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Adaptation to Climate Change in the Pastoral and Agropastoral Systems of Borana, South Ethiopia: Options and Barriers

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Abstract

The pastoral and agropastoral systems of the Borana in southern Ethiopia are highly vulnerable to climate change and its impacts. Assistance to enable these smallholders to successfully adapt to future climate change in locally relevant ways can be usefully informed by the analysis and better understanding of past and ongoing adaptation. We conducted farm household surveys, focus group discussions, expert consultations and secondary data collation in 2012 in the Borana. The study employed a combination of Pressure-State-Response (PSR) framework to analyse how climate change put pressure on pastoral and agropastoral farming systems and livelihoods, and Pelling's (2011) typological framework to analyse local adaptation responses. Results showed that pastoral and agropastoral households, their communities and institutions adopted a wide range of adaptation options primarily through adjusting their farming practices and diversifying into non-pastoral livelihoods. The smallholders primarily pursued a resilience approach to adaptation with short term goals intended to avoid system disruptions instead of long-term transformational approaches that significantly address the root causes of vulnerability. A range of barriers constrained local adaptive capacity and shaped routes for adaptation. Adaptation pathways that address critical barriers to adapt, integrate indigenous institutions into adaptation and link adaptation with local development process are necessary to bring long-term and non-marginal, major changes that reduce vulnerability and ensure co-benefit of improving livelihoods.

Keywords

Adaptation Options, Barriers, Resilience, Smallholder Agriculture, Vulnerability

"It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change." [1]

1. Introduction

Agriculture in Ethiopia is an important economic sector upon which the majority of Ethiopians depend for food, feed and income. The sector is dominated by smallholder agriculture responsible for 80% of the employment, 90% of the total agricultural output and 95% of the total area under agricultural land use [2] [3]. The smallholder sub-sector is predominantly comprised of subsistence and traditional rainfed systems which exhibit vulnerability to various internal and external pressures. Vulnerability within these agricultural systems can be broadly attributed to a variety of climate and non-climate factors which include bio-physical, socio-economic and political elements. These, among others, include changing climate [4], conflicts between formal and informal land tenure systems [2], ecological degradation [5] and poor agricultural market conditions [6]. These various climate and non-climate risk factors have contributed to abject poverty and food insecurity problems in the country including the study area [7] [8] [9]. Agriculture is identified as one of the most vulnerable sectors to climate change [10]. Subsequently, adaptation becomes an increasingly important aspect of agricultural development narratives that broadly aim to transform the sector from traditional to a "modern" market-based resilient one.

Perception of climate change and its associated impact is an important first step to adaptation [4] [11]. It helps to define climate change both as a problem and context for decision to adapt in the face of complex interaction between societies and their environment. Perception to varying extents is shaped by various socioeconomic, cultural, political and environmental factors [4] [12] [13]. Changes in local climate appear relatively easy to see as compared to the global climate because of heuristic experiences and more attachment to the local climate [11] [14]. More precisely, experienced impacts or anticipated risks of local climate change help to acknowledge climate change, vulnerability and associated adaptation deficit that trigger an adaptation need and decision to adapt [15]. Stemming from adaptation deficit and subsequent needs, different actors decide to respond whereby responses can take different visions, forms and scales. These responses are generally driven by vulnerability and livelihood risk in the face of biophysical and socioeconomic uncertainties mainly climate change.

Adaptations can be planned or unplanned, local or regional and involve adjustments through a variety of processes, practices and structures to actual or anticipated changes in climate [16] [17]. Depending on the vision and degree of intervention adaptation can intervene in development. Adaptation responses may be structured around one of the following goals-resilience (stability, functional persistence or maintaining the status quo), transition (incremental change) and transformation (radical change or reconfiguration of structures) [18]. However, some adaptive strategies may fail to bring intended positive out-

comes which result in insufficient adaptation or maladaptation that exacerbates vulnerability of the target group or neighbouring communities [19] [20]. More attention has to be paid to potential consequences of adaptation policies and practices with their implication for future adaptive capacity and long-term adaptation.

