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Understanding the Indicators of Adaptive Capacity Measurements among the Asals Smallholder Livestock Farmers in Kenya

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Abstract
With the IPCC prediction of continued climate change trends which is expected to intensify in the future, there is need to build resilience and adaptive capacity to climate change among the most vulnerable groups through adaptation. Farmers with high adaptive capacity would be better equipped to face the challenges and threats posed by climate change. Therefore, understanding adaptive capacity of farmers is an important consideration for effective policy interventions especially among the smallholder farmers in SSA. Using the sustainable livelihood framework, this study used five capital assets (natural, physical, human, social and financial) to assess the adaptive capacity smallholder livestock farmers in three different study sites. Majority (47%) of the households in Kajiado county were categorized as having moderate AC, while more than half (52%) of the sampled households in Taita Taveta were having high AC. However, bigger proportion (57%) of the household in Laikipia county had low AC. The differences in social, physical, and financial capital are mainly responsible for the differential adaptive capacity among the farming households in the three study sites. However, there were considerable differences among the villages in terms of asset distribution. Therefore, purpose-driven policy initiatives especially in training of CSA practices to enhance sustainable adaptive capacity through efficient adaptation are of paramount importance in this region.
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1. Introduction

Climate change is a worldwide phenomenon but it is also perhaps one of the greatest environmental threats that Sub Saharan African (SSA) is facing today especially in its agriculture and rural livelihoods. Although agriculture and especially livestock subsector has been identified as a major contributor of climate change, it is still among the most affected by these changes in climate. The IPCC has confirmed that the rapid and steady increase in earth surface temperature by an average of 0.80C, significantly affect agriculture in different ways (IPCC, 2014). Consequently, its negative effects have an impact on a bigger population especially within the SSA whose livelihoods revolve around livestock. A sizeable proportion of Africa's livestock are kept in extensive systems in the arid and semi-arid lands (ASALs) which are the most vulnerable regions to the effect of climate change (FAO, 2021). In Kenya, livestock sector accounts for 34 percent of the Agricultural GDP and about five percent of the country's overall GDP (Republic of Kenya, 2021). In addition, the sector is a key source of livelihood for over 10 million people living in the country's ASALs (Republic of Kenya, 2021). However, the sector is dominated by smallholder production systems which lack sufficient technical and financial capacity to adapt to climate change. Farmers in these regions are further predisposed to food insecurity, poverty through loss of productive assets and weakening of coping strategies (IPCC, 2014).

With the IPCC prediction of continued climate change trends which is expected to intensify in the future, there has been a lot of concerted efforts to build resilience and adaptive capacity to climate change among the most vulnerable groups through adaptation. Adaptation has been singled out as one major policy option for reducing the negative effects of climate change (Adger et al., 2007; Osumanu et al., 2017). However, the success of adaptation within a system depends greatly on its adaptive capacity. Hence, adaptive capacity has recently gained relevance in the political and scientific arena, since it is considered as the main pillar in the success of adaptation and resilience to climate changes. Actually, lack of adaptive capacity is the main component of vulnerability (Engle, 2011; Mesfin et al., 2020). Adaptive capacity has also becomes a critical requirement in the policy planning and design to achieve the sustainable development goals at global and national levels (Abdul-Razak & Kruse, 2017a; Adger et al., 2007). Equally within the scientific arena, adaptive capacity concept is rapidly gaining relevance within the research space as a number of studies have tried to explore its relation to vulnerability and adaptation to climate change among most susceptible groups (Datta & Behera, 2022;

Jamshidi et al., 2020; Matewos, 2020).

There are numerous ways that have been used by various scholars to define the concept of adaptive capacity according to the different contexts and systems. From a climate change point of view, IPCC (2014), defines adaptive capacity as the ability of a system to accommodate or cope with climate change (including climate variability and extremes) with minimal disruption. According to Brooks & Adger (2005) and Mesfin et al. (2020) adaptive capacity refers to the ability of a particular system or individual to adjust its characteristics or behaviours in a reactive and/or anticipatory manner to the current and perceived climate change stresses so as to moderate the potential damages or consequences. Adger et al. (2007) and Engle (2011) view adaptive capacity as an essential component of adaptation that forms the asset base from which adaptation actions and investments are anchored. Adaptive capacity is therefore a critical systems property that determines the inherent ability of that individual or system to reduce vulnerability to climate change and increase its survival within the changing environment (Jones et al., 2010; Lemos et al., 2013; Pelling & High, 2005; Smit & Pilifosova, 2003).

To ensure a better understanding of a system's vulnerability and adaptive capacity to climate change, detail assessment of the factors that determines their adaptive capacity to climate change is critical. Thus, it is fundamental to assess and measure the adaptive capacity in order to appraise adaptive capacity levels among those we expect to be the most vulnerable to climate change. However, the assessment and measurement of adaptive capacity is difficult since it's a multidimensional component which measures the latent nature (potential) of a system to respond to climate change and related hazards (Adger et al., 2007; Engle, 2011; Matewos, 2020). Although there are some attempts to assess and measure the adaptive capacity, these efforts are still at infancy stage. Even from the few studies done, there has been a number of discrepancies by various scholars on the components that makes up the adaptive capacity measurement, methods, approaches and the scale (Maldonado-Méndez et al., 2022). This has led to the evolution of the techniques and approaches used, with no standard method for measuring and assessing adaptive capacity.

