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Smallholder Farmers' Perceptions and Responses to Climate Change in Multi-stressor Environments: The Case of Maasai Agro-pastoralists in Kenya's Rangelands

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Abstract Farmers in Kenya's rangelands have been responding to simultaneous multiple sources of change in their socioeconomic and environmental conditions for some time. Under such conditions, it is not clear how the increasing effects of climate change are being perceived and reacted to. This paper presents the results of a study that was carried out in the Trans Mara sub-County in the southern rangeland of Kenya to assess the farmers' perceptions and adaptation to climate change and the constraints that they encountered. An open-ended questionnaire was used to collect data from 206 randomly selected farmers in Kilgoris and Lolgorien administrative Divisions of the sub-County. The results showed that the farmers had reasonable perceptions of climate variability and change and had taken steps to adjust their farming activities. These perceptions were based on their observed changes in rainfall pattern and intensity over the last couple of decades. Diversification of farm enterprises, changing of crop varieties, reducing flock sizes and changing of livestock breeds were the most common adaptation strategies. Lack of financial resources, insufficient labor and limited access to information were the major constraints that impeded adaptation. The results suggest that the farmers are able to discern and to some extent disaggregate the climate stimuli from other stressors. However, the adaptation strategies were closely intertwined with other stressors that go beyond the climate dimension.

Keywords: *farmers' perceptions, climate change, climate adaptation, Maasai agro-pastoralist, Kenyan rangelands*

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1. Introduction

Empirical evidence suggests that climate change is compromising food security and livelihoods of smallholder farmers in sub-Saharan Africa (SSA) [1,2,3,4]. This is principally because of their heavy reliance on rain-fed agriculture, agriculture being their main economic activity, and limited adaptive capacity that is aggravated by factors such as high levels of poverty and poor market access [5]. Adaptation to climate change to reduce its impacts on smallholder farmers' livelihoods is necessary. However, across much of Africa, adaptation to climate change is primarily in response to short-term motivations, is occurring autonomously at the individual/household level, and lacks support from government stakeholders and policies [6,7,8].

Farmers adapt to climate change depending on how they perceive the risk in consideration of their environmental conditions and socioeconomic circumstances. Personal experience is thought to be a key driver of risk perceptions. The perceived likelihood of a risk is found to increase with recent experience or if it can readily be imagined [9]. Adaptation is a complex process that begins with the perception of a risk or threat, followed by attaching of importance to the threat and assigning of scarce resources and capacities to taking action in response to the perceived threat [10,11,12]. The complexity in the process of response lies in part with the fact that most vulnerable populations experience multiple sources of stress that tend to change simultaneously. Adaptation to climate variability is not new amongst farmers in most parts of SSA, particularly those living in marginal lands, which are the areas of high variability of rainfall or high risks of natural hazards. In the past, farmers were able to discern climate trends from their casual observations and employed a diversity of strategies to sustain agricultural productivity and secure their livelihoods [13,14]. However, in the past several years, the nature of climate variability has changed. The magnitude of variability, frequency of extreme weather events (floods and drought) and the rate of change within climate systems have affected the ability of farmers to respond, cope and adapt [15,16]. Furthermore, the nature of climate variability being experienced currently is occurring in an environment that is characterized by major shifts in socio-economic and ecological conditions that compromise the traditional adaptation strategies.

There is a growing body of knowledge on farmers' perceptions and adaptation to climate variability and change in SSA [17,18,19,20]. However, considerable gaps in knowledge still remain on site-specific adaptation strategies in many parts of the continent. Adjustments to climate change are often conceptualized as a site-specific phenomenon, with notable differences in perceptions and adaptations reported between regions, villages and households. For example, Elmqvist and Olsson [21] found that drought was perceived as a key driver for change in gum arabic production in one community in Sudan, while another community in the same country was found to be relatively unaffected and supposedly more resilient. Thomas et al. [22] showed that there are differences in the recognition of distinctive climate risks between crop and livestock farmers in South Africa, with the former perceiving heavy rains as a major risk because of the potential to destroy crops.

Smallholder farms in SSA are highly diverse and heterogeneous due to spatial gradients of climate, soils, and landscape [23]. These factors often operating in complex socio-economic environments shape farmers perceptions and choice of adaptation strategies. Moreover local-level analyses are often recommended to gain a better understanding and for better targeting of policies by the government and other development agencies that support climate change adaptation efforts [24,25].