Smallholder agriculture in pastoral and agropastoral production systems exhibit distinct characteristics, and presents unique opportunities and challenges for agricultural research and development as well as adaptation. The dryland ecosystems these agricultural systems inhabit offer two key features—a highly variable climate, and increasingly limited natural resources to which smallholders for generations have strived to adapt [21] [22]. The ecosystems support inherently climate-sensitive and vulnerable agriculture-based livelihoods, and have continuously attempted to strike the delicate balance between meeting growing human need and diminishing natural resources base in changing environment [22]. The fact that pastoralism primarily depends on resource-extracting extensive livestock production underscores the centrality of natural resource management such as land use planning. Thus, addressing adaptation deficit in subsistence and traditional agricultural systems within such fragile ecosystems presents unique challenges with implications for development [23].

Pastoralism is highly valued livelihood style among traditional communities in drylands of Africa. The preference could be attributed to the ability of pastoralism to exploit prevailing ecological conditions and suitability to the socio-cultural structures of the society. Nevertheless internal and external pressures from both climate and non-climate factors are forcing pastoralist communities to transition into different livelihood systems. For example, Afar pastoralists in northern Ethiopia have moved into cultivation and non-pastoral livelihoods without detaching from the pastoral way of life [24]. Similarly, pastoralists in East Africa are increasingly pursuing non-pastoral income and livelihood strategies to buffer against systemic shocks, mainly climate perturbations manifested in terms of increased temperatures and frequency/intensity of droughts [25] [26]. The farming communities in the study area have always made efforts to adapt to a variable climate, often inadequately and on a limited basis. But there is a tremendous vulnerability to climate change which has become a growing concern [27]. Compounded with vulnerability from non-climatic forces such as conflicts and political instability, they now face increased pressure from increasingly unpredictable weather and associated climate-induced shocks often beyond the range of experiences [28]. In particular, where the succession of extreme events such as drought increases in frequency and severity [28] [29], adequate recovery periods are likely to be rarer and future adaptive capacity may be substantially eroded.

There is a growing global interest in the role of rain-fed smallholder agriculture in ensuring food security, reduced poverty and rural development in Africa in the face of environmental changes. Climate change manifesting itself in terms of below average extremely low seasonal rainfalls leading to severe droughts and high temperature are key features. These changes raise the demand for more

livestock water to substitute for loss due to dehydration and put increased evaporative demand on plants. There is deep concern about how this sector is positioned to withstand increasingly frequent and intense perturbations in the natural climate coupled with other external pressures from demographic changes (e.g. increased populations) and socio-economic changes associated with globalisation (e.g. weakening collective NRM regimes because of growing individualism) [9] [29] [30]. The concern underpins the proposition that adaptation and development have vital links implying climate change can impede the ability to achieve development whilst development can reduce vulnerability to climate change [31]. Thus, underdevelopment of this vital economic sector is associated with weak adaptive capacity which makes addressing vulnerability and adaptation deficit more challenging.

In Ethiopia, the agriculture sector enjoys strong political will and policy support to enhance its performance, address food insecurity, reduce vulnerability and adapt to climate change and its impacts. However, agricultural adaptation efforts often fail to significantly reduce vulnerability partly because of poor understanding of the local adaptive environment particularly with respect to available options and major barriers to adapt. Adaptation rather should be a continuous, progressive and iterative process [15] [32]. Current and future adaptation should build on past experiences due to increasing complexity of adaptation practices and processes. Therefore, assisting smallholders to successfully adapt to future climate change can be fostered through enhanced understanding of past and current adaptation that will inform future adaptation. This paper therefore aims to examine and enhance our understanding of how climatic change puts pressure on these agriculture-based vulnerable livelihood systems and associated responses to adapt.

