Introducing Experiences from African Pastoralist Communities to Cope with Climate Change Risks, Hazards and Extremes: Fostering Poverty Reduction

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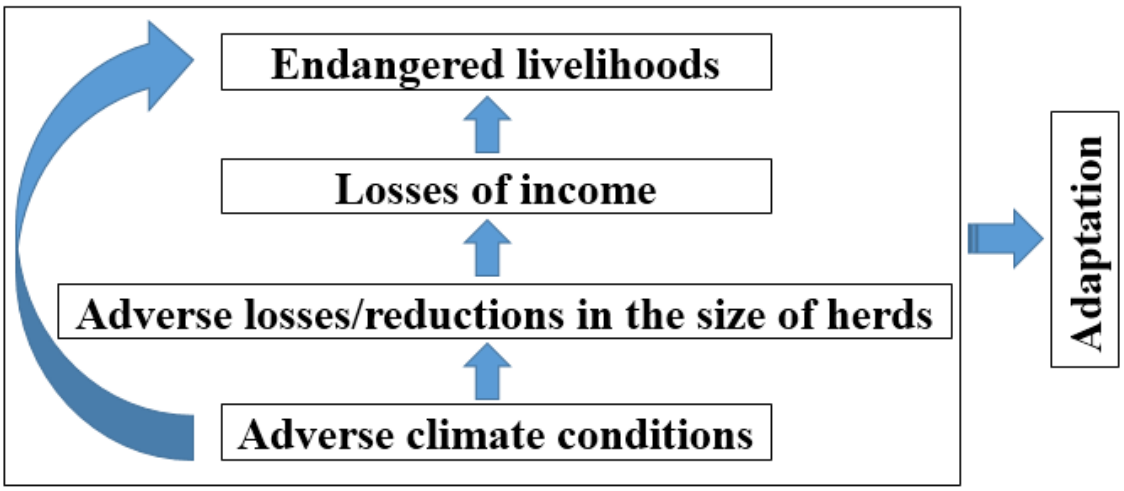
Abstract

Pastoralist communities all over Africa have been facing a variety of social and economic problems, as well as climate risks and hazards for many years. They have also been suffering from climate change and extremes events, along with a variety of weather and climate threats, which pose many challenges to

herders. On the one hand, pastoralist communities have little influence on policy decisions; however, on the other hand, they suffer to a significant extent from such policies, which limit their options for sustainable development and poverty alleviation. Also, the socio-cultural legacy of herders, and their role in food security and provision of ecosystem services, as well as their efforts towards climate change adaptation, are little documented, particularly in Eastern and Southern African countries. There is a perceived need for international studies on the risks and impacts of climate change and extreme events on the sustainability of pastoralist communities in Africa, especially in eastern and southern Africa. Based on the need to address this research gap, this paper describes the climate change risks and challenges that climate threats pose to the sustainability and livelihoods of pastoralist communities in eastern and southern Africa. Also, it discusses the extent to which such problems affect their well-being and income. Additionally, the paper reports on the socioeconomic vulnerability indices at country-level. Also, it identifies specific problems pastoralists face, and a variety of climate adaptation strategies to extreme events through field survey among pastoralist communities in a sample of five countries, namely Ethiopia, Kenya, Malawi, Uganda, and Zimbabwe. The study has shown that the long-term sustainability of the livelihoods of pastoral communities is currently endangered by climate change and the risks and hazards it brings about, which may worsen poverty among this social group. Also, the study suggests that a more systematic and structured approach is needed when assessing the climate vulnerability of individual pastoral communities, since this may help in designing suitable disaster risk reduction strategies. Moreover, the paper shows that it is also necessary to understand better the socio-ecological systems (SES) of the various communities, and how their livelihoods are influenced by the changing conditions imposed by a changing climate.

Keywords: Environmental change; Pastoralist communities; Risks; Hazards- Sustainable livelihoods; Vulnerability; Adaptation

Graphical/Visual Abstract and Caption



1. Introduction

The Intergovernmental Panel on Climate Change (IPCC, 2007) has made it clear that Africa is one of the most vulnerable continents to climate change (Mojisola, 2016; Masipa, 2017). In general, average summer temperature is expected to increase by 1.5°C by 2050 in Africa under an optimistic (2°C) global warming scenario. The area exposed to heat extremes is expected to expand to 45 per cent of the region by 2050. Under a more pessimistic (4°C) global scenario, these trends would be exacerbated. Decreasing precipitation and rising temperatures would likely worsen agricultural growing conditions in large parts of Africa, especially in coastal West Africa and in Southern Africa (Henderson et al. 2017). It is reported that two-thirds of Africa's arable land is expected to be lost by 2025 because of the lack of rainfall and drought (Liliana, 2005). This state of affairs suggests that many economic activities are likely to be negatively influenced by climate changes which are connected to Sustainable Development Goals (SDGs) (United Nations, 2015), including pastoralism, the subject matter of this paper.

There are various definitions of pastoralism, whose nature varies widely according to the viewpoint or emphasis provided by researchers. Primarily, two standard definitions, which derive from either a production or livelihood perspective, are broadly used for the term pastoralism. From the production viewpoint, pastoralism is animal husbandry, the branch of agriculture concerned with the care, tending, and use of grazing livestock in rangeland areas. From the perspective of livelihood (or the means of securing the necessities of life), pastoralism is a subsistence living pattern of tending herds of large animals (Blench et al. 2019) or a successful livelihood strategy on less productive lands through livestock herding (IFAD, 2011; Dong et al. 2016), which is the complex relationships between grazing pressure and carrying capacity (Vial, 2010). The sustainability of pastoralism is under pressure due to population growth, frequent droughts, deterioration of rangeland, scarcity of water, prevalence of livestock disease, and low livestock market value (Dong et al. 2016; Tessema et al. 2014; Schrepfer et al. 2014). However, pastoralism is seen as a resilient production system (Tessema et al. 2014) and a viable livelihood strategy for millions (Herrero et al. 2016).

The word 'pastoralism' in this article should not be understood to refer to societies that exclusively depend on animal rearing. Because of government pressure and self-initiatives, pastoralists have started practising food crop production. However, food crop production is in its infancy, and its contribution to household income is minimal. Besides, sedentary farming has not reached a stage of impeding mobile

120 livestock production. For this reason, it is challenging to label societies in the studied countries as
121 'agropastoralists'.