Climate variability and socio-environmental changes in the southern rangelands of Kenya

The southern rangelands fall within the Narok County of Kenya (see Figure 1) and comprise the Maasai Mara National Reserve (MMNR) and surrounding areas that are largely characterized by pastoral and agro-pastoral land use systems which act as ecologically contiguous wildlife dispersal areas [26]. The area surrounding MMNR can be divided into four units, based on bio-geographic and climatic differences [27,28]), namely: (1) Mara plains consisting of *Themeda* grassland, (2) Loita Plains characterized by dwarf-shrub and whistling thorn (*Acacia drepanolobium*) grassland, (3) Siana hills and plains supporting Croton bush and several other woody species interspersed with grasslands, and (4) Trans Mara plateau, separated from the MMNR by the Siria Escarpment, consisting of a mixture of forest and woodland with scattered bush land.

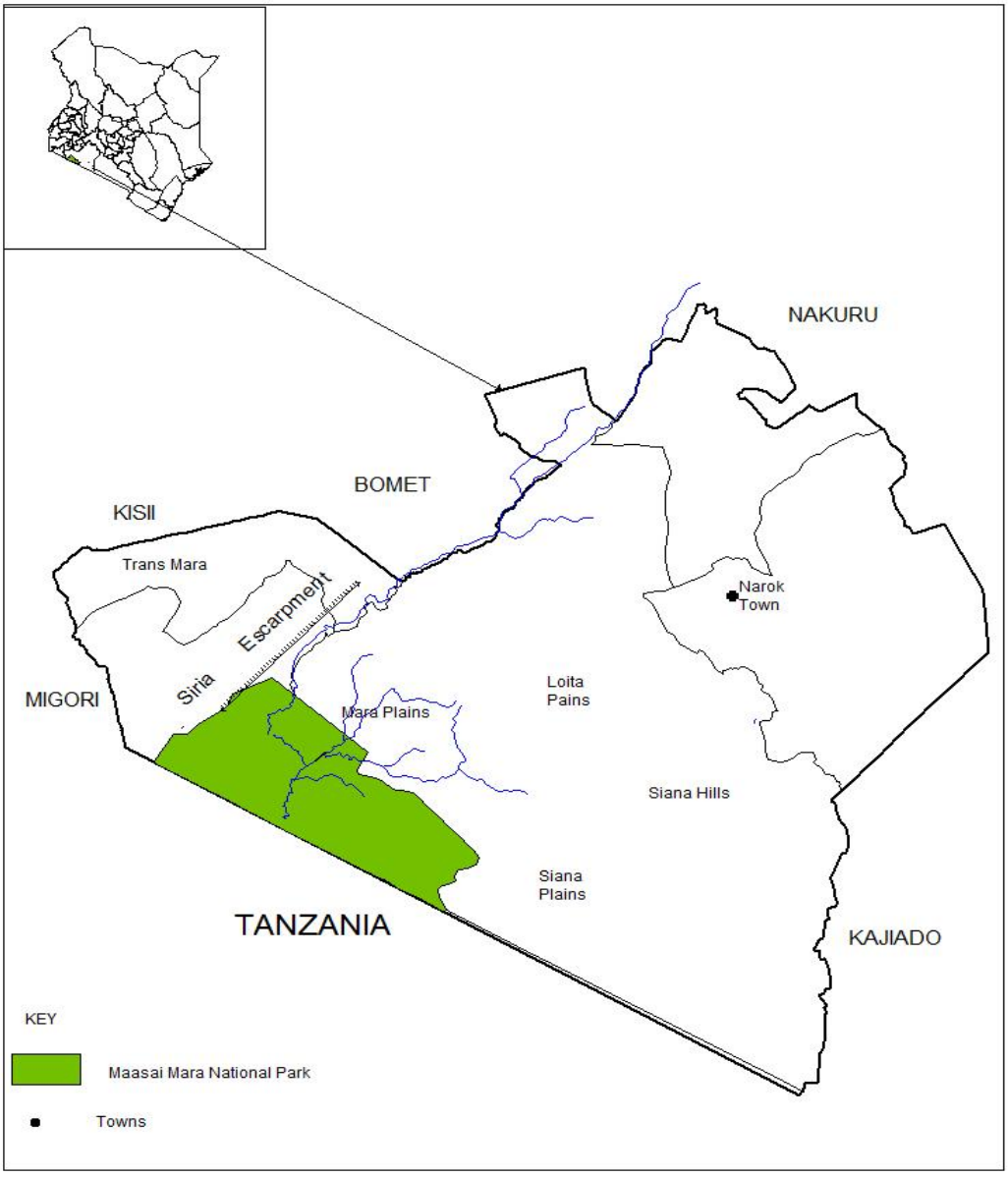

Figure 1. Map of Narok County showing the Maasai Mara National Reserve and surrounding areas