The Conceptual Framework

The study employs a combined use of the Pressure-State-Response (PSR) model and Pelling's typological framework to enhance our understanding of how climatic stresses put pressure on agriculture-dependent livelihoods and how these stresses are responded to in the middle of complex human-nature interactions (**Figure 1**). The PSR framework provides a widely used and intuitively accessible model [22] for developing detailed accounts of climatic pressure and farming communities response through adaptation. The PSR theory assumes that prevailing social and economic scenarios trigger human responses that pressure the natural environment often leading to changes in its state which often have negative impacts on human society [33]. People then collectively act to address the pressures and impacts by either reducing the adverse effects after they happen or act proactively on the driving forces to minimize or prevent the environmental response causing harm. The framework thus enables us to examine and enhance our understanding of**:** 1) how climatic stress puts pressure on pastoral/agropastoral systems, and 2) how smallholders respond to protect local agriculture and livelihoods.

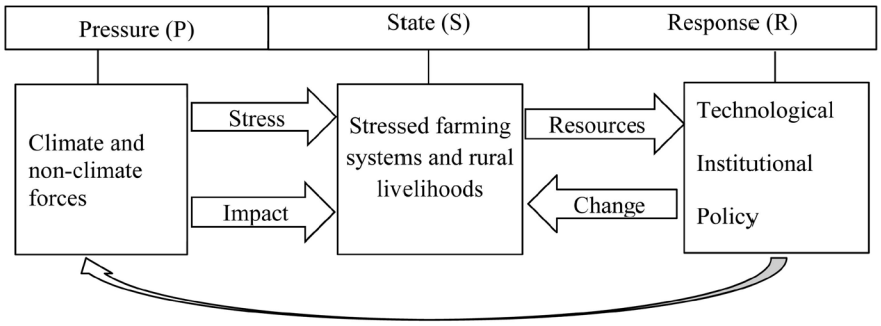

Figure 1. A conceptual framework used to analyze adaptation to climate change in the study area.

In relation to the PSR framework, pressure can be any climatic or non-climatic factor that brings economic, social or environmental stress, harm or distress that alters the state of an adaptation unit [34]. In this study, climate variability and change among other environmental changes will be focused on and examined as stress factors though both climatic and non-climatic forces operate simultaneously. State refers to the status or condition of the adaptation unit, often a farm or a farming system, as a result of exposure to climatic or interacting non-climatic pressures that result in stresses and eventually impact. These include enabling or restricting factors at play in which response (adaptation) must occur to pressures. Response is any adaptation measure or action taken by actors to reduce or avoid the potential negative impacts from pressures on the far left side of the framework that affect the state of a given adaptation unit vulnerable to the stress factor(s). Responses to adapt require resources and could involve technological, institutional and/or policy measures to buffer against change of state of a given unit or bring positive change. Results are presented in relation to the framework, and discussed in following sections to address the abovementioned central questions of this paper.

The study also employed Pelling's [18] typological framework to analyse adaptation measures or strategies adopted by various actors in the study area. The framework provided a useful typology of adaptation based on its different features—vision or goal, phasing, degree of collaboration and origin of measures. Pelling [18] argued that depending on vision of adaptation responses can be considered as; 1) "Resilience" when measures strive to maintain systemic function and the *status quo* or bring marginal change(s) in a changing climate by which the "normal" state of the adaptation unit continues to function in the context of constraining factors, without explicitly challenging these, 2) "Transitional" when measures push against the *status quo* by suggesting new ways of doing things are necessary as a result of experienced or predicted change which therefore aims to bring incremental change within established regime and system of concern, and 3) "Transformational" when adaptation measures allow the scale of change required to bring major, non-marginal change disturbing the relationship between society and environment. This type of adaptation therefore envisions reconfiguring the structure of development to enable adaptation which

necessitates establishing completely new ways of doing things, robust institutions, practices, processes and forms of governance.

2. Methods

2.1. The Study Area

Location

The study area, Borana pastoral and agropastoral systems, is part of the Borana administrative zone situated in Oromiya Regional State, southern Ethiopia (Figure 2). Geographically, the study area lies in the tropics region, and is located between 37 and 41 degrees E, and 3 and 7 degrees N. The study targeted lowland districts of the Borana Plateau which constitute the heartland of the Borana pastoral and agropastoral systems [35] subject to recurrent climate-induced stresses. The Borana people are an ethnic group of pastoralists inhabiting the arid and semi-arid areas of southern Ethiopia and the northern part of neighbouring Kenya. Strong social networks and bonds are important features of their collective lifestyle including natural resource governance. Traditional institutions are important entities in managing access to common property resources necessary to support the extensive livestock production system [5] [36] and collectively respond to climate perturbations.