Nonetheless, literature depicts two distinct measurement approaches, the deductive (theory driven) and the inductive (data driven) (Below et al., 2012; Matewos, 2020). The most commonly used is the inductive approach which it entails the use of proxy variables to identify determinants, indicators and sub indicators which are then scored base on expert opinion/ judgement or through correlation with the previous climate change induced disasters to generate a composite adaptive capacity index. However, selection of the appropriate indicators remains a critical exercise for the composite index to be reliable (Datta & Behera, 2022).Various dimensions and indicators have been proposed for measuring and characterizing adaptive capacity. Some have used four dimensions (Jamshidi et al., 2020), five dimensions (Datta & Behera, 2022; Pickson & He, 2021; Zanmassou et al., 2020), while others have used six (Maldonado-Méndez et al., 2022) with varied components making up the adaptive capacity indicators. The determination of the components making up adaptive capacity and the decision of the dimension and indicators to adopt for a particular study have been met with a lot of challenges and lack of consensus.

Notably, adaptive capacity is context and scale-dependent, the exact determinants of adaptive capacity vary from one area to another (Siders, 2019): what supports the ability of a particular group of farmers in a certain region to adapt to changing weather patterns may vary due to geospatial factors as well as cultural factors of the communities. Thus, there is need for a thorough understanding of the socioeconomic impacts of climate change at the local level (Mesfin et al., 2020). Consequently, the dimensions and the indicators of adaptive capacity could differ from one location to another. Much of the work from the scientific community however, have favoured national level assessment. Such assessment cannot vividly capture the unique nature of local level adaptations and determinants contributing to the adaptive capacity. In addition, different sectors have varied dimensional difference with regards to the determinants and the components making up the adaptive capacity assessment and measurements.

It is imperative therefore to develop sector, region and context-specific assessment designed with indicators adjusted to account for regional, socioeconomic and cultural context variations to be used in assessing adaptive capacity in livestock sub sector. In addition, it is also imperative to understand the different levels of adaptive capacity among the livestock farmers, which provides a basis to find more effective ways for supporting them to build their resilience and hence increase their adaptive capacity. Specific assessment of adaptive capacity focusing on small holder livestock farmer within the ASAL regions of Kenya a is therefore necessary so as to provide the needed critical information for policy development and interventions on climate change adaptation. It is with this backdrop that this paper seeks to address the existing knowledge gab by answering the following questions i) what are the different components and indicators used to assess AC among the pastoralists? ii) How do the levels of adaptive capacity differ among the livestock farmers? The results of the study will provide an thorough understanding of the measurements of adaptive capacity among the pastoralists.

1.1 Conceptual framework

Literature depict that adaptive capacity of a particular system is determined by an array of determinants and indicators which are neither independent nor mutually exclusive but are outcome of a combination of several factors depending on the context (Abdul-Razak & Kruse, 2017b; Datta & Behera, 2022). In this context, livestock farmer's adaptive capacity represents a stock of capital available to formulate the adaptation strategies to climate change that the farmer will adopt to achieve a sustainable livelihood (Scoones, 1998). Hence, with reference to previous scholars, a selection of appropriate indicators was done by adopting a sustainable livelihood framework which outlined five capital assets; natural, physical, financial, human and social capital (Datta & Behera, 2022; Defiesta & Rapera, 2014; Kabobah et al., 2018; Matewos, 2020; Scoones, 1998; Zanmassou et al., 2020). These indicators are all interconnected and contribute to the adaptive capacity of the household. Many empirical studies in Africa have shown that adaptive capacity measurement mostly consider the five capital base assets. Indicators for each of the five capital assets were identified based on the empirical review on adaptive capacity to climate change as well as the uniqueness of the study area. The adaptive capacity to climate change and variability of farming households was measured using a composite index. The index consists of various indicators of adaptive capacity following the sustainable livelihoods framework. Based on this approach, adaptive capacity is determined by ownership and access to resources, information and technology, and ability to diversify livelihoods to cope with climate-related stresses.