122 Approximately 25% of the global land area has been occupied by extensive pastoral production
123 (Schrepfer et al. 2014). Although there is a significant variation between countries, approximately 40% of
124 Africa's landmass is inhabited by pastoral communities that largely depend on livestock production for
125 their livelihood (AU, 2013). Pastoral production systems constitute around 10% of the world's meat
126 production and support some 200 million households, who heavily rely on rearing camels, cattle and small
127 ruminants, about a third of which are found in Sub-Saharan Africa (Schrepfer et al. 2014; Assefa et al.
128 2010).

129 About 25% of the total population of Africa is constituted of pastoralists and agro-pastoralists. Some
130 50 million pastoralists and up to 200 million agro-pastoralists live in the arid and semi-arid lands of Africa,
131 especially in Somalia, Mauritania, Ethiopia, Sudan, and Kenya (IIRR and CTA, 2013). Pastoralists are
132 uniquely known to occupy large areas of communally shared land and have kinship ties for mutual herding
133 and defence. Pastoralist communities generally live in isolated, remote and underdeveloped areas. These
134 areas are most often prone to conflict, drought and vulnerability with a great deal of food insecurity.
135 Consequently, livestock production remains the most viable opportunity to harness scarce biomass
136 resources, as pastoral areas are less suitable for crop husbandry (Schrepfer et al. 2013, AU, 2004).

137 Table 1 offers an overview of the population size and distribution of the most significant pastoralist
138 communities in Africa.

139 **Table 1** Overview of some of the most significant African pastoralist communities.

Community / ethnic group	Country/ Countries	Approximate Population	Literature
Bedouin	Egypt	380,000	(Morrow et al. 2007)
	Algeria	230,000	(Algeria-Watch, 2019)
Tuareg (a nomadic Berber people)	Niger	2,185,285	(World Factbook, 2019a)
	Mali	165,869	(World Factbook, 2019b).
	Burkina Faso	375,111	(World Factbook, 2019c; Menas, 2019)
	Algeria	>50,000	(World Factbook, 2019c; Menas, 2019)
Boran	Ethiopia	500,000	(IRIN, 2019)
Maasai	Kenya	841,622	(KNBS, 2019, Leal-Filho et al. 2017)

	Tanzania	682,000	(Eberhard et al. 2019)
Samburu (sub-tribe of Maasai)	Kenya	223,947	(KNBS, 2019)
Somali	Ethiopia	892,381	(CSA, 2019)
	Kenya	141,111	(KNBS, 2019)
	Somalia	3,075,000	(UNFPA, 2019)
Turkana	Kenya	855,399	(KNBS, 2019)

It should be noted that enumerating mobile pastoralists represents a significant challenge due to the general lack of statistics (Jenet et al. 2016). A study of census and health survey data across Africa revealed different patterns of statistical invisibility among most mobile African pastoralists. Despite progress in statistical documentation, it is concluded that "it is impossible to document the number of them with any accuracy over the last half-century" (Randall et al. 2016). The novelty of this article, therefore, arises precisely from its contribution to penetrate that intellectual darkness. The research is meant to provide a better undertaking of the nexus between climate change and extremes, and their impacts on pastoralists in the eastern and southern African region.

Livestock production in pastoral systems makes a significant contribution to national and regional economies (Holechek et al. 2017). Livestock or livestock-related activities contribute at least 50 % of the total value of production (AU, 2013). In 2010 alone, Sudan and Somaliland traded around 1,800,000 pastoral heads of livestock (Wellard-Dyer, 2012). Despite the significant contribution of pastoralism to local, national and regional economies, it attracts little investment from the government and private sectors. Curiously, other sectors - which contribute less than the livestock sector to the regional GDP - enjoy better policy attention and investment (Tessema et al. 2014; Fre et al. 2013, Ali et al. 2013).

In pastoral areas, many climate risks and hazards (e.g. droughts) lead to losses of livestock. This, in turn, results in significant damages to household, social, and economic structures, worsening already poor living conditions and leading to higher levels of poverty. For instance, many diseases associated with climate change and variability affect pastoralists and jeopardize their environment and life-support systems (AU, 2013; Assefa et al. 2010; Dirie et al. 2003). Pastoral communities, whose livelihood largely depends on livestock production, often suffer from consequences of climate change, especially extreme weather events (Leal Filho, 2015).

For instance, in rural areas, drought-related impacts include decreased pasture and water availability, reduced livestock productivity and increased vulnerability to disease. At the same time, extreme climate-related events accelerate the problems of food insecurity, malnutrition, and competition for limited resources such as water and pastures (Assefa et al. 2010; IIRR and CTA, 2013). Additionally, as a result of severe droughts, pastoralists are forced to displace their livestock to faraway places, potentially exposing them to various health risks (IIRR and CTA, 2013).

Both in the Horn of Africa and Sub-Saharan Africa, pastoralists survive in fragile ecosystems that are adversely affected by drought and are frequently threatened by desertification.

The complex relationship between grazing pressure and carrying capacity- a tool often used in rangeland management to describe the maximum number of livestock an area can support without endangering the whole system- , is also a factor which needs to be taken into account. Often, grazing intensity in some areas is higher than their carrying capacity. A recent study undertaken in Ethiopia, for instance, identified that overstocking or grazing pressure exceeded 5.1 TLU/ha (7.2 cattle/ha) (Meshesha and Yosuf 2019).

Pastoralists and agro-pastoralists struggle to adapt to various climatic change-related challenges. Based on the understanding of these fragile ecosystems with scarce and variable resources, pastoralists who settle in the arid and semi-arid lands have adopted a free and flexible pattern of resource use which is proven to be sustainable (AU, 2013; Fratkin, 2003; Fre et al. 2013).

Climate change is damaging the foundations of pastoralism by significantly reducing the population size of cattle, goats, sheep, equines and camels. Such factors explain the worrisome conditions of pastoralists and agro-pastoralists in countries such as Ethiopia, Malawi, Uganda and Zimbabwe, which are the subject of this paper. Mobility is a critical pastoral risk management strategy, especially when pastoralists face an acute shortage of water and pasture. Mobile pastoral communities, compared to those with sedentary livelihoods, are less vulnerable to loss of livestock (Little et al. 2001).

Some primary factors are likely to compel pastoralists to embrace alternative community-based adaptation (CBA) strategies that enhance their resilience to climate change (Paul et al. 2016; Wolf et al. 2010; Saptutyningsih et al. 2019). These include i) creating stronger urban-rural socio-economic linkages; ii) income source diversification; iii) involvement in local government processes; iv) ensuring adequate

191 social services; v) owning land in the semi-sedentary system; vi) improved communication facilities; vii)
192 change in gender roles (Fre et al. 2013).

