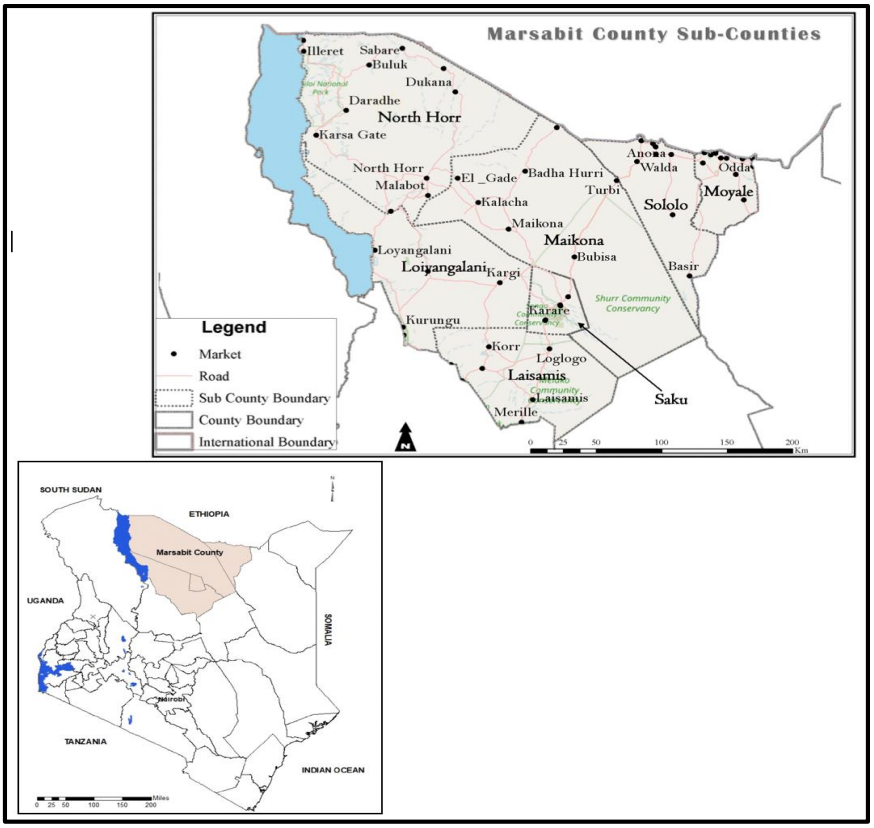

Figure 1. Study area

Sampling Procedure

This study selected the Gabra Community who are agro-pastoralists in Marsabit County. To identify the households that took part in this study, the area was first divided into clusters that represented the nine sub counties in Makueni County. Multistage random sampling was then used to identify the villages and households who participated in this study. Table 1 displays the number of households from each sub-county that took part in the study. The numbers were computed based on the total number of households in each sub-county. The Yamane (1967) formula was used in this study to determine the sample of Gabra pastoralists in Marsabit County.

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

Where n = sample size, N = target population and, e = precision level (0.05)

$$n = \frac{77495}{1 + 77495(77495)^2}$$

Data Collection

This study used KoBoCollect , which is an open-source Android app for collecting data in offline situations, to administer questionnaires in collecting survey data. A sample of 398 households was selected for data collection after the questionnaire was piloted. The sample was selected from seven sub-counties where Gabra communities are resident (Table 1). The collected primary data was on household vulnerability to climate change while secondary data, which was obtained from the Kenya Meteorological Department, was on rainfall and temperature.

Table 1. Survey participants in Marsabit County

Sub-County		Households (Pastoralists)	Sample Size
1	Loiyangalani	7774	40
2	Marsabit South	11615	60
3	Marsabit Central	15849	81
4	Marsabit North	7521	39
5	North Horr	9789	50
6	Moyale	17709	91
7	Sololo	7238	37
Total		77495	398

Data Analysis

This study employed two methods to analyse the livelihood vulnerability of the Gabra Community in Marsabit County: the composite Livelihood Vulnerability Index (LVI) and the Intergovernmental Panel for Climate Change (LVI-IPCC) vulnerability index.

Livelihood vulnerability index: composite index method

Livelihood vulnerability index has seven chief components: socio-demographic, livelihood strategies profile, health, food, water, climate variability and natural disasters and, social networks. In each major component, there are a number of related subcomponents. In order to ensure that each sub-component contributes equally to the overall index, a balanced weighted average approach is utilized. Since each sub component is assessed on a distinct scale, standardization is performed in order to generate an index for each of them. The equation used for standardization is:

$$index_{s_c} = \frac{S_c - S_{min}}{S_{max} - S_{min}} \quad \textbf{(2)}$$

Where s_c is the sub-component for subcounty c, and s_{min} and s_{max} are the minimum and maximum values derived using data from sub-counties. The minimum and maximum values for variables that measure frequencies, such as percentage, were set to 0 and 100, respectively. The sub-components are averaged standardization using equation (3) to find the value of each major component (Hahn et al., 2009),.

$$M_c = \frac{\sum_{i=1}^{n} index_{s_c i}}{\sum_{i=1}^{7} W_{M_i}} \quad \textbf{(3)}$$

Where M_c is one of the seven major components for subcounty (c), $index_{sg}$ is the sub components that make up each main component indexed by i , and n is the number of sub-components in each main component. After determining the values for each of the seven main components for each sub-county, they were averaged using equation (4) to generate the overall

LVI score for gender.

$$LVI_c = \frac{\sum_{i=1}^{7} W_{M_i} M_{c_i}}{\sum_{i=1}^{7} W_{M_i}} \quad \textbf{(4)}$$

Where LVI_c, the Livelihood Vulnerability Index for subcounty is the weighted average of the seven major components. The number of sub-components that make up each main component determines the weights of each major component. In this study, This study, the scale which ranges from 0 (least vulnerable) to 0.5 (most vulnerable) was adopted as developed by Hahn et al. (2009). The major components and their respective subcomponents are provided in Table 2.