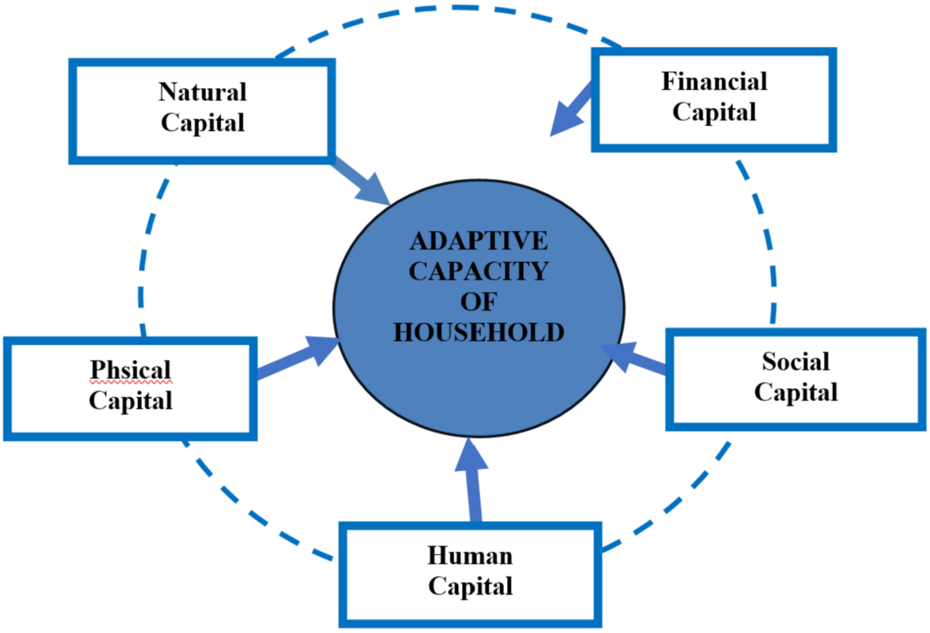

Figure 1: Conceptual framework for assessing the adaptive capacity of livestock farmers.
Modified from Jones et al. Arrows indicate direct effects, while the broken circle depicts secondary or indirect relationships between the components.

2. MATERIALS AND METHODS

2.1. Description of study area

The study was conducted in three ASAL Counties in Kenya where households are mainly involved in livestock-based livelihoods (Figure 2). These Counties are Laikipia (0.36060N; 36.78200E), TaitaTaveta (3.31610S; 38.48500E) and Kajiado (2.09810N; 36.78200E) counties. The Counties were selected to take into account varying levels of vulnerability to climate change, reliance on livestock-based livelihoods, and variability on agroecological characteristics.

The study was conducted in three ASAL Counties in Kenya where households are mainly involved in livestock-based livelihoods (*Figure 2*). These Counties are Laikipia (0.3606^0N; 36.7820^0E), TaitaTaveta (3.3161^0S; 38.48500E) and Kajiado (2.0981^0N; 36.7820^0E) counties. The Counties were selected to take into account varying levels of vulnerability to climate change, reliance on livestock-based livelihoods, and variability on agroecological characteristics. Kajiado County has a total area of 21,871.1km^2 with a human population of 1,117,840 with 79% of the households being food insecure (Republic of Kenya, 2019). Livestock rearing is the main economic activity although crop farming is also done majorly along rivers and streams. According to the National Census report 2019, the county is ranked the second and fifth with regards to the population of cattle (557,710) and sheep (1,120,649) respectively among the ASAL counties. The frequency and severity of droughts in the county have resulted in crop failure and livestock losses and triggered severe food shortages in the past with crop failure in the county reported at more than 90%, while livestock losses were in excess of 70% in most areas within the county (MoALF, 2017a).

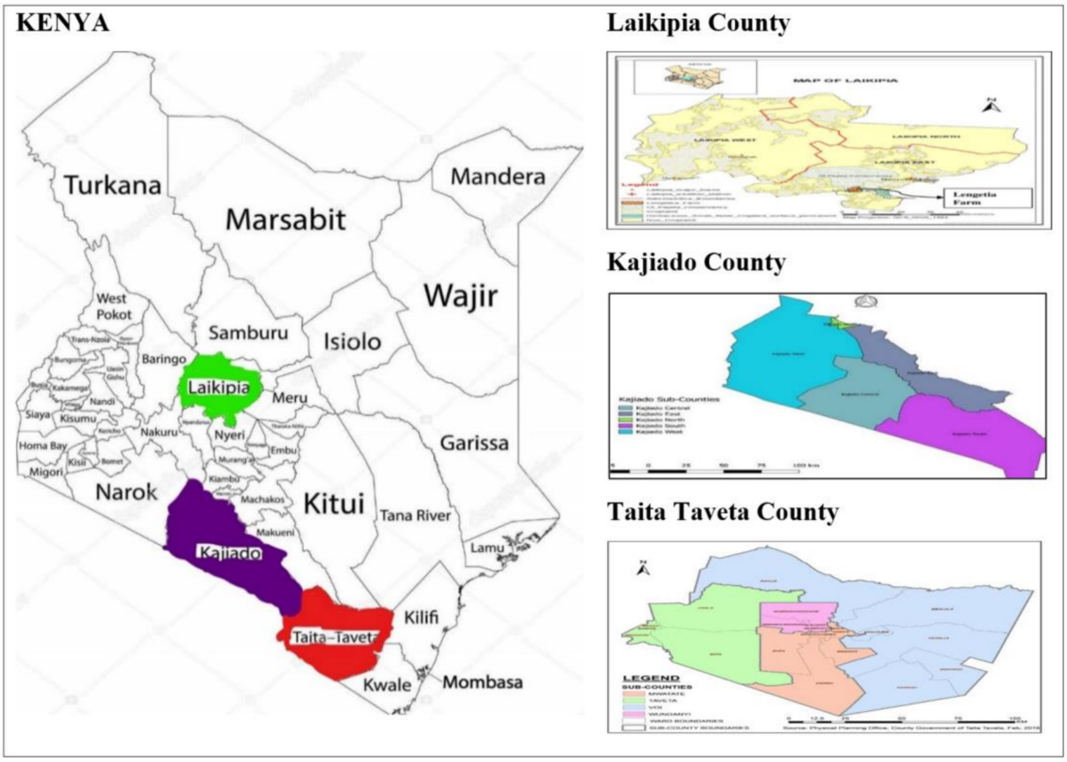

Figure 2: Map showing the study area (Laikipia, Taita Taveta and Kajiado Counties)

Laikipia County has a total area of 9,462km^2 and a population of 513,879. There is crop farming which is found only in 20% total area categorized as high and medium potential while the rest (80%) low potential region have livestock as the main sources of livelihood. About 43% of the population are in absolute poverty while 27.2% rely on food aid during food shortages. The county has livestock population distributed as follows; cattle 270,065, goats 402,526, sheep 613,782 and camels 7,827 (MoALF, 2017b).