The rainfall pattern in the southern rangelands of Kenya is bimodal, with the main rains falling from March to May and a minor peak falling from November to December. Rainfall is generally associated with the movement of the Inter-Tropical Convergence Zone [29,30]. Local variations in topography, such as high hills and escarpments plus orographic and diurnal effects, play a major role in influencing the rainfall patterns within the rangelands. These rangelands in Kenya are among the most productive in East Africa, with high forage production potential that supports the greatest densities of wild and domestic herbivores [27,31].

Sufficient longitudinal or observational data on temperature and annual precipitation are needed for the analysis of climatic change. However, most areas in SSA lack such observational data, and it becomes difficult to draw any conclusions about trends in annual precipitation in SSA over the past century [32]. Nonetheless, extreme precipitation changes such as droughts and heavy rainfall in eastern Africa have been experienced more frequently during the last 30 to 60 years [33,34,35,36]. In the case of the southern rangelands in Kenya, temperature data from a local weather station in Narok County showed an increase in temperature at an average of 1.47℃ per month for the period 1993-2008 compared to the period between 1946 and 1976 [37]. Agro-pastoral and pastoral farmers, mostly the Maasai inhabiting the rangelands, have been adapting their livelihood strategies to changes in environmental and socioeconomic conditions for some time. Some major changes in demography, livelihoods and environment have been reported in these areas since the 1980's. Such changes include a rapid expansion of human population due to in-migration and growth, transition of land tenure from communal to individual ownership, destruction of natural vegetation and soil degradation [38,39]. These changes have triggered autonomous adjustments to livelihood strategies. For example, the shift in livelihood from pastoralism to agro-pastoralism and sedentary mixed crop-livestock production is thought to be the result of change in land tenure. For most of farmers in the rangelands, adaptation is part of an ongoing process to manage resources in the face of multiple stressors [40]. Climate change only adds to the long list of stressors that the farmers must deal with. Under such dynamism, it is not clear how the climate risk is perceived and reacted to alongside other non-climate drivers of adaptation. This paper reports the results of a study that was conducted in the rangelands in the Narok County of Kenya to elucidate farmers' perceptions and responses to the climate change stimuli in an environment that is characterized by dynamic changes in socio-economic and environmental conditions. An attempt is made to disaggregate adaptation strategies to climate change from other non-climatic drivers.

2. Study Site and Methods

The study was carried out in Trans Mara sub-County within the Narok County. The area lies approximately between latitude 0° 50' and 1°50' South and longitude 34°35' and 35°14' East and covers about 2,859 km^2. Topographically, the sub-County comprises highlands on the northern side lying between 2,200m and 2500m above sea level and plateau stretching on the southeastern part at elevations of between 900m and 2220m above sea level. Two administrative Divisions, Kilgoris and Lolgorien were selected to reflect differences in modes of agricultural production. In Kilgoris, production is mostly sedentary mixed crop-livestock while in Lolgorien, farming is agro-pastoral with subsidiary cropping [41]. Generally, the landscape is characterized by six major land use types based on vegetation: forest, farmland, Acacia species woodland, grassland, wooded grassland and Maasai Mara National Reserve (MMNR). However, the landscape has been changing in favor of agricultural land.

Primary data was collected from two hundred and six famers that were randomly selected in two villages in the two Divisions. Face to face formal interviews were conducted with household heads or their representatives using an open-ended semi-structured questionnaire. The questions focused on the changing farming conditions rather than on climate so that the climate dimension could be identified independently during the interviewing process. Further prodding was done when a farmer mentioned climate related issues during the questioning. Generally, the respondents were asked whether they had noticed any long-term changes in farming conditions over the past 20 years, what they thought were the reasons behind the observed changes and any adjustments they had made to cope with the changes.

3. Results

3.1. Farmers' Socio-economic Profile

Majority (92 percent) of the 206 respondents were male, which reflected the patriarchal cultural practices whereby women are generally not allowed to talk on behalf of the household heads. Seventy eight percent had attended some formal education. About fifty percent possessed formal land title deeds, with the remaining ones being owners under customary tenure. The average farm size was 35 acres. The most common land holdings were those that were less than 10 acres and those between 20 and 50 acres at 47 percent and 27 percent respectively. On average, about 2 percent of the total farmland was under woodlots and about 16 acres were under natural forest. Until recently (after mid-2000s), most land in the sub-County (including the non-gazetted natural forest) was held under communal trust. However, most of the land ownership has since been individualized, thereby explaining the presence of natural forest on farmland. The sale of livestock and livestock products was the major source of income for 53 percent of the respondents. However, a closer look at income sources by farm size showed that the livestock to crop income ratio had decreased with the decrease in the size of the land holding, with crops becoming the dominant source of income for the households with small land holdings while the livestock remained the principal income source for the households with large farms.