LVI-IPCC framework method

The LVI-IPCC method was also used to determine livelihood vulnerability to climate change in Marsabit County. This approach groups the seven primary components of LVI into three vulnerability contributory factors: exposure, sensitivity and adaptive capacity (Table 3). Equations (2), (3), and (4) are used in computing the LVI. However, in the LVI-IPCC technique the primary components of the LVI are not combined into the LVI in one step as they are in the composite LVI method. In this case, they are first combined into LVI using the following equation:

$$CF_c = \frac{\sum_{i=1}^{n} W_{M_i} M_{c_i}}{\sum_{i=1}^{n} W_{M_i}} \quad \textbf{(5)}$$

Where CF_g is an IPCC definite vulnerability contributing factor for sub-county c, M_{ci} is the main component for subcounty c indexed by i, W_{Mi} is the weight of each major component and, n is the total number of major components in each IPCC contributory factor. After determining exposure, sensitivity and adaptive capacity, the LVI-IPCC is calculated by integrating the three vulnerability contributory factors using the following equation:

$$LVI - IPCC_c = (e_c - a_c) * s_c \quad \textbf{(6)}$$

Where LVI-$IPCC_c$ denotes the Livelihood Vulnerability Index for subcounty c, e represents the

calculated exposure score for subcounty c, a represents the estimated adaptive capacity score for subcounty c and, s_c represents the sensitivity score for subcounty c. In this study, the LVI-IPCC scale ranging from -1 (least vulnerable) to +1 (most vulnerable) was adopted as developed by Hahn et al. (2009).

Table 2. LVI major components and sub-components

Major component	**Sub-components**	**Explanatory notes for sub-components**	**Units**	**Data source**
Socio-demographic profile	Dependency ratio	Ratio of people aged 15 to 64 years old (inactive population) to people aged 15 to 64 years old (active population)	Ratio	Survey
	Proportion of male/female headed households	If a male household head is absent for more than six months, the female is considered the head of the household.	Percent	Survey
	Average age of male/female head of household	Household heads' average age	1/Years	Survey
	The proportion of households where the head of the household has not attended school	Percentage of households where the head of the household reports having attended 0 years of school	Percent	Survey
	The proportion of households with orphans	The proportion of households with at least one orphan under the age of 18 whose one or both parents have died.	Percent	Survey

Livelihood Strategies	The proportion of households in which no family member works in a different community.	Percentage of households where no family member works and earns a living outside of their community Question is modified to give a positive vulnerability score when a household doesn't have a member working outside the community	Percent	Survey
	Percentage of households whose sole source of income is pastoralism	Percentage of households reporting agriculture as their sole source of income	Percent	Survey
	Average agricultural livelihood diversification index	The inverse of (the number of agricultural livelihood activities reported by a household +1) The livelihood activities considered in this study included crop farming, animal rearing and collecting of natural resources for sale	1/#Livelihoods	Survey
Social Networks	Average receive: Give ratio	The ratio of (the number of types of help received by a household in the previous month +1) to (the number of types of help given to someone else by a household in the previous month +1)	Ratio	Survey
	Average borrow: Lend money ratio	The ratio of a household borrowing money in the previous month to a household lending money in the previous month	Ratio	Survey
	Percentage of households that sought assistance from their local	The percentage of households who reported seeking help from their local government.	Percent	Survey

	government in the previous 12 months	Question is modified to give a positive vulnerability score when a household seeks help as seeking help is seen as a sign of helplessness which signifies vulnerability		
Health	Average time to health facility on foot	The average time it takes households to walk to the nearest health facility.	Minutes	Survey
	Percentage of households with a chronically ill family member	Percentage of households with at least one chronically ill member	Percent	Survey
	Percentage of households in which a family member missed work or school in the previous two weeks due to illness	The percentage of households where a member missed work or school in the previous two weeks due to illness.	Percent	Survey
	Average Malaria Exposure*Prevention Index	Months of malaria exposure*owning at least one bed net (with bed net = 0.5, without bed net = 1)	Months *Bed net Indicator	Survey
Food	Percentage of households relying solely on family farm for food	Percentage of households who solely rely on their family farm for food	Percent	Survey
	Average number of months households struggle to find food	Average number of months in a year households struggle with food shortage	Months	Survey
	Average Crop Diversity Index	The inverse of (a household's number of crops grown +1)	1/#Crops	Survey
	Percentage of households that do not save crops	Percentage of households that do not save crops from their harvest	Percent	Survey
	Percentage of households that do not save seeds	Percentage of households that do not save seeds for future seasons	Percent	Survey

Water	Percentage of households reporting a water conflict	Percentage of households reporting the occurrence of water conflicts in their community	Percent	Survey
	Percentage of households that use a natural water source	The proportion of households that get their water from natural sources such as rivers, streams, and traditional river wells.	Percent	Survey
	Average time to water source on foot	Average time households take to reach their primary water source on foot	Minutes	Survey
	Percentage of households without a reliable water supply	Percentage of households reporting that water is not available at their primary water source every day	Percent	Survey
	Inverse of the average amount of water stored per household.	The inverse of (the average number of litres of water stored by each household+1)	1/Litres	Survey
Natural Disasters and Climate Variability	Average number of floods, drought and windstorms in the past six years	Total number of droughts, floods and wind storms reported by households in the past six years	Count	Survey
	Percentage of households that did not receive a warning about impending natural disasters	Percentage of households who did not receive any prior warning about imminent natural disasters in the past six years	Percent	Survey
	Percentage of households affected by recent natural disasters in terms of injury or death	The proportion of households reporting a natural disaster-related death or injury in the previous six years.	Percent	Survey
	Mean standard deviation of monthly average of average maximum daily temperatures (last six years)	The standard deviation of the average daily maximum temperature by month between 2015 and 2020	Celsius	Kenya Meteorological Department

	Mean standard deviation of monthly average of average minimum daily temperatures (last six years)	The standard deviation of the average daily minimum temperature by month between 2015 and 2020	Celsius	Kenya Meteorological Department
	Mean standard deviation of monthly average precipitation (last six years)	The standard deviation of the average monthly precipitation between 2015 and 2020	Millimeters	Kenya Meteorological Department

Table 3. LVI-IPCC vulnerability contributory factors

Vulnerability contributing factors	Main components
Sensitivity	Food, Health and Water
Exposure	Natural disasters and climate variability
Adaptive capacity	Socio-demographic profile, Social networks and Livelihood strategies