Taita Taveta has a human, population of 340,671 according to 2019 census and a total land coverage 5, 876km^2 for farming and agriculture being the main source of livelihood. Absolute poverty stands at 57% while 48% of the population experience food poverty. The livestock distribution within the county is as follows 114,814 cattle, 46,535 sheep, 202,113 goats and 2,938 camels. Taita Taveta county has been experiencing changes and variabilities in climate for the last four decades which has caused the long-term environmental changes including soil degradation, reduction of water volumes in rivers, landslides, deforestation, drying of wells and rivers, and increased human wildlife conflicts (MoALF, 2016).

2.2. Sampling procedures and Data sources

A multi stage sampling procedure was used in the study. The first stage involved the purposeful selection of three counties Kajiado, Taita Taveta and Laikipia to represent the varying levels of vulnerability to climate change within the ASAL regions. Secondly, based on the differences in livestock-based livelihoods, three sub-counties were selected from each county. Two wards from each sub county were then selected on the basis of the promotion of livestock related CSA practices as documented in the Kenya Climate Smart Agricultural Project (KCSAP) reports. From the list of farmers acquired from the selected wards, simple random sampling procedure was then used to select a total of 750 livestock farming households that were used in the survey conducted between July and September 2022. Structured questionnaires were administered where information on livestock farmers household and farm characteristics, knowledge or awareness of CSA, household vulnerability context, livelihood strategies, uptake of CSA practices, household capitals, and household's outcome variables such as food security status, household income and household welfare were collected. In addition, purposive sampling techniques were used in selecting the respondents for 6 FGDs and15 KIIs to get an in-depth search of more information on the subject matter. The selection of participants covered gender, age, physical impairments, religion, culture, level of CSA use, county government livestock office representation as well as livestock, veterinary and animal health officers and agrovets dealers. The FGDs and the KIIs also gave information vital in judgmental ranking of the indicators based on their view as the key people in the community.

2.3. Description of the indicators

2.3.1 Natural capital

In this study natural capital is considered as the availability and accessibility of the natural resources on which households engage in livestock production(Datta & Behera, 2022; Jones et al., 2019; Kabobah et al., 2018). Land tenure, access to community grazing land, and access to water were taken as the important indicators for natural capital within the livestock rearing communities. Land tenure often plays an important role in promoting adaptation to climate change as this will influence the decision on long term investment on the land; for instance water pans, fodder establishment and paddocking for rotational grazing (Chepkoech et al., 2020; Datta & Behera, 2022; Kassa & Abdi, 2022; Ooga & Gikunda, 2021). Pastoral communities have certain large tracks of land which are usually exclusively protected and only used during extreme scarcity of pastures. Access to community grazing land among the pastoralist is an important factor in increasing productivity and survival rates of the livestock during drought periods (Kabubo-Mariara, 2008; Opiyo et al., 2014). Accessibility to water is also ranked as a vital asset. The source of the water was considered important in ranking this particular indicator. Hence access to piped water was assigned the highest rank because it is assumed to enhance adaptive capacity as it more reliable and usually located next to the homestead. Borehole water was ranked the second highest based on its constant availability even though most of them were located away from the households. Rivers and streams were also ranked third, although they could be far from the homestead, they were considered more reliable especially if the drought does not prolong. Wells and tanks, although also mostly located next to homesteads, were considered to be more unreliable because they are mainly dependent on weather hence at higher risk of drying up during the dry season (Chepkoech et al., 2020; Maldonado-Méndez et al., 2022).

2.3.2 Physical capital

In this study, physical capital included the ownership of the house, type of house, ownership of radio, Television, mobile phone. It also considered the main road accessibility during rainy season. Ownership of radio, television and mobile phones are often associated with access to information relevant for the livelihoods of households (Mesfin et al., 2020). Better information will enable households to make informed decisions, particularly on their farming activities and to take proactive adaptation measures against climate–related risks. Good road connectivity influences mobility and access of the household to other important amenities like health care facilities, financial institutes and markets for livestock (Datta & Behera, 2022; Zanmassou et al., 2020).

2.3.3 Human capital

Human capital in this study refers to the knowledge, skills, and any capacity that is required to improve livelihood. Livestock farming experience, educational level of the household head, household size, proportion of the adults in a household and access to extension services were considered as human capital indicators. It is often believed that education enhances farmers' awareness on the impacts of climate change and the importance of adaption strategies (Abegunde et al., 2019; Abid et al., 2015; Mesfin et al., 2020; Silvestri et al., 2012; Yirga et al., 2015). Hence, better-educated household heads are more likely to influence the implementation of climate change adaptation strategies leading to improved adaptive capacity(Mesfin et al., 2020). Several studies have shown a relationship between agricultural farming experience and uptake of adaption strategies (Datta & Behera, 2022; Defiesta & Rapera, 2014; Nhemachena et al., 2010). Livestock farming experience improves farmers' understanding of the impacts of climate change on livestock and hence make appropriate decision on the adaptations strategies to implement. Farmers are believed to acquire necessary skill over time that can allow them to invest in strategies and assets that contribute to increasing the adaptive capacity (Datta & Behera, 2022; Maldonado-Méndez et al., 2022). Similarly access to extension services is also linked with adaptive capacity. Through extension service exposure, it is expected that the farmers become more aware of adaptation practices and their importance, hence the high uptake levels lead to high adaptive capacity (Abegunde et al., 2019; Andati et al., 2022; Escarcha et al., 2018; Kifle et al., 2022; Muriithi et al., 2021; Negera et al., 2022; Sardar et al., 2021).