3.2. Farmers' Perceptions of Climate Variability and Change

The analysis of the farmers' perceptions and adaptation to climate variability and change was based on responses from 136 respondents aged 40 years and above. The age restriction was considered reasonable given that the study was based on their observations in the past 20 years. Majority of the farmers (87 percent) believed that the area had progressively become less productive to crop farming and/or livestock production over the past twenty years. Seven percent of the farmers believed that the area had become more productive with respect to agricultural activities while the remaining 6 percent believed the conditions had not changed. Table 1 gives details on the farmers' views of what they perceived to be the reasons for the unfavorable farming conditions.

The results show that unpredictable rainfall pattern (53 percent), inadequate rainfall (56 percent) and delayed onset of rains (40 percent) were the major weather-related elements that the farmers thought had shown the greatest variability over time, thereby affecting crop and livestock productivity. The general view by most farmers was that the rains were more regular twenty years ago and that they would begin when they were expected to and fell in sufficient quantities throughout the growing season. Although there were a few occasions when this regularity would be disrupted, such events were few and wide apart. However, with the passage of time, rainfall had become increasingly unpredictable, either coming too early or too late in the season. It was also reported that, unlike in the past, rainfall was heavy but not well distributed through the growing season. The heavy rainfall would be short-lived and would cause flooding and soil erosion. Apart from flooding and soil erosion, the other rainfall-associated causes of unfavorable farming conditions that were reported by the farmers in the study area included poor distribution of rainfall (27 percent) and extended dry periods (13 percent).

Table 1. Farmers' perceptions of causes of unfavorable farming conditions in Trans Mara sub-County

Reasons for unfavorable farming conditions	n	Percent
Inadequate rainfall	76	55.9
Unpredictable rainfall pattern	72	52.9
Delayed onset of rains	64	39.7
Crop diseases and pests	47	34.6
Declining soil fertility	39	28.7
Poor distribution of rainfall through planting season	37	27.2
Destruction of natural vegetation	23	16.9
Extended dry periods	17	12.5
Increased subdivision of land	15	11.0
Poor quality of seeds	14	10.3

Source: Survey data 2013.

Indirectly related to rainfall was the reported destruction of natural vegetation, mainly forests, that had occurred over the years. About seventeen percent of farmers associated the changed rainfall pattern with the destruction of the forest resources in the sub-County. According to the farmers, forests used to attract rainfall. However, after most of what was there as forests in the past was cleared to create land for agricultural production, the pattern of rainfall got somewhat affected. Another interesting perspective related to forest clearing was the role of forests in the protection of water sources. It was reported that before the forests were cleared, the area had many all-year round water streams and seasonal rivers that provided easily accessible water for livestock and domestic use. However, because of forest destruction, most of these water sources had disappeared. It was reported that the duration between the rainy seasons had now become progressively longer than it was twenty years ago. This factor is closely related to inadequate rainfall, as it led to extended dry periods.

Other factors that affected farming conditions, though not directly related to weather conditions, were declining soil fertility (29 percent), increasing crop pests and diseases (35 percent) and increased subdivision of land (11 percent). Other causes of poor agricultural productivity that were mentioned but at lesser frequencies (less that 5 percent) were the rising cost of agricultural inputs (especially the cost of fertilizer), poor farming techniques, livestock diseases and elevated temperatures. An elevated environmental temperature is one of the key elements of weather that is frequently associated with climate change. In this study, hardly any famers (0.7 percent) attributed the deteriorating farming conditions to an increase in environmental temperature. However, one would expect the reported extended dry periods to be associated with elevated environmental temperatures.