Results

Demographic profile of the respondents

The survey data for this study was obtained from a sample of 398 households among the Gabra community in Marsabit County. In the study, representative samples were obtained from North-Horr, Moyale, Marsabit North, Marsabit Central, Marsabit South, Loiyangalani, Sololo subcounties (Table 4). According to the results, out of the total sample interviewed, female respondents were 20 percent from North-Horr, 22 percent from Marsabit North, 30 percent from Loiyangalani, 38 percent from Loiyangalani, 38 percent from Sololo, 46 percent in Moyale and, 20 percent from Marsabit Central. The average age of household heads in North-Horr was found to be 49.52 years, while it is 49.76 years in Marsabit North, 47.96 years in Loiyangalani, 49.38 years in Sololo, 45.06 years in Moyale and, 45.06 years in Marsabit Central. Literacy analysis indicates that majority of the respondents interviewed had primary school education. The mean monthly income for household heads was low in most households. The average monthly income is Ksh.9980.00 in North-Horr, Ksh.8931.00 in Marsabit North, KSh.6350.00 in Loiyangalani, Ksh.6673.50 in Sololo, Ksh.7320.00, Ksh. 9470.00 in Marsabit Central and, Ksh. 7698.00 in Marsabit South. Descriptive statistics of the survey data shows varied household sizes across the sub counties are varied. In North-Horr the average household size is 5.24 while it is 5.26 in Marsabit North, 5.18 in Loiyangalani, 5.12 in Sololo, 5.88 in Moyale, 6.32 in Marsabit Central and, 6.04 in Marsabit South.

Livelihood Vulnerability Index - The Composite Index Approach

The livelihood vulnerability results for Marsabit County are provided in Table 5. According to the analysis, North Horr is the most vulnerable sub-county to climate change (LVI = 0.337). Also, Moyale (LVI = 0.317), Marsabit North (LVI = 0.337) and, Loiyangalani (LVI = 0.282) were also found to be highly vulnerable to climate change. Marsabit Central (LVI = 0.247), Sololo (LVI = 0.246) and, Marsabit South (LVI = 0.168) are moderately vulnerable to climate change according to the analysis (Table 5 and 6). An analysis of the major LVI components indicated that households in all subcounties were vulnerable to climate change in socio-demographic profile, livelihood strategies, social networks, food, water, and natural disasters and climate variability.

A spider diagram (Figure 2) was used to plot the LVI scores for North-Horr, Moyale, Marsabit North, Marsabit Central, Loiyangalani, Sololo subcounties. The diagram shows that Gabra Community were more vulnerable to climate change in six components: socio-demographic profile, livelihood strategies, social networks, food, water, and natural disasters and climate variability. In Marsabit South, the Gabra community were vulnerable in to climate change in five components: livelihood strategies, social networks, food, water, and natural disasters and climate variability

Table 4. Demographic profile of survey participants

Sub-County	Variable	Mean	Std. Dev.	Min	Max
North-Horr	Gender	0.20	0.40	0.00	1.00
	Age	49.52	14.25	30.00	82.00
	Education	0 .32	0.91	0.00	4.00
	Monthly income	9980.00	13862.56	2000.00	85000.00
	Household size	5.24	2.45	0.00	13.00
Marsabit North	Gender	0 .22	0.42	0.00	1.00
	Age	49.76	13.35	29.00	75.00
	Education	0.66	1.12	0.00	4.00
	Monthly income	8931.00	8829.71	550.00	50000.00
	Household size	5.26	1.77	2.00	10.00
Loiyangalani	Gender	0.30	0.46	0.00	1.00
	Age	47.96	11.99	27.00	75.00
	Education	0.34	0.77	0.00	3.00
	Monthly income	6350.00	4291.91	1200.00	15000.00
	Household size	5.18	2.01	2.00	12.00
Sololo	Gender	0.38	0.49	0.00	1.00
	Age	49.38	14.50	29.00	92.00
	Education	0.14	0.50	0.00	2.00
	Monthly income	6673.50	5314.74	0.00	20000.00
	Household size	5.12	1.96	2.00	12.00

Moyale	Gender	0.46	0.50	0.00	1.00
	Age	45.06	14.92	21.00	81.00
	Education	.24	0.62	0.00	2.00
	Monthly income	7320.00	5454.67	0.00	20000.00
	Household size	5.88	2.13	2.00	11.00
Marsabit Central	Gender	0.12	0.33	0.00	1.00
	Age	51.70	15.12	20.00	85.00
	Education	0.38	0.81	0.00	3.00
	Monthly income	9470.00	8378.62	500.00	50000.00
	Household size	6.32	2.74	3.00	16.00
Marsabit South	Gender	0.20	0.40	0.00	1.00
	Age	51.80	15.47	30.00	99.00
	Education	0.18	0.66	0.00	3.00
	Monthly income	7698.00	8102.14	500.00	50000.00
	Household size	6.04	2.53	3.00	13.00
	N= 398				

Table 5. Livelihood vulnerability results for Marsabit County

Sub-County	Major Component	Sub component	Units	Actual value	Max Value	Min value	Standardized value	Major component value
North Horr	Socio-Demographic Profile	Dependency ratio	Ratio	2.900	7.000	0.000	0.414	0.337
		Percentage of female-headed households	Percent	42.170	100.000	0.000	0.422	
		Average age of female head of household	1/Years	0.022	0.043	0.014	0.276	
		Percentage of households where head of household has not attended school	Percent	20.750	100.000	0.000	0.208	
		Percentage of households with orphans	Percent	36.460	100.000	0.000	0.365	
	Livelihood Strategies	Percentage of households without family member working	Percent	41.000	100.000	0.000	0.410	0.363

		in a different community						
		Percentage of households dependent solely on agriculture as a source of income	Percent	52.000	100.000	0.000	0.520	
		Average agricultural livelihood diversification index	1/# Livelihoods	0.290	0.500	0.250	0.160	
	Social Networks	Average receive: Give ratio	Ratio	3.380	7.000	0.250	0.464	0.433
		Average borrow: Lend money ratio	Ratio	1.150	2.000	0.500	0.433	
		Percentage of households that have gone to their local government for assistance in the past 12 months	Percent	40.250	100.000	0.000	0.403	
	Health	Average time to health facility	Minutes	68.690	390.000	3.000	0.170	0.226
		Percentage of households with family member with chronic illness	Percent	36.410	100.000	0.000	0.364	
		Percentage of households where a family member had to miss work or school in the last two weeks due to illness	Percent	23.440	100.000	0.000	0.234	
		Average Malaria Exposure*Prevention Index	Months *Bednet Indicator	1.110	5.000	0.500	0.136	
	Food	Percentage of households dependent solely on family farm for food	Percent	79.550	100.000	0.000	0.796	0.445
		Average number of months households struggle to find food	Months	2.860	12.000	0.000	0.238	
		Average Crop	1/#	0.14	1.000	0.07	0.075	