2.3.4 Social capital

Social capital in this content includes the features of social life which are essential for achieving livelihood objectives. The indicators within the social capital includes participation in collective action, presence of community position holders in the household. Membership in collective action within the community broadens individuals' social networks and allows them to exchange and learn new information(Datta & Behera, 2022; Mesfin et al., 2020). As revealed through focus group discussion, farmers who were members of particular group got easy access to information on climate change and adaptation strategies which forms a powerful tool in decision making. They were also able to access loans with which they acquire livelihood assets, create wealth, and set up small businesses to combat risks. The presence of community position holders also enhances a household's adaptive capacity. More often, most positions are elected based on a person's social standing, hence they are more likely to have a larger amount of social capital and, as a result, more access to common pools for adaptation (Datta & Behera, 2022; Matewos, 2020; Mesfin et al., 2020; Zanmassou et al., 2020)

2.3.5 Financial capital

Financial capital indicators include access to credit, number of income sources the household depends on and having any off-farm income source. It has been noted that diverse income sources uplift households' financial capacity as well as creating an opportunity to reduce risk due to diversification if one source of income is affected by the climatic shocks(Chepkoech et al., 2020; Datta & Behera, 2022; Mesfin et al., 2020). A positive relationship is often reported between access to credit and adaptive capacity (Datta & Behera, 2022). Households' adaptive capability can be improved by the credit accessibility as this might increase the cash flow, allowing farmers to engage in more capital-intensive technologies, thereby increasing their adaptability(Chepkoech et al., 2020). Likewise access to credit enhance farmers' flexibility to adjust production strategies in response to forecasted climatic circumstances for instance purchasing fodder and feed for the livestock during drought.

Table 1: Capital assets and their Indicators

Capital	Indicators		Supporting Source	Description/ Measure clusters	Scores	Normalized scores
	Access to community grazing land	NC1	Mesfin et al., 2020	No Yes	0 1	0 1
	Land Tenure	NC2	Chepkoech et al., 2020; Datta & Behera, 2022; Matewos, 2020	Without title teed With title teed	0 1	0 1
	Sources of water	NC3	Chepkoech et al., 2020; Maldonado-Méndez et al., 2022	Water Boozers Water pans/ tanks /catchments/ wells Rivers/ streams Boreholes Piped	0 1 2 3 4	0 0.25 0.50 0.75 1
		Total Natural capital Index				**x/3**
Physical capital	Home ownership	PC1	Chepkoech et al., 2020; Datta & Behera, 2022; Defiesta & Rapera, 2014; Matewos, 2020	1= Borrowed 2= rented 3= Owned	1 2 3	0.33 0.67 1
	TV ownership	PC2	Matewos, 2020	No Yes	0 1	0 1
	Radio ownership	PC3	Matewos, 2020	No Yes	0 1	0 1
	Mobile phone ownership	PC4	Matewos, 2020	No yes	0 1	0 1
	Main road accessibility during rainy season	PC5	Jamshidi et al., 2020; Maldonado-Méndez et al., 2022	Not accessible Partially accessible Fully accessible	1 2 3	0.33 0.67 1
		Total Physical Capital index				**x/5**
Human resource capital	HH size	HC1	Chepkoech et al., 2020	1-5 6-10 >10	1 2 3	0.33 0.67 1
	Percent of adults in the family	HC2	Jamshidi et al., 2020	1-25 26-50 51-75 76-100	0 1 2 3	0 0.33 0.67 1
	Level of Education of HHH	HC3	Chepkoech et al., 2020; Defiesta & Rapera, 2014; Datta & Behera, 2022; Jamshidi et al., 2020; Osumanu et al., 2017; Pickson & He, 2021; Zanmassou et al., 2020)	None Primary Secondary Tertiary	0 1 2 3	0 0.33 0.67 1
	Frequency of extension	HC4	Abdul-Razak & Kruse, 2017b; Defiesta & Rapera, 2014; Pickson & He, 2021	No extension Once 2-5 times 6-10 times >10 times	0 1 2 3 4	0 0.25 0.50 0.75 1
	Livestock farming experience	HC5	Dafiesta & Rapera, 2014;	1-5 6-10 11-15 16-20 >20	0 1 2 3 4	0 0.25 0.50 0.75 1
		Total Human resource index				**x/5**
Social Capital	Collective action participation	SC1	Abdul-Razak & Kruse, 2017b; Datta & Behera, 2022; Zanmassou et al., 2020	No Yes	0 1	0 1
	Received training on CSA	SC2	Abdul-Razak & Kruse, 2017b; Chepkoech et al., 2020	No Yes	0 1	0 1
	Presence of community position holder in the household	SC3	Datta & Behera, 2022	No Yes	0 1	0 1
		Total Social capital index				**x/3**
Financial Capital	Diversification to crop production	FC1	Datta & Behera, 2022; Jamshidi et al., 2020; Matewos, 2020; Osumanu et al., 2017; Zanmassou et al., 2020	No Yes	0 1	0 1
	Number of income sources	FC2	Chepkoech et al., 2020; Datta & Behera, 2022; Jamshidi et al., 2020; Matewos, 2020; Osumanu et al., 2017; Zanmassou et al., 2020	1 2 More than 2	1 2 3	0.33 0.67 1
	Formal /Informal access to credit	FC3	Chepkoech et al., 2020; Datta & Behera, 2022; Jamshidi et al., 2020; Matewos, 2020	No Yes	0 1	0 1
	HH have Off-farm income source	FC4	Kabobah et al., 2018; Mesfin et al., 2020; Zanmassou et al., 2020	No Yes	0 1	0 1
	Livestock Owned (TLU)	FC5	Jamshidi et al., 2020	<1 1-10 10.1-30 30.1-60 >60	0 1 2 3 4	0 0.25 0.50 0.75 1
		Total Financial capital index				**x/5**