193 For this paper, coping refers to managing the climate impacts on a day-to-day basis, whereas
194 adaptation refers to long-term strategies leading to better readiness to reduce the impacts of climate
195 change. Based on the above considerations, this article tries to answer the following fundamental questions:
196 What are the manifestations of climate change of particular relevance to pastoralist communities? How do
197 pastoralists perceive the impact of climate change and variability on their livelihoods? Are pastoralists
198 uniquely vulnerable to climate change and extreme weather events? What are the mechanisms of climate
199 adaptation that are frequently used among pastoralists in southern and eastern Africa? "The purpose of
200 the paper is to offer an overview of the measures and strategies being adopted and
201 implemented by pastoralist communities, to cope with climate change hazards. It is also
202 meant to describe the pressures pastoralists are subjected to, based on experiences at the local
203 level". The responses to these questions and strategies followed by the pastoralists are based
204 on their perceptions expressed through discussion meetings and questionnaires.
205

206 The above research questions were inspired by the United Nations 2030 plan to achieve the
207 Sustainable Development Goals (SDGs) (United Nations, 2015). By considering the SDGs, this article
208 examined broad patterns on the nature and impact of climate change, variability and extreme events (from
209 now on referred to as climate stressors) among pastoralists at the country and communal levels.
210 Adaptation strategies may affect adaptive capacity as a whole. By so doing, the study sought to identify not
211 only the risks and hazards but also the adaptive capacity of pastoralists in different countries as determined
212 by local resources and national factors like human development indices and per capita income differences.
213 From a global point of view, the study demonstrates the greater vulnerability of Africa to climate change.
214 From a regional point of view, the study reveals the determinants of climate adaptation among pastoralists
215 in Ethiopia, Kenya, Malawi, Uganda and Zimbabwe.

216 **2. Impacts of climate change to African pastoralist communities**

This section introduces some of the impacts of climate stressors at the broad, regional and local pastoralist community levels, respectively. It should be stated that the broad-scale is seen as the African one, the regional scale refers to the eastern and southern African region, and the community level scale refers to the local one. Due to their importance, they are described in turn.

2.1. The broad-scale

Scientific evidence on weather patterns indicates a changing climate, mainly regarding an increase in temperature and extreme events (IPCC, 2012; Hulme et al. 2014). With ranges from 0.2℃ to more than 0.5℃ per decade, the projected growth of mean global warming will be rather high in Africa (IPCC, 2007; Epule et al. 2017). Such warming will have unknown consequences given the level of uncertainty and the lack of enough assessments, as well as the multiple stresses and low adaptive capacity of African smallholders (Magal et al. 2017). This vulnerability is also related to poor technological, social and economic conditions which aggravate the continent's vulnerability to weather and climate extremes (Leal-Filho, 2018a, 2018b). On average, Africa experienced a 0.5°C rise in temperature in the previous century (Niang et al. 2014). High-resolution climate projections reveal that Africa will continue experiencing increased mean annual temperatures and marked seasonal variation in rainfall amounts and distribution patterns (Cuni-Sanchez et al. 2018).

2.2. The regional scale

The climate in the studied sites of eastern and southern Africa is characterized as humid equatorial to seasonally arid tropical, showing high variability and sensitivity to small changes in the global climate scale. Regional climate variability is expected to worsen the shortage level of water and pasture and increase food insecurity and conflicts, as well as the spread of certain diseases and related economic problems (Eriksen et al. 2018). An increase in temperatures and a decrease in rainfall is predicted in many rural areas in the studied sites. Likewise, it is expected that rainfall will be unpredictable, and there will be recurrent droughts (IPCC, 2007, 2012, 2014). For instance, in the drylands of southern Kenya, water is a seasonally scarce resource for many rural people due to increased demand for water caused by population growth and lack of access to dry season water areas. Also, the increase in temperature in the dry season exacerbates water scarcity, which lowers the moisture level needed for good pasture (Weesie, 2018; Adano

et al. 2012). Furthermore, conflict can result from scarce resources and increasing population pressures (Ced and Cotula, 2018).

Extreme rainfall, maximum temperature events, and extensive droughts are among the hazards substantially increasing in Ethiopia (Suryabhagavan, 2017). In Malawi, while climate projections vary among models depending on assumptions, the majority of climate models suggest temperature increases by 1.1 to 3.0 degrees Celsius by 2060. Also, an increase in the frequency of days considered to be 'hot' in the current climate is likely, whereas estimated rainfall events are likely to decrease, leading to more frequent droughts (McSweeney et al. 2008). In Uganda, the warming trend is expected to continue, with some projections suggesting an increase of up to 1.5°C as early as by 2030. Similarly, temperatures could rise between 0.9°C and 3.3°C by the 2060s (Ministry of Water and Environment, 2014). In Zimbabwe, daily minimum temperatures have risen by approximately 2.6°C over the last century while daily maximum temperatures have risen by 2°C during the same period; while the number of cold days has decreased, the number of hot days increased (Brown et al. 2012). Whereas it is not the purpose of this paper to discuss climate extremes, the above details outlining a warming trend seen in Africa.

Climate-related stressors and the poor socio-environmental conditions of pastoralists could generate negative consequences in two layers or on two levels (IFAD, 2011; Niang et al. 2014; Eriksen et al. 2018; Christian Aid, 2018):

- To natural systems: Deforestation; rangeland degradation and fragmentation; poor water access; invasive tree and weed species.
- To human-systems: aid dependency; migration; sedentarization; immigration of non-pastoralists into grazing areas; conflict and political crises; weak social safety nets; lack of opportunities for livelihood diversification; changes in land tenure and insecure access to land, markets, and other resources; increased vulnerability.

Like the Ethiopian highlands, in regions of high or complex topography, the downscaled projections indicate increases in rainfall and extreme rainfall by the end of the 21st century (Niang et al. 2014). Climate predictions such as those presented in the African Chapter of the 5th Assessment Report of IPCC (IPCC 2014) suggest that there will be temperature increases and rainfall variability in the studied areas. By the middle of the 21st-century, it is estimated that the temperature will increase by 2°C. Despite the

global phenomenon, in the studied sites - similar to what happens elsewhere in Africa - the regions will mainly suffer by drought and other climate-induced shocks and stresses (Muluken et al. 2017).