		Diversity Index	Crops	0		0		
		Percentage of households that do not save crops	Percent	43.750	100.000	0.000	0.438	
		Percentage of households that do not save seeds	Percent	68.000	100.000	0.000	0.680	
	Water	Percentage of households reporting water conflicts	Percent	67.000	100.000	0.000	0.670	0.578
		Percentage of households that utilize a natural water source	Percent	70.000	100.000	0.000	0.700	
		Average time to water source	Minutes	74.980	390.000	0.000	0.192	
		Percentage of households that do not have a consistent water supply	Percent	85.000	100.000	0.000	0.850	
		Inverse of the average number of litres of water stored per household	1/Litres	0.036	0.075	0.000	0.478	
	Natural Disasters and Climate Variability	Average number of floods, drought and windstorms in the past six years	Count	5.890	8.000	0.000	0.736	0.546
		Percentage of households that did not receive a warning about the pending natural disasters	Percent	47.250	100.000	0.000	0.473	
		Percentage of households with an injury or death as a result of recent natural disasters	Percent	5.750	100.000	0.000	0.058	
		Mean standard deviation of monthly average of average maximum daily temperatures (last six years)	Celsius	2.970	3.280	1.410	0.834	
		Mean standard deviation of monthly average	Celsius	1.240	1.570	0.770	0.588	

		of average minimum daily temperatures (last six years)						
		Mean standard deviation of monthly average precipitation (last six years)	Millimeters	5.340	8.780	0.370	0.591	
Moyale	Socio-Demographic Profile	Dependency ratio	Ratio	2.900	7.000	0.000	0.414	0.317
		Percentage of female-headed households	Percent	32.170	100.000	0.000	0.322	
		Average age of female head of household	1/Years	0.022	0.043	0.014	0.276	
		Percentage of households where head of household has not attended school	Percent	20.750	100.000	0.000	0.208	
		Percentage of households with orphans	Percent	36.460	100.000	0.000	0.365	
	Livelihood Strategies	Percentage of households without family member working in a different community	Percent	41.000	100.000	0.000	0.410	0.363
		Percentage of households dependent solely on agriculture as a source of income	Percent	52.000	100.000	0.000	0.520	
		Average agricultural livelihood diversification index	1/# Livelihoods	0.290	0.500	0.250	0.160	
	Social Networks	Average receive:Give ratio	Ratio	3.380	7.000	0.250	0.464	0.433
		Average borrow:Lend money ratio	Ratio	1.150	2.000	0.500	0.433	
		Percentage of households that have gone to their local government	Percent	40.250	100.000	0.000	0.403	

		for assistance in the past 12 months						
	Health	Average time to health facility	Minutes	68.690	390.000	3.000	0.170	0.226
		Percentage of households with family member with chronic illness	Percent	36.410	100.000	0.000	0.364	
		Percentage of households where a family member had to miss work or school in the last two weeks due to illness	Percent	23.440	100.000	0.000	0.234	
		Average Malaria Exposure*Prevention Index	Months *Bednet Indicator	1.110	5.000	0.500	0.136	
	Food	Percentage of households dependent solely on family farm for food	Percent	59.550	100.000	0.000	0.596	0.405
		Average number of months households struggle to find food	Months	2.860	12.000	0.000	0.238	
		Average Crop Diversity Index	1/# Crops	0.140	1.000	0.070	0.075	
		Percentage of households that do not save crops	Percent	43.750	100.000	0.000	0.438	
		Percentage of households that do not save seeds	Percent	68.000	100.000	0.000	0.680	
	Water	Percentage of households reporting water conflicts	Percent	67.000	100.000	0.000	0.670	0.573
		Percentage of households that utilize a natural water source	Percent	70.000	100.000	0.000	0.700	
		Average time to water source	Minutes	64.980	390.000	0.000	0.167	
		Percentage of households that do not have a consistent water	Percent	85.000	100.000	0.000	0.850	

		supply						
		Inverse of the average number of litres of water stored per household	1/Litres	0.036	0.075	0.000	0.478	
	Natural Disasters and Climate Variability	Average number of floods, drought and windstorms in the past six years	Count	5.890	8.000	0.000	0.736	0.513
		Percentage of households that did not receive a warning about the pending natural disasters	Percent	27.250	100.000	0.000	0.273	
		Percentage of households with an injury or death as a result of recent natural disasters	Percent	5.750	100.000	0.000	0.058	
		Mean standard deviation of monthly average of average maximum daily temperatures (last six years)	Celsius	2.970	3.280	1.410	0.834	
		Mean standard deviation of monthly average of average minimum daily temperatures (last six years)	Celsius	1.240	1.570	0.770	0.588	
		Mean standard deviation of monthly average precipitation (last six years)	Millimeters	5.340	8.780	0.370	0.591	
Loiyangalani	Socio-Demographic Profile	Dependency ratio	Ratio	1.700	7.000	0.000	0.243	0.282
		Percentage of female-headed households	Percent	36.170	100.000	0.000	0.362	
		Average age of female head of household	1/Years	0.022	0.043	0.014	0.276	
		Percentage of households where head of household has	Percent	20.750	100.000	0.000	0.208	

		not attended school						
		Percentage of households with orphans	Percent	32.160	100.000	0.000	0.322	
	Livelihood Strategies	Percentage of households without family member working in a different community	Percent	41.000	100.000	0.000	0.410	0.310
		Percentage of households dependent solely on agriculture as a source of income	Percent	52.000	100.000	0.000	0.520	
		Average agricultural livelihood diversification index	1/# Livelihoods	0.250	0.500	0.250	0.000	
	Social Networks	Average receive:Give ratio	Ratio	3.380	7.000	0.250	0.464	0.433
		Average borrow:Lend money ratio	Ratio	1.150	2.000	0.500	0.433	
		Percentage of households that have gone to their local government for assistance in the past 12 months	Percent	40.250	100.000	0.000	0.403	
	Health	Average time to health facility	Minutes	68.690	390.000	3.000	0.170	0.226
		Percentage of households with family member with chronic illness	Percent	36.410	100.000	0.000	0.364	
		Percentage of households where a family member had to miss work or school in the last two weeks due to illness	Percent	23.440	100.000	0.000	0.234	
		Average Malaria Exposure*Prevention Index	Months *Bednet Indicator	1.110	5.000	0.500	0.136	