2.4. Ranking and scoring of the adaptive capacity indicators

Identification of a set of capital assets and indicators to measure each capital asset was done based on literature and subject of interest where five capital assets and a total twenty indicators were finally considered as summarized in *Table 1.1 in Appendix*. The sub indicators within each indicator were first ranked before scoring was done. Information on ranking and scoring individual sub-indicators was generated from a review of previous literature on AC assessment and measurement. Although there is no definite procedure within the literature, this study adopted a combination various method which include analytical hierarchical process (AHP) method, judgmental and expert opinion following the works of (Abdul-Razak & Kruse, 2017b; Chepkoech et al., 2020; Datta & Behera, 2022; Defiesta & Rapera, 2014; Jamshidi et al., 2020; Maldonado-Méndez et al., 2022; Matewos, 2020; Pickson & He, 2021). The measure scale for each indicator differed and this necessitated normalizing of scores before the computation of the adaptive capacity. The scores were normalized using min-max method, where all the scores were converted to values ranging from 0 to 1 using the formula as shown in equation 1.1

$$X_{i(0\ to\ 1)} = -\frac{X_i - X_{Min}}{X_{Max} - X_{Min}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.1$$

Where $X_{i(0\ to\ 1)}$ is the normalized score ranging from 0 to1, X_i represents the individual rank point to be transformed, X_{Min} the lowest rank value for that indicator, X_{Max} the highest rank value for that indicator.
The index for each capital asset was then calculated by summing up all the scores in every indicator constituting the capital asset then dividing it by the expected maximum score as show by equation 1.2

$$CAC_m = \frac{1}{K}\sum_{i=1}^{n} S_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.2$$

Where CAC_m is the capital asset index for a particular capital asset (m); S_{ij} is the score of jth item for ith respondent; K is the maximum expected capital asset score.
Finally, the overall adaptive capacity (AC) was obtained by dividing the total score of the five capital assets for each household by five, thereby reducing the adaptive capacity to a scale of 0≤AC≤1 as shown in equation 1.3

$$AC_i = \frac{1}{M}\sum_{i=1}^{m} CAC_m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.3$$

Where AC_i is the overall capital asset index for ith respondent; CAC_m is the capital index of mth capital asset category for ith respondent; M is the total number of capital assets used (in this case M=5).

3. Results and discussion

3.1.Descriptive statistics

Table 2:Descriptive test statistics of difference between farmers with low, moderate and high AC

Variable	**Variable Measurement**	**Pooled n=737**
		Percent /mean
Age of household head	Years (SD in brackets)	48.74 (14.47)
Gender of household head	Female	22.66
	Male	77.34
Household size	Number (SD in brackets)	5.21 (2.13)
Education level of Household head	None	33.38
	Primary	36.91
	Secondary	19.54
	Tertiary	10.18
Marital status	Married	82.36
	Single/separated	5.97
	Widowed	11.67
Source of livelihood	Livestock rearing	63.50
	Other sources	36.50
Household average monthly income	KES (SD in brackets)	15201.47 (16709.99)
Types of livestock production system	Agro-pastoralism	24.69
	Pastoralism	75.31
L/S farming experience	Years (SD in brackets)	19.45 (13.53)
Household TLU	Number (SD in brackets)	16.6 (46.3)

Variable	Variable Measurement	Pooled n=737 Percent /mean
Access to Extension services	No	44.50
	Yes	55.50
Access to Credit	No	46.68
	Yes	53.32
Collective action participation	No	32.70
	Yes	67.30

Household demographic descriptive statistics results in *table 1.1* shows that the mean age for the household head is 48 years. Majority of household were male headed (77%) while the remaining (23%) were female headed. The study area has a noticeably low level of education with household heads who had no formal education being 33% and those who had attained primary school education (37%). Eighty two percent of the respondents are married. The rest are single/separated (6%), or widowed (12%). The average household size is five. The smallest household has only one member while the largest has twenty-two. Majority of these households are nuclear families consisting only of parents and children. Considering the production systems and resources, the main source of livelihood to majority of farmers is livestock rearing (64%) and the most common livestock production system was pastoralism (75%). The mean TLU was 16.6 units. Years of experience in livestock farming was 19 years. Average monthly income was KES 15,201. Similarly, descriptives of institutional factors also revealed that 55% of the households accessed to extension services, while 53% accessed credit. Further, 67% participated in collective action within the communities.