2.3. The local community-level scale

Table 2 summarizes some of the sustainability challenges posed by climate-related stressors to pastoralist communities in the eastern and southern Africa region. The climate-related challenges shown in Table 2 might be related to the following SDGs: 1. No poverty. 2. Zero Hunger. 3. Good Health and Well-being. 6. Clean Water and Sanitation. 10. Reducing Inequality. 11. Sustainable Cities and Communities. 13. Climate Action. 15. Life on Land. 16. Peace, Justice, and Strong Institutions.

Table 2 Examples of synergic sustainability challenges posed by climate change, extremes, and non-climate stressors to pastoralist communities in Sub-Saharan Africa

Climate-related challenge	Region	Impacts / Adverse effects	SDGs	References
Reduced rainfall and water stress. Drought is becoming more frequent and more extended in the dry areas. Flooding.	Botswana, Zimbabwe, and Ethiopian lowland areas are more climate-vulnerable than the wet areas of Tanzania or Zambia. Southern Africa.	Domestic water shortage affects crop production and livestock. In lowland areas: livestock-based pastoralists.	1 2 3 4 6 15	(IFAD, 2011).
	East and southern Africa.	Water scarcity. Food insecurity and reduced cereal production and the yields of high-value perennial crops.	1 2 3 6 11 16	(Eriksen et al. 2018).
High temperatures and changes in rainfall. Changes in temperature and rainfall.	East and southern Africa.	Risk of disease due to the expansion of areas for malaria transmission. Human health.		(Eriksen et al. 2018).
Erosion and floods in low-lying areas.	East and southern Africa (e.g. Tanzania).	Erosion Costs of about 5% to 10% of gross domestic product (GDP).	3 6 11 13	(Leal-Filho, 2018a; Eriksen et al. 2018).
The rise in temperature and change in precipitation pattern: By the end of this century,	Across Africa, particularly Sub-Saharan Africa, and east and	Reduced crop production: -2% for sorghum to - 35% for wheat crop productivity; yield reductions of - 10% in	1 2 3 10	(IFAD, 2011, Niang et al. 2014, Nelson et

the mean annual temperature is expected to rise by more than 2°C.	southern Africa.	the production of maize, sorghum, millet, sugar cane, and wheat.	11 13 15	al. 2019).
Soil erosion	Major droughts occurred in the 1970s and 1980s in the Sahel.	Pastoralist livestock production. Livestock mobility and controlled breeding of animals.	1 2 10 11 13 15 16	(Sangeda et al. 2014). (Sangeda et al. 2014, Iticha et al. 2018)
Water availability, heat stress.	Tanzania Mvomero district, Tanzania.	Quality and quantity of feed. Rural Livelihoods. Massive death of livestock in 2016. Satellite images indicated that pasture resources reduced from 82% in 1985 to 5% in 2015.		(Christian Aid, 2018; Magita, 2019). Boko et al. 2019).
Future climate change.	Sub-Saharan Africa The highland regions of eastern Africa.	Increase in pests, weeds, and diseases. Crops and livestock. Striga weed causing cereal yield reduction. Diseases in the coffee berry borer; burrowing nematode, black leaf streak disease (that also threatens bananas).	1 2 10 11 15	(Niang et al. 2014). (Niang et al. 2014; Jaramillo et al. 2011; Cotter et al. 2012).
Climate change and extreme events.	Turkana, Kenya.	Possible worsening of conflicts in livelihood systems. Increased poverty and competition over scarce resources in rural areas are transforming the cultural practice of livestock raiding into a commercial activity with criminal motives. The use of automatic weapons has caused insecurity and hindered pastoralists' mobility.	1 2 10 16	(Magita et al. 2019; Boko et al. 2019).

Source: Compiled by the authors

As can be seen in the table above, climate stressors disrupt rural livelihoods by triggering conditions which may negatively influence agricultural production. Besides crop yield reduction and death of livestock, climate change may compound health problems and hamper overall wellbeing. That being the case, the prospects of achieving the SDGs, such as no poverty, no hunger, good health and wellbeing,

clean water and sanitation are not high, and hence must raise concerns among both policymakers and the rest of the population.

3. Methodology used

In understanding trends related to disasters risk reduction, this study seeks to tackle the currents constraint posed by the paucity of studies specific to problems faced by pastoralists' communities in the eastern and southern African region, which focus on climate change, variability and extremes and how they influence their livelihoods. The limited availability of data in most countries poses a challenge to efforts aimed at fostering an understanding of trends at a regional level. Since this study focused on the climate-related impacts, as well as the adaptation strategies of pastoralists in five East and South African countries (see Figure 1), it is believed it provides a welcome addition to the literature and expands the knowledge on regional trends.

The study consisted of the use of two main methods, namely a) the collection of field data, complemented by b) an analysis of available literature in the sampled countries. Due to the lack of data on credit, extension services and off-farm income activities, and since some of these facilities or services are not widely available, they were not included in the study. The authors in each country actively engaged in the data collection.

The study is divided into general country-level economic and human development (World Bank, 2018; UNDP, 2018), climate vulnerability and adaptation (ND-Gain, 2018) (section 4.1, table 3), and an aggregated community-level in situ research of the pastoralists' perceptions of climate stressors, impacts, and adaptation options in the five studied countries (section 4.2). The national-level indicators were used since they are required by international organizations, while a local-level index is required when analyzing trends related to local-level governments (Sachs et al. 2019). As there is a lack of appropriate sub-national level indicators for pastoralist communities, we used national-level indices as proxies for the three elements of vulnerability (exposure, sensitivity, adaptive capacity) which are assessed for use by policy-makers (Leal-Filho, 2018b). These indices are useful to develop top-down and bottom-up (mainstreaming) adaptation actions and policies (Leal Filho et al. 2019).

Therefore the secondary data are used as a reference for the country-level development status affecting the potential top-down capacities, not to depict the local realities. Better

316 national-level indices of development are assumed as being associated with a better top-down
317 flow of information and assistance. Despite that the local reality is often not represented by
318 national-level circumstances, it is assumed that they influence it. For instance, the
319 improvements in real-time weather/climate forecast and modelling, and communication to
320 pastoralists, will foster adaptive capacities (Leal Filho et al. 2018c). However, this paper
321 focuses on the hypothesis that local actions and attitudes are essential to cope to and adapt to
322 climate stressors, and lies on the responses of pastoralists to understand local reality.