	Food	Percentage of households dependent solely on family farm for food	Percent	51.550	100.000	0.000	0.516	0.389
		Average number of months households struggle to find food	Months	2.860	12.000	0.000	0.238	
		Average Crop Diversity Index	1/# Crops	0.140	1.000	0.070	0.075	
		Percentage of households that do not save crops	Percent	43.750	100.000	0.000	0.438	
		Percentage of households that do not save seeds	Percent	68.000	100.000	0.000	0.680	
	Water	Percentage of households reporting water conflicts	Percent	67.000	100.000	0.000	0.670	0.578
		Percentage of households that utilize a natural water source	Percent	70.000	100.000	0.000	0.700	
		Average time to water source	Minutes	74.980	390.000	0.000	0.192	
		Percentage of households that do not have a consistent water supply	Percent	85.000	100.000	0.000	0.850	
		Inverse of the average number of litres of water stored per household	1/Litres	0.036	0.075	0.000	0.478	
	Natural Disasters and Climate Variability	Average number of floods, drought and windstorms in the past six years	Count	4.690	8.000	0.000	0.586	0.490
		Percentage of households that did not receive a warning about the pending natural disasters	Percent	32.250	100.000	0.000	0.323	
		Percentage of households with an injury or death as a result of recent natural	Percent	2.150	100.000	0.000	0.022	

		disasters						
		Mean standard deviation of monthly average of average maximum daily temperatures (last six years)	Celsius	2.970	3.280	1.410	0.834	
		Mean standard deviation of monthly average of average minimum daily temperatures (last six years)	Celsius	1.240	1.570	0.770	0.588	
		Mean standard deviation of monthly average precipitation (last six years)	Millimeters	5.340	8.780	0.370	0.591	
Marsabit South (Laisamis)	Socio-Demographic Profile	Dependency ratio	Ratio	1.190	7.000	0.000	0.170	0.168
		Percentage of female-headed households	Percent	22.170	100.000	0.000	0.222	
		Average age of female head of household	1/Years	0.022	0.043	0.014	0.276	
		Percentage of households where head of household has not attended school	Percent	10.750	100.000	0.000	0.108	
		Percentage of households with orphans	Percent	6.460	100.000	0.000	0.065	
	Livelihood Strategies	Percentage of households without family member working in a different community	Percent	41.000	100.000	0.000	0.410	0.363
		Percentage of households dependent solely on agriculture as a source of income	Percent	52.000	100.000	0.000	0.520	
		Average agricultural livelihood diversification index	1/# Livelihoods	0.290	0.500	0.250	0.160	

	Social Networks	Average receive:Give ratio	Ratio	3.380	7.000	0.250	0.464	0.370
		Average borrow:Lend money ratio	Ratio	1.150	2.000	0.500	0.433	
		Percentage of households that have gone to their local government for assistance in the past 12 months	Percent	21.250	100.000	0.000	0.213	
	Health	Average time to health facility	Minutes	68.690	390.000	3.000	0.170	0.226
		Percentage of households with family member with chronic illness	Percent	36.410	100.000	0.000	0.364	
		Percentage of households where a family member had to miss work or school in the last two weeks due to illness	Percent	23.440	100.000	0.000	0.234	
		Average Malaria Exposure*Prevention Index	Months *Bednet Indicator	1.110	5.000	0.500	0.136	
	Food	Percentage of households dependent solely on family farm for food	Percent	59.550	100.000	0.000	0.596	0.367
		Average number of months households struggle to find food	Months	2.860	12.000	0.000	0.238	
		Average Crop Diversity Index	1/# Crops	0.140	1.000	0.070	0.075	
		Percentage of households that do not save crops	Percent	24.750	100.000	0.000	0.248	
		Percentage of households that do not save seeds	Percent	68.000	100.000	0.000	0.680	
	Water	Percentage of households	Percent	67.000	100.000	0.000	0.670	0.567

		reporting water conflicts						
		Percentage of households that utilize a natural water source	Percent	70.000	100.000	0.000	0.700	
		Average time to water source	Minutes	52.980	390.000	0.000	0.136	
		Percentage of households that do not have a consistent water supply	Percent	85.000	100.000	0.000	0.850	
		Inverse of the average number of litres of water stored per household	1/Litres	0.036	0.075	0.000	0.478	
	Natural Disasters and Climate Variability	Average number of floods, drought and windstorms in the past six years	Count	3.890	8.000	0.000	0.486	0.471
		Percentage of households that did not receive a warning about the pending natural disasters	Percent	27.250	100.000	0.000	0.273	
		Percentage of households with an injury or death as a result of recent natural disasters	Percent	5.750	100.000	0.000	0.058	
		Mean standard deviation of monthly average of average maximum daily temperatures (last six years)	Celsius	2.970	3.280	1.410	0.834	
		Mean standard deviation of monthly average of average minimum daily temperatures (last six years)	Celsius	1.240	1.570	0.770	0.588	
		Mean standard deviation of monthly average precipitation (last	Millimeters	5.340	8.780	0.370	0.591	