3.3. Farmers' Adaptation Strategies to Climate Variability and Change

Farmers made a number of adjustments to their farming practices in order to cope with the long-term shifts in weather pattern and unfavorable farming conditions in general. Table 2 provides a list of adaptation strategies used by farmers in Trans Mara sub-County in the order of the frequency. Change in crop variety (61 percent) and livestock breed (60 percent), reduction in herd size (51 percent) and diversification of farm enterprise (41 percent) were the predominant means by which the farmers adapted to long-term changes in climate. In general, farmers indicated that they had changed crops varieties and adopted more drought tolerant and disease resistant varieties. For example, some farmers reported that they had shifted from the 600 series of maize hybrids (613, 614, 615) to the fast growing and generally more drought resistant *Katumani* maize variety or the unimproved local variety which was believed to have similar characteristics. Another strategy that was reported by about 8 percent of the farmers was to plant different crop varieties on different plots (crop rotation) to minimize the risk of suffering from a total crop failure since different crops are affected differently by climatic events. A small proportion (about 2 percent) reported that they prepared land early, during the dry spell that precedes the rainy season, so as to allow for the decomposition of crop residues and weeds. Planting was then done as soon as the rains fell.

Table 2. Farmers' adaptation strategies to climate variability and change in Trans Mara sub-County

Adaptation strategy	n	Percent
Change crop variety	83	61.0
Change livestock breed	81	59.6
Reduce number of livestock	59	50.7
Diversification of farm enterprise	56	41.2
Use fertilizer and agrochemicals	20	14.7
Change from crop to livestock	18	13.2
Crop rotation	11	8.1
Find off-farm job	8	5.9
Water harvesting	7	5.1
Lease land	7	5.1
Change from livestock to crops	6	4.4
Timely land preparation and planting	2	1.5
Crop/livestock insurance	1	0.7

Source: Survey data 2013.

Reduction in herd sizes (50.7 percent) and change of local breeds (59.7 percent) were the main livestock-specific farmers' responses to unpredictable weather conditions and unfavorable farming conditions. Erratic and insufficient rainfall had reduced the quantity of pastures, thereby compelling most farmers to reduce their herd sizes and undertake measures to improve their local breeds to ensure that production was not adversely affected. The Sahiwal cattle breed was found to be the most preferred for beef production. However, a few farmers reported having tried out crosses of some dairy breeds.

Diversification of farm enterprises (41.2 percent) was yet another adaptation strategy used to spread the risk of climate change and variability on agricultural production. The study found that the farmers diversified from the traditional maize and bean enterprises to other crops, such as millet, sorghum, potatoes, bananas, tomatoes, onions, vegetables and trees. An unexpected finding was the existence of aquaculture enterprises. Some farmers, about 4 percent, also reported having diversified from a livestock only enterprise to a mixed crop-livestock enterprise. Thirteen percent reported that they had diversified from a crop only enterprise to a mixed crop-livestock enterprise.

Seeking off-farm jobs (6 percent) mainly in the informal sector was another adaptation strategy that the farmers used in response to the declining income from agricultural activities caused by poor weather and farming conditions. Examples of the off-farm jobs included the motorcycle business (popularly referred to as *bodaboda* in Kenya), selling of food and clothing items at local markets and participation in the cattle sale business, mainly as brokers. Land leasing (4 percent) and water harvesting (5 percent) were the other adaptation strategies to climate change and variability. Land was commonly leased for a single cropping season while rain water was harvested mainly for domestic and livestock use and for small-scale irrigation activities. A few farmers (0.7 percent) took crop/livestock insurance. Insurance and water harvesting can effectively cushion farmers against the effects of climate variability as well as support increased investment in agricultural production.

3.4. Constraints to Adaptation to Climate Variability and Change

Farmers faced several challenges in adjusting their farming practices to cope with the changing climate. Table 3 lists the constraints to adaptation to climate change.

Table 3. Constraints to adaptation of farming practices to climate variability and change in Trans Mara sub-County

Constraint	N	Percent
Lack of money	83	61.0
Lack of information	64	47.0
Insufficient labor	15	11.0
Insufficient sahiwal bulls	6	4.4
Cattle rustling	2	1.5
Insufficient land	1	0.7
Livestock diseases	1	0.7

Source: Survey data 2013.

The results in Table 3 show that lack of money (61 percent), information (47 percent) and labor (11 percent) were the main constraints that the farmers in the study area faced in their endeavor to adjust their farming practices to cope with the changing climate. In general, farmers indicated that they needed financial resources and information to make the right and optimal adjustments to their farming practices. For example, they did not quite know the profitable enterprises to take up, given their circumstances and available opportunities. In most cases, farmers reported having tried out different enterprises, mostly based on what they thought was profitable or what they saw their neighbors doing. A case in point was the horticultural enterprises where some farmers reported that they had taken up the enterprise only to abandon it later when they failed to get markets for their produce. Another notable example was the aquaculture enterprise which was introduced by the national government through the economic stimulus package. Whereas some farmers took up the enterprise as a strategy to diversify their farming activities, the requisite market information and infrastructure were not set up to ensure that the produce was disposed of profitably. This led some of them to abandon the enterprise. A number of fish ponds were found in a disused state during the survey.