323 In section 4.1, the ND-GAIN Country Index (ND-Gain, 2018) summarizes a country's vulnerability to
324 climate change and other global challenges in combination with its readiness (the preparedness to take
325 actions) to improve resilience. The definitions of vulnerability elements, ecosystem services, and readiness
326 are described below:

327 Exposure: nature and degree to which a system is exposed to direct, significant climate change
328 impacts. It considers vulnerability independent of the socio-economic context.

329 Sensitivity: the extent to which a country is dependent upon a sector negatively affected by a climate
330 hazard, or the proportion of the population particularly susceptible to a climate change hazard.

331 Adaptive Capacity: the availability of resources to support sector-specific sustainable adaptation
332 solutions.

333 Ecosystem Services: the vulnerability of natural capital to climate change, the ecological resources
334 that humans rely upon to support lives and livelihoods.

335 Readiness: It measures the ability of a country to leverage investments accompanied by alternative
336 adaptation actions through considering three components, such as commercial readiness, governance
337 readiness and social readiness (Leal-Filho, 2018b; ND-Gain, 2018; UNISDR-AF, 2014).

338 The development, vulnerability and SDG indices serve to estimate the levels of adaptive capacity and
339 accomplishment of SDGs in each country. The indices used are i) the Gross National Income (GNI)
340 (World Bank, 2018); ii) the Human Development Index (HDI) (UNDP, 2018), and iii) the assessment of
341 the countries' distance from achieving the SDGs (Leal-Filho, 2018c). As stated above, these indices are not
342 directly associated with local-level adaptive capacities but with the potential from the top level.

The sites were selected based on the existence of pastoralist communities that could be accessed by the research team, and which were willing to share information with the authors through a focus group discussion (FGD) that collected data from each site. The study sites (see Table 1 and Figure 1) are the following pastoralist communities in Afar, Yabello, and Arero (Ethiopia); Kajiado (Kenya); Nakasongola (Uganda); Lake Chilwa, Lower Shire river Nsanji, and Chlkawa (Malawi); Chitulapsi, Beitbrisge, Chitulapsi (Zimbabwe).

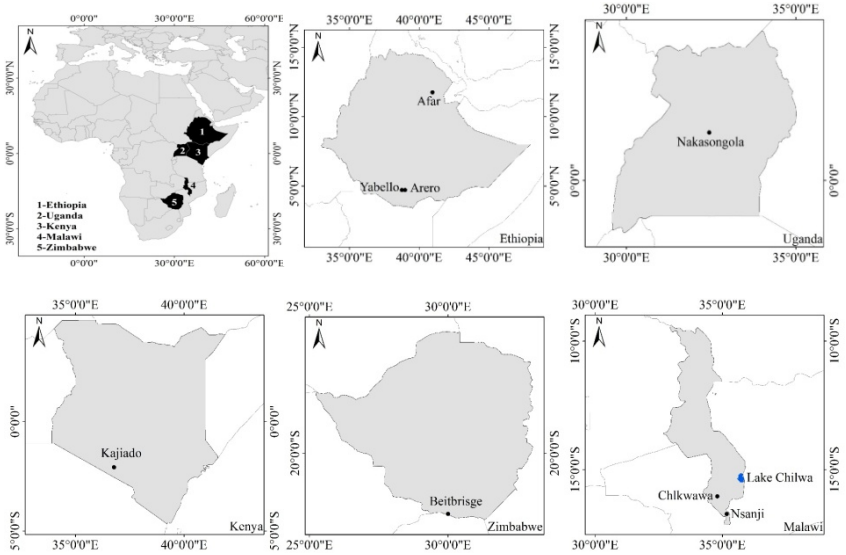


Figure 1 Countries involved in the study and their distribution

The provision of data on the sub-national level is not even in Africa. Whereas some countries are well organized, and data is widely available, in others it is not so. Therefore the study uses the national level as the baseline and uses local indicators to "zoom in" at the local reality. Such as, local dimension is essential in understanding the specific realities in each country. The study used the following approaches. Firstly, the study listed significant climate change, variability and extremes, and associated impacts that are critical to human wellbeing and livelihoods across the studied regions from the existing literature. Secondly, field data was collected to identify the occurrence of those problems in each country. Finally, given the influence of both socio-economic and ecological conditions in different countries, the results were discussed to comparatively assess the nature of climate stressors and the performance of adaptation efforts among pastoralists.

Consequently, the comparison moves beyond the traditional juxtapositions based on national-level development (developed vs underdeveloped) or the type of economic activity (pastoral vs agricultural). By

364 transcending such differences, the study adopts a geographical frame of analysis to the phenomenon of
365 climate stressors. The comparison builds on qualitative descriptions since the authors could not use
366 standardized measurements for climate risks and the performance of adaptation efforts.

367 Table 3 summarizes the methodology used in the fieldwork. Manifestations of climate stressors were
368 examined based on extensive focus group discussions (FGD), crucial informant semi-structured interviews
369 with 20 male representatives of the pastoralist communities in each country, and open-ended questions.
370 The selection of 20 male respondents per community introduces a gender bias in the community perception
371 because they were identified by the community leaders and only access to them was granted. The surveys
372 have two parts, as follows:

373 Part 1 asked if they believe that global environmental change and climate change, in particular, are
374 affecting their community.

375 Part 2 provided the reply to question 1 was a "yes", continued with a discussion focused on questions
376 to guide the conversation, as summarised in section 4.2 (tables 5-10).

377 Survey participants were recruited based on the instructions provided by the traditional leaders. As
378 part of the survey of 20 male representatives of the pastoralist communities in each country- chosen
379 because they are usually the ones leading households- questions about coping and adaptation mechanisms
380 to climate stressors were asked and cross-checked with previous studies. The participants - all male - were
381 recruited based on the instructions provided by the traditional leaders, who are the foremost authorities in
382 the surveyed communities.

383 The respondents described manifestations of climate stressors, perceived ecosystem changes,
384 income and livestock losses, adaptation options used, the level of climate change and extreme
385 impacts, and the climate adaptation mechanisms deployed in each area.

386 Statements collected from the respondents, which mirrored existing socio-economic, institutional and
387 governance conditions, were used by the authors to evaluate the nature of adaptive capacity of each site to
388 climate stressors. This task was supported by the respondents' intimate knowledge of local climate impacts
389 and coping responses, as well as the socio-economic, political and cultural conditions surrounding them,
390 which are vital in understanding the dynamics of climate change adaptation. In this way, the research dealt
391 with the nature of climate vulnerability attributable to the skills, knowledge, and experience possessed by
392 the locals, but also considered governance issues (the capacity to downscale measures). Similarly,

manifestations of climate extremes and their attendant impacts (such as flooding, drought, erratic rainfall, and diseases) as well as the community responses were synthesized from available studies and were supplemented by field observations among the sampled pastoralists.