		six years)						
Marsabit Central (Saku)	Socio-Demographic Profile	Dependency ratio	Ratio	1.490	7.000	0.000	0.213	0.247
		Percentage of female-headed households	Percent	22.170	100.000	0.000	0.222	
		Average age of female head of household	1/Years	0.022	0.043	0.014	0.276	
		Percentage of households where head of household has not attended school	Percent	20.750	100.000	0.000	0.208	
		Percentage of households with orphans	Percent	31.460	100.000	0.000	0.315	
	Livelihood Strategies	Percentage of households without family member working in a different community	Percent	41.000	100.000	0.000	0.410	0.363
		Percentage of households dependent solely on agriculture as a source of income	Percent	52.000	100.000	0.000	0.520	
		Average agricultural livelihood diversification index	1/# Livelihoods	0.290	0.500	0.250	0.160	
	Social Networks	Average receive:Give ratio	Ratio	3.380	7.000	0.250	0.464	0.433
		Average borrow:Lend money ratio	Ratio	1.150	2.000	0.500	0.433	
		Percentage of households that have gone to their local government for assistance in the past 12 months	Percent	40.250	100.000	0.000	0.403	
	Health	Average time to health facility	Minutes	58.690	390.000	3.000	0.144	0.164
		Percentage of households with	Percent	16.410	100.000	0.000	0.164	

		family member with chronic illness						
		Percentage of households where a family member had to miss work or school in the last two weeks due to illness	Percent	21.440	100.000	0.000	0.214	
		Average Malaria Exposure*Prevention Index	Months *Bednet Indicator	1.110	5.000	0.500	0.136	
	Food	Percentage of households dependent solely on family farm for food	Percent	44.550	100.000	0.000	0.446	0.315
		Average number of months households struggle to find food	Months	2.860	12.000	0.000	0.238	
		Average Crop Diversity Index	1/# Crops	0.140	1.000	0.070	0.075	
		Percentage of households that do not save crops	Percent	13.750	100.000	0.000	0.138	
		Percentage of households that do not save seeds	Percent	68.000	100.000	0.000	0.680	
	Water	Percentage of households reporting water conflicts	Percent	67.000	100.000	0.000	0.670	0.545
		Percentage of households that utilize a natural water source	Percent	70.000	100.000	0.000	0.700	
		Average time to water source	Minutes	10.980	390.000	0.000	0.028	
		Percentage of households that do not have a consistent water supply	Percent	85.000	100.000	0.000	0.850	
		Inverse of the average number of litres of water stored per household	1/Litres	0.036	0.075	0.000	0.478	

	Natural Disasters and Climate Variability	Average number of floods, drought and windstorms in the past six years	Count	2.190	8.000	0.000	0.274	0.420
		Percentage of households that did not receive a warning about the pending natural disasters	Percent	47.250	100.000	0.000	0.473	
		Percentage of households with an injury or death as a result of recent natural disasters	Percent	2.175	100.000	0.000	0.022	
		Mean standard deviation of monthly average of average maximum daily temperatures (last six years)	Celsius	2.970	3.280	1.410	0.834	
		Mean standard deviation of monthly average of average minimum daily temperatures (last six years)	Celsius	1.240	1.570	0.770	0.588	
		Mean standard deviation of monthly average precipitation (last six years)	Millimeters	3.140	8.780	0.370	0.329	
Marsabit North	Socio-Demographic Profile	Dependency ratio	Ratio	2.900	7.000	0.000	0.414	0.337
		Percentage of female-headed households	Percent	42.170	100.000	0.000	0.422	
		Average age of female head of household	1/Years	0.022	0.043	0.014	0.276	
		Percentage of households where head of household has not attended school	Percent	20.750	100.000	0.000	0.208	
		Percentage of households with orphans	Percent	36.460	100.000	0.000	0.365	
	Livelihood	Percentage of	Percent	41.0	100.0	0.00	0.410	0.363

	Strategies	households without family member working in a different community		00	00	0		
		Percentage of households dependent solely on agriculture as a source of income	Percent	52.000	100.000	0.000	0.520	
		Average agricultural livelihood diversification index	1/# Livelihoods	0.290	0.500	0.250	0.160	
	Social Networks	Average receive:Give ratio	Ratio	3.380	7.000	0.250	0.464	0.433
		Average borrow: Lend money ratio	Ratio	1.150	2.000	0.500	0.433	
		Percentage of households that have gone to their local government for assistance in the past 12 months	Percent	40.250	100.000	0.000	0.403	
	Health	Average time to health facility	Minutes	68.690	390.000	3.000	0.170	0.226
		Percentage of households with family member with chronic illness	Percent	36.410	100.000	0.000	0.364	
		Percentage of households where a family member had to miss work or school in the last two weeks due to illness	Percent	23.440	100.000	0.000	0.234	
		Average Malaria Exposure*Prevention Index	Months *Bednet Indicator	1.110	5.000	0.500	0.136	
	Food	Percentage of households dependent solely on family farm for food	Percent	79.550	100.000	0.000	0.796	0.445
		Average number of months	Months	2.860	12.000	0.000	0.238	

		households struggle to find food						
		Average Crop Diversity Index	1/# Crops	0.140	1.000	0.070	0.075	
		Percentage of households that do not save crops	Percent	43.750	100.000	0.000	0.438	
		Percentage of households that do not save seeds	Percent	68.000	100.000	0.000	0.680	
	Water	Percentage of households reporting water conflicts	Percent	67.000	100.000	0.000	0.670	0.578
		Percentage of households that utilize a natural water source	Percent	70.000	100.000	0.000	0.700	
		Average time to water source	Minutes	74.980	390.000	0.000	0.192	
		Percentage of households that do not have a consistent water supply	Percent	85.000	100.000	0.000	0.850	
		Inverse of the average number of litres of water stored per household	1/Litres	0.036	0.075	0.000	0.478	
	Natural Disasters and Climate Variability	Average number of floods, drought and windstorms in the past six years	Count	5.890	8.000	0.000	0.736	0.546
		Percentage of households that did not receive a warning about the pending natural disasters	Percent	47.250	100.000	0.000	0.473	
		Percentage of households with an injury or death as a result of recent natural disasters	Percent	5.750	100.000	0.000	0.058	
		Mean standard deviation of monthly average of average maximum daily temperatures	Celsius	2.970	3.280	1.410	0.834	