3.2. Scores and levels of adaptive capacity

Adaptive capacity was measured by summing up the scores of the indicators of the five capital assets (natural, physical, financial, human and social) as discussed in section 2.3. The index was categorized into three levels, low medium and high, following Asante et al. (2012), Chepkoech et al. (2020) and Defiesta & Rapera (2014), thus household with low adaptive capacity ($AC \leq 0.44$) were 248, moderate adaptive capacity ($0.44 < AC \leq 0.56$) were 248 and high adaptive capacity ($0.56 < AC \leq 1.0$) were 245.The mean adaptive capacity index for the whole sample was 0.506. Comparison with the different study areas was noted where T/Taveta had the highest mean of 0.553 while Laikipia had the lowest mean of 0.452. Majority (47%) of the households in Kajiado county were categorized as having moderate AC, while more than half (52%) of the sampled households in Taita Taveta were having high AC. However, bigger proportion (57%) of the household in Laikipia county had low AC as shown in *Figure 2*

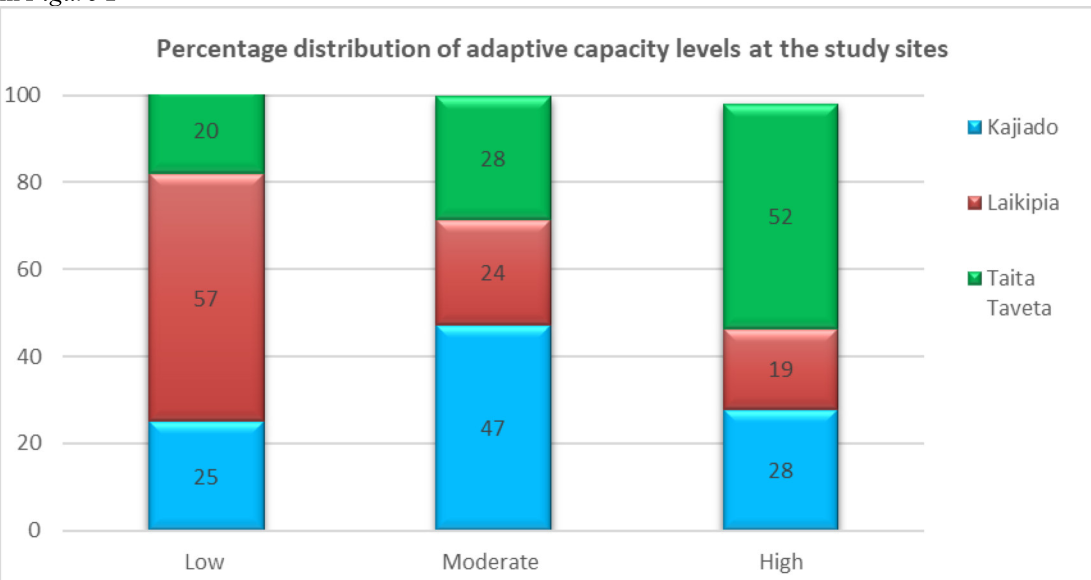

Figure 2:Percentage distribution of adaptive capacity levels comparison in the three counties

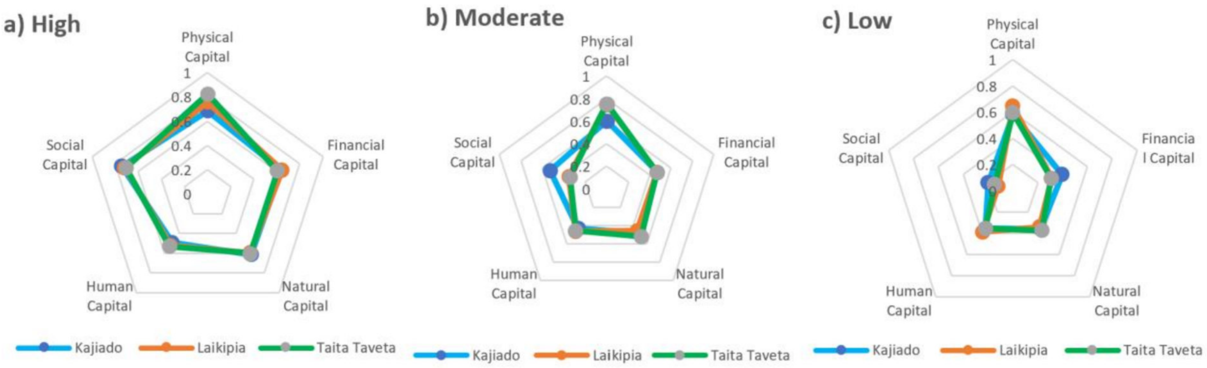

Figure 3:Average indicator score under the five capitals comparing the three study sites a) High b) Moderate c) Low

Figure 3 shows that the main difference between those with low, moderate and high adaptive capacity levels is the social capital. The scores of physical, natural, and financial assets for households with high and moderate adaptive capacity are also relatively higher than those with low adaptive capacity. The households having a high level of adaptive capacity also attained relatively higher scores in social capital. In general, households' adaptive capacity was influenced by the social and human capital indicators to a greater extent. In addition, a substantial variation in the levels of adaptive capacity was found even within the villages. This finding concurs with Datta & Behera (2022), who also reported that adaptive capacity varies greatly due to socioeconomic differences and access to different capital assets within the same geographical and agro-ecological situation.