Table 3. The methodological approach of community-level discussion and survey

Criteria followed in selecting the study sites	Discussion and Survey approaches
1. Research team expert judgment. 2. Existence of pastoralist communities. 3. Representativeness.	One Focus Group Discussion (FGD) with semi-structured interviews and open-ended questions per site. The informants provided prior and informed consent. The research team summarizes the results in specific tables related to the discussion and questions.
4. Accessibility. 5. Willingness to share information. 6. Diversity.	The research team purposely selected researcher key informants per FGD session with community participants in each one (knowledgeable elders, professionals actively engaged in climate and environmental change impact and adaptation). A skilled team researcher acts as the moderator who asks broad probe questions to elicit responses and generate discussion among the participants. Semi-structured interviews and dialogues with critical informants provided the research team with a flexible way to deepen awareness of the livelihood issues associated with global environmental change and climate extremes at each site and focus on their qualitative importance. Open-ended questions provided information about the pastoralists' perceptions of climate stressors, overall impacts, and responses.

By combining the collected local-level primary and secondary national-level data, plus the perceptions of community leaders, the study depicts a broad comparative sketch of the climate impacts and the pastoralists' responses in the five studies countries, in a way not seen before. It brings in fresh evidence which addresses the nexus between climate change and poverty in pastoralism.

4. Results and Discussion

4.1. Country-level development, vulnerability and readiness status

Table 4 introduces the country-level status of socio-economic and human development, the vulnerability and readiness, and the level of accomplishment of SDGs of countries included in the study. This overview of the studied countries serves to depict the (lack of) top-down adaptive capacity. This assessment is based on secondary sources such as the Gross National Income (GNI per capita) and the UNDP's Human Development (HDI) Indices, the ND-Gain overall vulnerability (V: E + S – AC), including ecosystem services vulnerability (ESS), which relates to pastoralism, the overall readiness, and the percentage of achievement of overall SDG indicators.

411 **Table 4** Economic and Human Development, vulnerability and readiness status, and the Sustainable
412 Development Goal Index (SDG-I) of the studied countries.

Country	Development		ND-Gain Vulnerability and Readiness (2017)						
	Per Capita GNI (US$ PPP) 2018	UNDP HDI 2017	Overall Vulnerability					Readiness	SDG-I 2018 (%)
			V	E	S	AC	ESS	Read	
Ethiopia	2,010	0.46	0.57	0.51	0.50	0.71	0.49	0.27	0.45
Kenya	3,430	0.59	0.55	0.51	0.50	0.65	0.47	0.28	0.55
Malawi	1,310	0.48	0.55	0.49	0.48	0.63	0.51	0.26	0.48
Uganda	1,970	0.52	0.58	0.52	0.58	0.66	0.51	0.29	0.49
Zimbabwe	3,010	0.53	0.54	0.52	0.55	0.60	0.51	0.20	0.52

413
414 Kenya and Zimbabwe are lower-middle-income countries, and the other three are low-income ones.
415 Kenya is the only country with medium human development, whereas the other four show low HDI. The
416 indices of development, vulnerability components (E, S, and AC), and readiness are quite similar and
417 interrelated. All five countries show levels of readiness placed in the bottom world quintile, with little
418 capacity to implement adaptation options at the country-level. As a result, the importance of community-
419 level adaptation to overcome climate stressors is discussed hereunder. The studied countries perform well
420 or better/score well in regards to Ecosystem Services (associated with the pastoralism habitat), and less
421 well in regards to readiness. This fact supports the statements of several authors (e.g. Blench, 2019; IFAD,
422 2011; Dong et al. 2016; Tessema et al. 2014; Herrero et al. 2016) about the sustainability of pastoralism
423 and the need for better policies. Finally, the five countries show a similar global SDG Index, below the
424 global median (UNISDR-AF, 2018). The relatively higher level of achievement of the SDGs in Kenya and
425 Zimbabwe is in line with their higher development indices.

426 **4.2. Community-level perception survey**

427 This sub-section presents the aggregated results of the community-level field surveys. The topics presented
428 include perceptions of the pastoralist communities of climate-related stressors and impacts on the
429 communities, assets and environment (Tables 5 and 6), climate impacts on land-use and livestock (Tables
430 7 and 8) and climate adaptation options (Tables 9 and 10). Because of the lack of local-level data (e.g.
431 damages and poverty level), the perceptions of the community leaders, supported by national-level
432 indicators, are used. The percentages shown in the tables are an approximation to express perceptions, not
433 a quantitative assessment of the local reality. The community-level bottom-up approach facilitates
434 engagements with stakeholders and considers the socio-economic and ecological states of existing

vulnerabilities, thereby making informed decisions to manage future risks (Vincent, 2007). Socio-economic and environmental sustainability can be improved by the disaster risk management and adaptation approaches. Therefore, addressing the fundamental causes of vulnerability is a prerequisite for sustainability in the context of climate change (IPCC, 2012; Weesie et al. 2018). Tables 5 to 10 show the pastoralists´ perceptions of the influence of climate-related stressors, vulnerability and impacts. The tables summarize climate impacts on land use, livestock, and adaptation options for pastoralism and income loss.

The well-being of their communities and their food security are the main general climate-related concerns of pastoralists. Also, impacts on agriculture, natural resources and traditional social institutions are observed (Table 5). Such concerns show that livelihoods, the physical environment, and social institutions are the most adversely affected by climate and environmental changes. Together with other variables, these elements form the basis of a "poverty trap" (Grassetti et al. 2018; Paumgarten et al. 2018; Lin et al. 2018), outlined in Figure 2 and here defined as conditions which limit access to resources and hence perpetuate poverty.

Table 5 Perceived negative influence of climate-related stressors in the surveyed communities. Question: How significant are the negative influences of climate change and extreme weather events on the overall and economic well-being, livestock, agriculture, food security, natural resources and community's social institutions?