		(last six years)						
		Mean standard deviation of monthly average of average minimum daily temperatures (last six years)	Celsius	1.240	1.570	0.770	0.588	
		Mean standard deviation of monthly average precipitation (last six years)	Millimeters	5.340	8.780	0.370	0.591	
Sololo	Socio-Demographic Profile	Dependency ratio	Ratio	2.100	7.000	0.000	0.300	0.246
		Percentage of female-headed households	Percent	27.170	100.000	0.000	0.272	
		Average age of female head of household	1/Years	0.022	0.043	0.014	0.276	
		Percentage of households where head of household has not attended school	Percent	14.750	100.000	0.000	0.148	
		Percentage of households with orphans	Percent	23.460	100.000	0.000	0.235	
	Livelihood Strategies	Percentage of households without family member working in a different community	Percent	41.000	100.000	0.000	0.410	0.297
		Percentage of households dependent solely on agriculture as a source of income	Percent	32.000	100.000	0.000	0.320	
		Average agricultural livelihood diversification index	1/# Livelihoods	0.290	0.500	0.250	0.160	
	Social Networks	Average receive: Give ratio	Ratio	3.080	7.000	0.250	0.419	0.375
		Average borrow: Lend money ratio	Ratio	1.150	2.000	0.500	0.433	
		Percentage of households that have gone to their	Percent	27.250	100.000	0.000	0.273	

		local government for assistance in the past 12 months						
	Health	Average time to health facility	Minutes	48.190	390.000	3.000	0.117	0.200
		Percentage of households with family member with chronic illness	Percent	31.410	100.000	0.000	0.314	
		Percentage of households where a family member had to miss work or school in the last two weeks due to illness	Percent	23.440	100.000	0.000	0.234	
		Average Malaria Exposure*Prevention Index	Months *Bednet Indicator	1.110	5.000	0.500	0.136	
	Food	Percentage of households dependent solely on family farm for food	Percent	42.550	100.000	0.000	0.426	0.371
		Average number of months households struggle to find food	Months	2.860	12.000	0.000	0.238	
		Average Crop Diversity Index	1/# Crops	0.140	1.000	0.070	0.075	
		Percentage of households that do not save crops	Percent	43.750	100.000	0.000	0.438	
		Percentage of households that do not save seeds	Percent	68.000	100.000	0.000	0.680	
	Water	Percentage of households reporting water conflicts	Percent	67.000	100.000	0.000	0.670	0.558
		Percentage of households that utilize a natural water source	Percent	70.000	100.000	0.000	0.700	
		Average time to water source	Minutes	34.980	390.000	0.000	0.090	
		Percentage of households that do not have a	Percent	85.000	100.000	0.000	0.850	

		consistent water supply						
		Inverse of the average number of litres of water stored per household	1/Litres	0.036	0.075	0.000	0.478	
	Natural Disasters and Climate Variability	Average number of floods, drought and windstorms in the past six years	Count	5.890	8.000	0.000	0.736	0.536
		Percentage of households that did not receive a warning about the pending natural disasters	Percent	41.250	100.000	0.000	0.413	
		Percentage of households with an injury or death as a result of recent natural disasters	Percent	5.750	100.000	0.000	0.058	
		Mean standard deviation of monthly average of average maximum daily temperatures (last six years)	Celsius	2.970	3.280	1.410	0.834	
		Mean standard deviation of monthly average of average minimum daily temperatures (last six years)	Celsius	1.240	1.570	0.770	0.588	
		Mean standard deviation of monthly average precipitation (last six years)	Millimeters	5.340	8.780	0.370	0.591	

Table 6. LVI for major component and overall LVI scores for households in Marsabit County

Sub-County	Major Components							
	Socio-demographic profile	Livelihood Strategies	Social Networks	Health	Food	Water	Natural disasters and climate variability	Overall LVI
Moyale	0.317	0.363	0.433	0.226	0.405	0.573	0.513	0.317
Loiyangalani	0.282	0.310	0.433	0.226	0.389	0.578	0.490	0.282
Marsabit South	0.168	0.363	0.370	0.226	0.367	0.567	0.471	0.168
Marsabit Central	0.247	0.363	0.433	0.164	0.315	0.545	0.420	0.247
Marsabit North	0.337	0.363	0.433	0.226	0.445	0.578	0.546	0.337
Sololo	0.246	0.297	0.375	0.200	0.371	0.558	0.536	0.246
North Horr	0.337	0.363	0.433	0.226	0.445	0.578	0.546	0.337

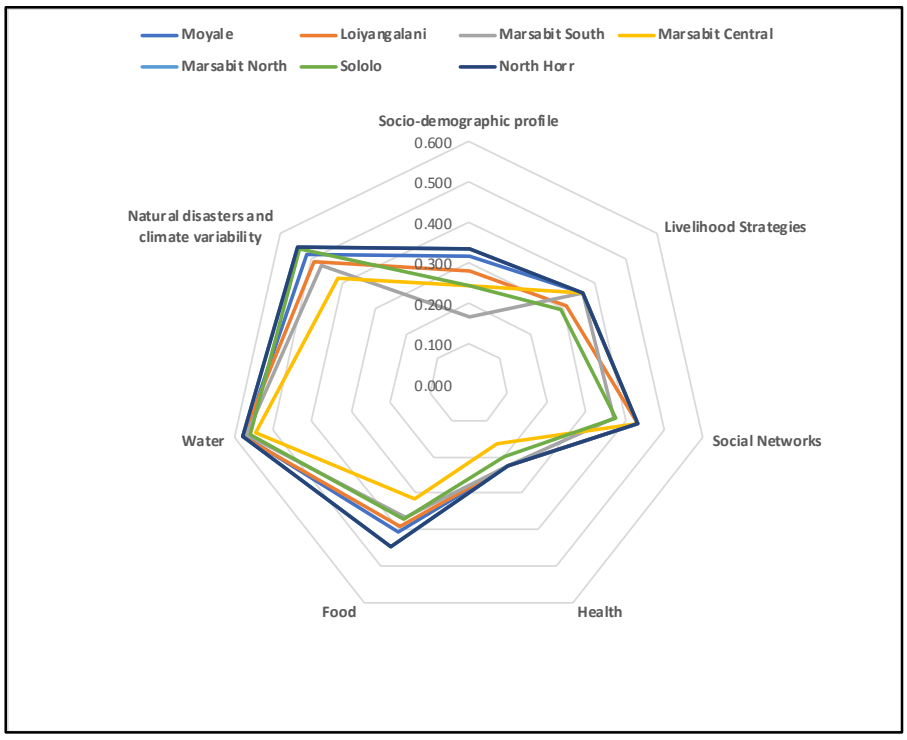

Figure 2: Vulnerability spider diagram of major components of the livelihood vulnerability index for Gabra Community in Marsabit County

The LVI-IPCC Method

A summary of results of the study obtained using LVI-IPCC model are provided in Table 7 below. According to the results, all the seven subcounties considered in the study indicated that Gabra community was vulnerable to climate change: Sololo (IPCC-LVI=0.094), Marsabit South (IPCC-LVI=0.078), Marsabit North (IPCC-LVI=0.076), North Horr (IPCC-LVI=0.076), Loiyangalani (IPCC-LVI=0.065), Moyale (IPCC-LVI=0.063) and, Marsabit Central (IPCC-LVI=0.032). All the LVI-IPCC vulnerability contributory factors, adaptive capacity, sensitivity and exposure, revealed distinct disparities over all the sub-counties.