3.3. Adaptive capacity and differential capital assets

In *Figure 4*, its noted that the households that recorded high level of adaptive capacity had higher scores in social (participation in collective action and having received CSA training), physical (ownership of a mobile phone and a radio), and financial capital (having income sources diversity in the household and access to credit).

In all the study sites within all levels of adaptive capacity scored well in home ownership. This means that majority of the households resided on their own houses. Access to mobile phones Radio and Television set have the potential to improve linkage of farmers to holders of technical information and serve as effective tools for communication and accessing information on changing weather patterns (Egyir et al., 2015).

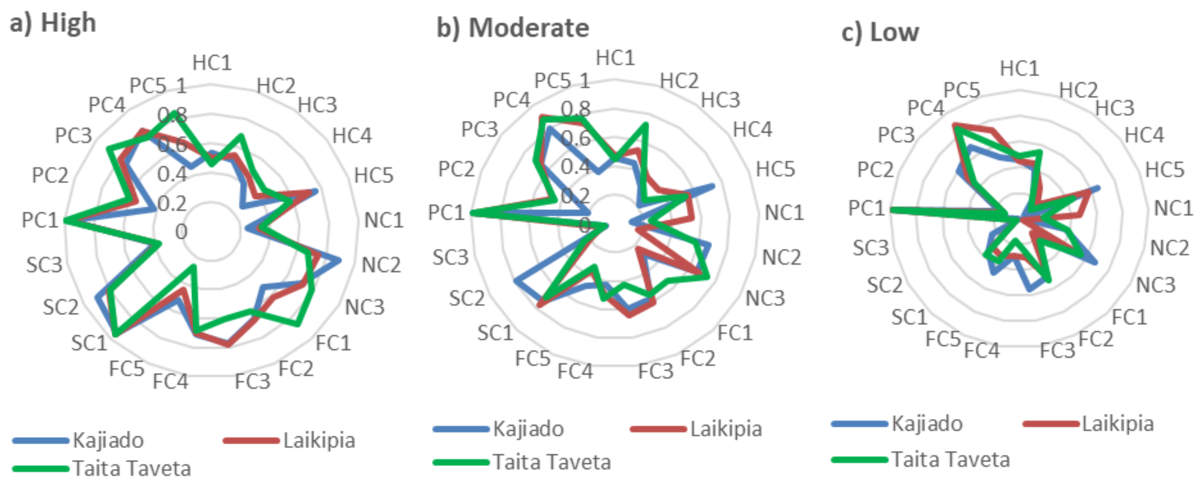

Figure 4: Distribution of average capacity indicators score at a) High, b) Moderate, and c) Low adaptive capacity farming households (HC1-HC5:- Human capitals; NC1-NC3:- Natural capitals; FC1-FC5:- Financial capitals; SC1-SC3:- Social capitals; PC1-PC5:- Physical capital

However, these connections are yet to be fully explored by respondents in all the communities. Low purchase of television sets, Radio and mobile phones was linked to poverty, while the high ownership of radio sets was linked to its cheap cost. In Kajiado and Laikipia counties, years of livestock experience contributed greatly in boosting the adaptive capacity of the household. This variable indicates that the higher the livestock farming experiences the higher the AC. Experienced farmers therefore can make appropriate decision on the adoption of adaptations strategies which eventually enhances their adaptive capacity. Farmers' knowledge on impact of climate change on livestock is believed to increase with increase in farming experience. Similarly, it is assumed that skill acquired over time allow them to invest in strategies and assets that contribute to increasing the adaptive capacity.

However, there was a great disparity in the social capital scores across the levels of adaptive capacity where the household with low level had conspicuously low scores (*Figure 4*). Participation in collective action positively influenced adaptive capacity across all the AC levels. This is believed to broadens individuals' social networks thus allowing them to exchange and learn new information (Datta & Behera, 2022; Mesfin et al., 2020). Participation in collective actions is also assumed to increases farmers ability to building savings through merry-go-round initiatives, increase accessibility to loans which can be used to create wealth or start up small businesses leading to increased adaptive capacity to climate change

The high financial capital score in the Taita Taveta county, was connected to the high involvement in crop production as a way of income diversification. Implying that having other sources of income really boosts the adaptive capacity of the household. These results are in collaboration with (Ayal et al., 2017; Silvestri et al., 2012). Likewise, having alternative off-farm jobs contribute greatly to increasing the adaptive capacity, it is important that policy interventions in the area prioritize creation and encouragement in alternative livelihoods sources as a means of increasing the adaptive capacity of livestock farming communities within the ASAL regions.

4. Conclusion and policy implications

This study was conducted to assess of adaptive capacity among the livestock farming households of different selected three counties located at ASALs of the Kenya. It was found that most of the sample households in the study area had a moderate level of adaptive capacity followed by low and high. The differences in social (participation in collective action and having received CSA training), physical (ownership of a mobile phone and a radio), and financial capital (having income sources diversity in the household and access to credit) are mainly attributed to the overall adaptive capacity in the study regions. Taita Taveta county recorded the highest number of households categorized as high-level adaptive capacity due to their high engagement in crop production as an alternative livelihood option. The study proves that encouraging the livestock farmers to engage in alternative sources of income and also increasing the trainings on the CSA practices could increase their adaptive capacity and resilience to climate change risks and threats.

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