Sectors	The extent of the Negative Influence of Global Environmental Change (%)					
	Substantially	Moderately	Little	Very little	Not at all	Rank
The well-being of the community as a whole	95.8	4.2	0	0	0	1
Livestock	79.2	20.8	0	0	0	6
Agriculture	91.7	8.3	0	0	0	4
Food security	95.8	4.2	0	0	0	1
The economic well-being of the community	95.8	4.2	0	0	0	1
Traditional natural resources and social institutions	91.7	8.2	0	0	0	4

The studied countries in this paper (e.g. Kenya, Ethiopia, and Uganda, in the range of 15-82%, and Malawi and Zimbabwe in the range of 27%-86%) have some specific populations that have access to weather and climate services (WCS). These amount of people able to access such services is lower for pastoralist than for farming communities. Indeed, the lower access to WCS by pastoralists represents a barrier towards coping with climate stressors and improving economic sustainability, which needs to be addressed by the relevant authorities.

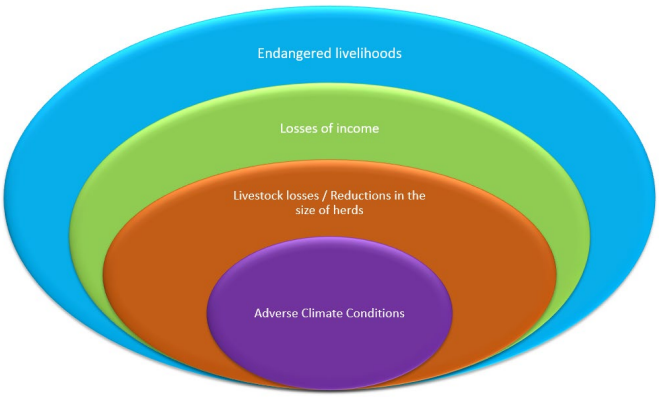


Figure 2 Elements which are related to the poverty trap in pastoralist communities

Table 6 reveals that the surveyed communities are aware of the risks of higher variability in extreme climate and weather extremes. They perceived impacts of climate change and extremes on land resource degradation through land deterioration, soil erosion and water depletion, reduced livestock productivity and population as a serious problem. It can be surmised that land degradation and agricultural productivity are highly sensitive to climate stressors. The expansion of invasive plants and grasses was the least felt impact of climate change. Responses in Tables 7 to 9 reinforce such findings.

For instance, a reduction in income and crop and livestock productivity was ranked the highest climate change-related impact, followed by a reduction in grass availability, and prevalence of disease (Table 6). Resource-based conflict and the invasion of low-value invasive woody species were not perceived to be significant problems. Despite the degree of variations, the results show that climate change has affected all aspects of the pastoralists' lives in many ways. These adverse effects are apparent concerning the impacts on land use and the environment (Table 7). All respondents agree that climate negatively affected rangelands and forests, while 95.5% of the respondents reported climate also leads to a decrease in grasslands. Finally, 91.7% of the respondents perceived climate impacts through the losses of shrubland and farmland. The effects on livestock are also substantial, e.g. decreases in cattle population (Table 8); priority is given to the sources of income (cattle, goats, and sheep). As camels are drought-resistant, they are the least affected, followed by equines; this, coupled with high market value, attracted pastoralists to rear camels. For instance, in Borana, the recently introduced camel population has increased at the expense of indigenous cattle breeds at the household level.

Table 6 Climatic stressors and environmental impacts in the surveyed communities

Question: Which are the main climate-stressors and environmental impacts on your communities?

Climatic Stressors / Impacts	Percentage of	Rank

	affected respondents	
Increased frequency and magnitude of drought	100	1
Higher variability in climate extremes	100	1
Reduced crop yield	95.8	2
Land degradation/ soil erosion and water depletion	91.7	3
Reduced productivity and population of livestock	91.7	3
Expansion of invasive plants and grasses	33.3	5
Other environmental changes	33.3	5

Table 7 Impacts of climate change on land use

Question: Which are the most critical climate impacts and losses on land use and the environment?

Climatic Impact	Percentage of affected respondents	Rank
Loss of rangelands	100	1
Loss of forests	100	1
Decrease in grassland	95.8	3
The decline in shrubland	91.7	4
Loss of farmland	91.7	4

Table 8 General impacts of climate change and priorities among Pastoralists

Question: Which are the main impacts of climate change on your livestock?

Climatic Impact	Percentage of respondents implementing these measures	Rank
The decrease in population of cattle	83.3	1
A decrease in the population of goats	70.8	2
The decline in the population of sheep	70.8	2
The decline in the population of equines	45.8	4
Impact on other types of livestock	16.7	5
The decrease in population of camels	8.3	6

As Table 6 shows, climate change affected agricultural production (both crop and livestock), natural resources and household income. In decreasing order, the impact is not only evidently felt by the pastoralists but was remarkable on cattle, goats, sheep, and equines (unclear what table this statement is referring to). Table 9 shows that the use of drought-resistant crops is the most preferred adaptation mechanism, adopted by 91.7% of the respondents, followed by changing the cultivation period, which is practised by 29.2% of the respondents (Table 9). Rainwater harvesting/storage is the least used adaptation mechanism, which might be explained by poor government support. That only 16.7% of respondents practised livestock movement during drought is difficult to interpret, since that is the salient feature of the pastoral way of life. The results presented in Table 5 are in line with those in Table 2 (synergic sustainability challenges). These results place the negative influence on livestock above the other assets, and the claim that the introduction of crop production restricts the traditional rangeland management and adaptation strategies of the pastoral communities (Brooks, 2005).

Table 9 Adaptation options to climate change

503 Question: Which are the options you take into account to reduce the severity of the effects
504 caused by climate-related and non-climate stressors on your land, crops, and livestock?

Adaptive response options	Percentage of respondents implementing these measures	Rank
Adopt the use of more drought-resistant crops	91.7	1
Different adaptation strategies (others)	50.0	2
Change in the cultivation period	29.2	3
Movement of livestock to other areas	16.7	4
Use rainwater harvesting/storage	12.5	5