Table 7. LVI-IPCC scores for households in Marsabit County

Sub-County	Adaptive capacity	Sensitivity	Exposure	LVI-IPCC Scores
Moyale	0.361	0.414	0.513	0.063
Loiyangalani	0.331	0.410	0.490	0.065
Marsabit South	0.276	0.398	0.471	0.078
Marsabit Central	0.329	0.354	0.420	0.032
Marsabit North	0.370	0.430	0.546	0.076
Sololo	0.295	0.389	0.536	0.094
North Horr	0.370	0.430	0.546	0.076

A vulnerability triangle was plotted using the LVI-IPCC scores (Figure 3). According to the figure, Gabra community are vulnerable in all the three indicators of livelihood vulnerability. The results show that North Horr and Marsabit North sub-counties had the scores in adaptive capacity (0.370) and sensitivity (0.430) indicators livelihood vulnerability. Sololo sub-county was found to have the highest score for exposure0.094) indicator.

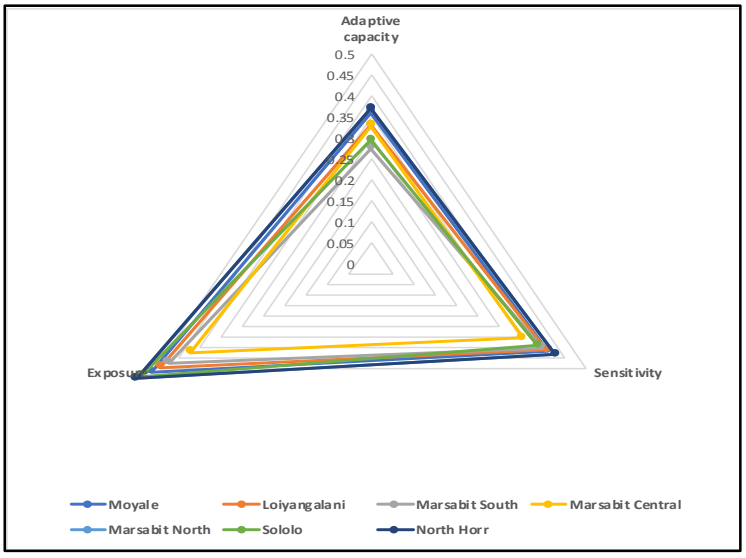

Figure 3 Vulnerability triangle diagram of the contributing factors of the livelihood vulnerability index-IPCC for Gabra Community in Marsabit County

Discussion

LVI – the composite index approach

The findings of this study reveal that vulnerability is conditioned by environmental circumstances, geography, social structures, time, social position, availability of livelihood opportunities and also availability of resources. Similar results have been obtained by other studies (Muia et al., 2024). The vulnerability of Gabra community to climate change can be partly attributed to illiteracy, insufficient resources, and limited access to information (Abbasi et al. 2019). Agro-pastoralists diversify their income through growing of crops besides keeping livestock. Also, the Gabra households have been sending their husbands and sons outside the community to work and send remittances home as a coping strategy. Collection of natural resources for sale in the local markets has been used as an alternative source of income among the agropastoral community.

Household characteristics contribute to vulnerability of Gabra community to climate change in all the studied sub-counties. For example, the distance to water sources has increased following the increased frequency of drought. This may be the reason for high vulnerability score for water major component in all the sub-counties. Related studies have also shown vulnerability in terms of livelihood strategies and water main components due to difficulty in procuring the resource (Alhassan et al., 2019).

In all the sub-counties of Marsabit County, agro-pastoralists are depend on natural resources for maintenance of their livelihood. This implies that the livelihood of households are highly vulnerable to climate change. Lack of preparation for potential climate shocks may be responsible for high vulnerability score the food sector. These findings relate to the study by Abbasi et al. (2019), which attributed food insecurity to climate drought. The county of Marsabit has been impacted by a high number of natural disasters over the last six years. This has been exacerbated by a variability in monthly average minimum and maximum daily term

The LVI-IPCC findings show that Gabra community is vulnerable to climate change. This is attributed to demographic imbalance, low diversification of livelihood strategies and poor storage of food. Since the adaptation strategies by agro-pastoralists are low, sensitivity to climate change has increased. Poor adaptation to climate change may also be linked to low household income. The study by Muia et al. (2024) linked high vulnerability to adaptive capacity for households, since people with lower income are usually poor and thus lack assets to liquidate. In addition, lack of secure land tenure to support land use investments can affect adaptation to climate change (Alhassan et al., 2019; Basiru et al., 2022).

Conclusions

This study assessed the susceptibility of households to climate change in Marsabit County using two livelihood vulnerability indices: the LVI and the LVI-IPCC. The used methods of analysis proved robust in analysis of vulnerability diversity. In Marsabit County, the findings show that livelihood vulnerability is intertwined with

community inequality patterns and location differentiated. Using the LVI approach, socio-demographic profile, livelihood strategies, social network, health, food, water, natural disasters and climate variability were found to have overlapping effects. These factors, in turn, increase the exposure to and sensitivity to climate change, while limiting their adaptive capacity.

There is need for the County Government of Marsabit and National Government, through the Ministry of Environment and Forest, to design climate-related interventions that boost resilience of the Gabra Community through diversification of livelihoods thus enhancing the adaptive capacity of pastoral households. It is also important for the respective governments to promote climate change mitigation programmes in the county address the related climate shock. Policy instruments should be developed to address the primary drivers of livelihood vulnerability of Gabra community to climate change.

Authors' contributions

All authors contributed equally.

Conflict Of Interest

Authors declare no conflict of interest.

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