4. Discussion

The results of this study showed that the farmers in Trans Mara sub-County had reasonable perceptions on the effects of climate variability and change and had taken steps to adjust their farming activities. These findings are largely consistent with the findings from similar studies that have reported generally high levels of perceptions on climate change among smallholder farmers [42,43]. Changes in rainfall pattern and intensity were the key ways in which farmers' perceived climate change and variability, expectedly so because rainfall is one of the significant climatic parameters affecting agricultural production. Most of agricultural production in the Trans

Mara sub-County is dependent on rainfall. Therefore, any variations in the pattern and intensity of rainfall are expected to be easily observable. Farmers' knowledge and understanding of the phenomena of rainfall variability, intra-seasonal factors (including the timing of the onset of the rainy seasons and the rainfall distribution), and periodicity of rains within the growing seasons appeared to be relatively broad. Therefore, it was not surprising that the farmers were able to perceive the long-term elements of rainfall uncertainty and unpredictability within the climate change and variability phenomenon. This perception was perhaps well illustrated by the diverse but often related perspectives on rainfall variability.

The effects of climate change on agricultural production in Trans Mara are confounded by other production and environmental challenges. Increased prevalence of crops diseases and pests, declining soil fertility, destruction of natural vegetation and increased subdivision of land appeared to exacerbate the effects of climate variability on agricultural production. Coincidentally, the maize crop in the sub-County was under attack by the maize lethal necrosis disease at the time of the survey. These findings highlight the need for a multi-pronged approach when dealing with climate related challenges in agriculture which must inevitably go beyond the climate variability to include other constraints to agricultural production and productivity.

The results of this study show that the farmers made adjustments to their farming practices in response to climate variability. Diversification of farm enterprises, changing crop varieties, reducing flock sizes and changing livestock breeds were the most common adaptation strategies. Most of these strategies would not require huge financial outlays to implement and this factor possibly explains their popularity among the Trans Mara sub-County farmers. Some interesting inclusions in the list of adaptation strategies, though not too common, were water harvesting and crop/livestock insurance. Insurance and water harvesting can effectively cushion farmers against the effects of climate variability as well as support increased investment in agricultural production. Alternative income generating activities, such as land leasing and off-farm jobs were other strategies that farmers used to cushion themselves against the cyclical downturns on profitability of farm enterprises caused by climate variability and change and other production challenges.

Although the farmers reported using various adaptation measures in response to changes in climate, it is noted that these actions transcend the climate dimension and are clearly played out within the context of the other factors that exert pressure and disturbance on livelihoods. For example, the reduction in herd size may be correlated to subdivision of the previously communal land or breed improvement may be profit- driven rather than a response to the changing weather pattern. The intertwined nature of such disturbances and change-inducing factors in livelihoods, including the attempts to disaggregate the effects and show their linkages, cannot be ignored and this is widely recognized in the literature [44,45]. For adaptation to climate change to occur, it is not necessary for households and communities to ignore other livelihood disturbances. Indeed, to be successful, adaptation arguably needs to be embedded in the full milieu of life-affecting processes. However, it is important for climate change to be recognized as a significant factor, and for the subtle dimensions of climate parameter change, which are the experienced realities, to be understood and reacted to.

In the case of the southern rangelands in the Narok County of Kenya, the farmers faced considerable challenges as they endeavored to adjust their farming practices to climate variability. Lack of financial resources, insufficient labor and limited access to information were the major constraints that impeded adaptation. Resource constraints limit farmers' ability to take up adaptation measures in response to changes in climatic conditions because they are often unable to meet the transaction costs necessary to acquire new adaptation measures [46]. Labor availability is considered an important input constraint. The expectation is that farm households with more labor are better able to take on various adaptation management practices in response to changes in climatic conditions compared to those with limited labor.

Information concerning adaptation options and other agricultural production activities remains an important factor affecting the use of various adaptation measures for most farmers. Lack of and/ or limitations in information increase high downside risks from failure associated with the uptake of new technologies and adaptation measures [46,47]. Availability of better climate and agricultural information helps farmers make comparative decisions among alternative crop management practices and this allows them to better choose strategies that make them cope well with changes in climatic conditions [48].

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