505
506 Regarding adaptation options, the priority is the use of more drought-resistant crops and alternative
507 income sources such as tourism, while abandoning pastoralism is not favoured by most respondents.
508 Indeed, pastoralists take several adaptation measures (see Tables 6-8). However, they do not prioritize
509 water harvesting/storage like other researchers have found with herders in the drylands of southern Kenya
510 (Niang et al. 2014). Community-level (bottom-up) adaptation strategies are prioritized because of the lack
511 of adequate financial resources, skills and access to timely top-down information (e.g. prognosis and early
512 warning about extreme events). These responses agree with previous works (Niang et al. 2014; Weesie,
513 2018; Marshall et al. 2018), which are essential for the planning of innovative climate adaptation options
514 and the implementation of climate risk management (CRM).
515 Mainstreaming community-level climate action and combining bottom-up and top-down approaches
516 to mobilize available resources would facilitate the implementation of new adaptation strategies such as
517 National-level Adaptation Plans-NAPs and CRM supported from the community-level action (Leal-Filho
518 et al. 2017; 2018a,b,c, 2019).
519 The social capital of pastoralists that was once geographically bounded is now spreading across larger
520 areas because of changing flows of people, resources and information, all of which can provide alternative
521 sources of income. This new, diversified income, may also increase their ability to adapt to climate
522 change and better manage climate-related risks (Herrero et al. 2016).
523 Finally, the two most preferred adaptation measures to reduce the losses in income were combining
524 pastoralism with tourism and diversification of income sources (Table 10). The community leaders have
525 not detailed if they are practising agro/eco-tourism, but their interest in such an income alternative. Only
526 33.3% of respondents considered abandoning pastoralism, and 20.8% used migration to cities and
527 changing types of livestock as adaptation measures. Therefore, pastoralists are more interested in
528 employing more adaptation measures without abandoning their age-old craft. As regards the communities'
529 livelihood sustainability, key informants and herders highlight the lack of financial capital, a weak physical

capital, and a moderate human, natural and social capital. These results are in close agreement with the findings made in Inner Mongolia (China) (UNISDR-AF, 2018) and in Yogyakarta, Indonesia (Saptutyningsih et al. 2019).

Table 10 Adaptation options to ameliorate income loss due to climate change
Question: Which are your preferred options to reduce your losses in income due to climate change and extreme events?

Adaptive response options	Percentage of respondents implementing these measures	Rank
Combining pastoralism with tourism	100	1
Income diversification	95.8	2
Different adaptation strategies	75	3
Abandon pastoralism for other jobs	33.3	4
Considering a migration to other cities	20.8	5
Change in type of livestock being reared	20.8	5

The perception of climate-related impacts on communities focuses on well-being and environmental sustainability. Recent literature supports the environmental sustainability of pastoralism (Dong et al. 2016; Tessema et al. 2014; Markakis, 2004). Conversely, researchers have identified the impacts of climate change and extremes on the foundations of pastoral livelihoods: agricultural yields, grassland, and income, loss of rangeland and forests. Despite such disparities, it is evident that climate-related and non-climate stressors have the potential to exacerbate existing threats to human security, including food, health, and economic insecurity (Niang et al. 2014). Pastoralists' concerns tally with the UN SDGs 13, which envisions strengthening the resilience and the adaptive capacity to climate-related hazards and natural disasters (United Nations, 2015).

In summary, the studied eastern and southern African countries face significant challenges in achieving many SDGs (e.g.1. poverty; 2. undernourishment; 3. health and well-being; 11. cities and communities). On the other hand, they perform relatively better at the country-level in achieving SDGs 13 (climate action) and 14 (terrestrial ecosystems) (Sachs et al. 2019). For instance, Ethiopia, Kenya, and Uganda are in a better position to achieve SDGs 1, 2, 3, while Zimbabwe has good potential regarding SDGs 1 and 3. Except for Kenya, other countries are doing quite well regarding the SDG on Life on Land (Sachs et al. 2019).

The main limitation of this paper has to do with the lack of objective measurements of vulnerability and readiness at the community level. However, the main perceived threats, impacts, and several response options were prioritized, since the observations from the people interviewed in the communities provide evidence which corroborates previous studies and the international literature.

5. Conclusions

The paper aimed to offer an overview of the extent to which climate change risks and hazards affect pastoralist communities in eastern and southern Africa and to consider how these may be duly considered, against a complex background. There are limitations in the methods used, such as the size of the sampled pastoralist communities. However, these limitations do not detract from the merits of the paper, as one of the few investigations which have looked at the influence of climate change risks and hazards to the livelihoods of pastoralist communities in five African nations.

The relevance of the results obtained can be better assessed if one considers that the study sheds light on the various means being deployed by pastoralists in the region to cope with, and adjust to, the impacts of a changing climate.

The implications of this paper are threefold. Firstly, the study has shown that the long-term sustainability of the livelihoods of pastoral communities is currently endangered by climate change and the risks and hazards it brings about, which may worsen poverty among this social group. Secondly, the study suggests that a more systematic and structured approach is needed when assessing the climate vulnerability of individual pastoral communities. Thirdly, the paper shows that it is also necessary to understand better the socio-ecological systems (SES) of the various communities, and how their livelihoods are influenced by the changing conditions imposed by a changing climate. Moreover, an improved understanding of SES may help both policy-makers and managers to develop more suitable plans and undertake more adequate climate change adaptation initiatives to increase the resilience of pastoral communities all over Africa.

The strengthening of pastoral communities should focus on tackling some pressing issues which concern them now, i.e. from a changing dynamic of flood and drought risks to the inherent vulnerability of the SES they live in. In this context, rural communities should not be regarded in isolation. Instead, they need to be part of a set of associated social actors and institutions, which need to be interacting in an integrated manner to fulfill their roles as guardians of rangelands. It is not only about rearing livestock, but also about land-management and conservation of biodiversity, as well as handling a wide range of environmental, social, and economic impacts. Such a combined approach would allow for the maintenance of the ecosystem services these areas provide, with the benefits associated with it.

584 It is equally important to assist pastoralist communities and the organizations which support them, in
585 their efforts towards coping with the impacts of stressors such as drought, whose intensity is likely to
586 increase. The ability of individuals and institutions at a local level to deal with such stressors needs to be
587 fostered. By doing so, pastoralists may be in a better position to respond to the various pressures they are
588 exposed to, and the imminent danger of long-term damages to their socio-ecological systems and their
589 livelihoods. Mainstreaming community-based adaptation (bottom-up) within the upper-level policies (top-
590 down) seems to be among the best low-cost strategies, and likely to work as long as the relevant
591 stakeholders are on board.
592 To yield the expected benefits attempts to support pastoralist communities to cope with the many
593 challenges climate change and extreme events pose to them should also consider:
594 a) the specificity of the rangeland ecosystems and livestock production systems of each area;
595 b) the specific responses needed during a drought or post-drought recovery;
596 c) the implications to their livelihoods and sustainability of their herds
597
598 To ensure the sustainability of pastoral communities, it is also essential to enhance access to climate
599 information services, such as a phone and radio warning about coming droughts. Additionally, provisions
600 of access to insurance may help herders to cope with their problems in a more sustainable way, and to be
601 better prepared to avoid the poverty traps that surround them.

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