Climate

The study area exhibits four seasons crucial to the rainfed agriculture which shaped the transhumant lifestyle of the rural community. These are *Bona* the long dry spell from December to February, *Gana* the long rainy period from March to May, *Adolessa* the short dry spell from June to August and *Hagaya* the short rainy period from September to November. Rainfall has bimodal pattern of

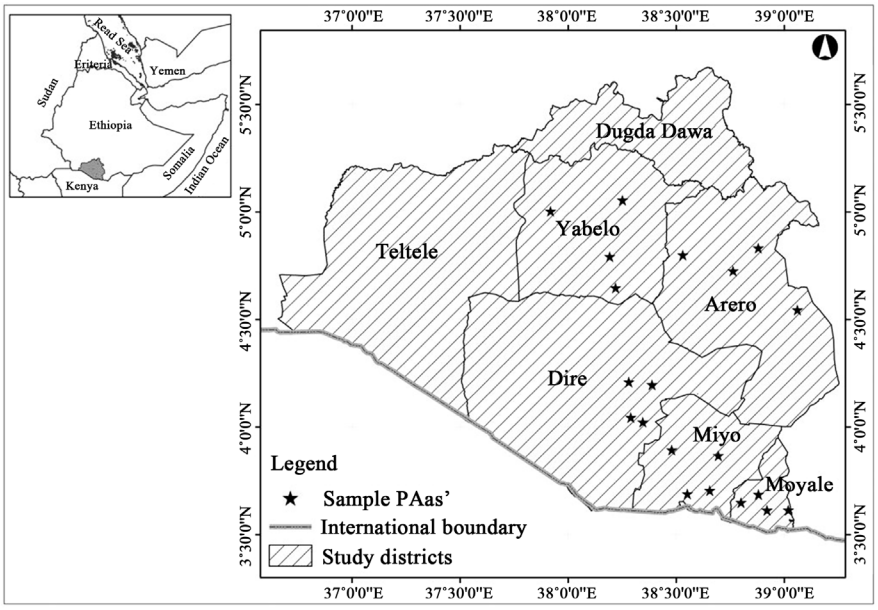

Figure 2. Location map of the study area, southern Ethiopia (Note: PA refers to pastoral or agropastoral association which is the lowest administrative unit).

distribution with increasing unpredictability which necessitates adaptation and risk management. With a total average of about 700 mm, the study area receives an average annual rainfall ranging from 350 mm around Wachile in Arero district to about 1100 mm in Moyale town in Moyale district on the border with neighbouring Kenya. The area on average gets 86 rainy days throughout the year distributed through the two rainy seasons.

Though long term local climate data are not available to accurately examine potential changes in climate, existing limited data show that the study area exhibits high level of climate variability which is typical feature of dryland climates. The climate in the study is largely variable in terms of rainfall and temperature (**Figure 3**). The seasonal rainfall demonstrated pronounced level of interseasonal and interannual variability which was locally perceived and identified to be major challenge for agricultural production in the area [11]. Variability in terms of amount with a declining trend often going into extreme lows below average and uneven distribution are climatic attributes felt by rural communities relying on seasonal rain for agricultural production. Particularly, the long rainy season exhibited a rapid decline since the end of 1980s until recently.

Air temperature in the study area has much less inter-seasonal and inter-annual variation as compared to rainfall which is similar phenomena to most of the sub-Saharan Africa [35]. Moreover, the air temperature deviation has not been felt by rural communities and was mentioned to be less important than fluctuations in rainfall. Higher temperatures during peak drought periods raises the demand for more livestock water to substitute for loss due to dehydration and puts increased evaporative demand on plants.

Farming systems

Farming systems of the Boran lowlands are complex and heterogeneous pre-dominantly characterized by semi-arid pastoral and agro-pastoral systems. Small-scale extensive livestock production, particularly transhumant pastoralism is the pillar of the economy, and the main source of food and income for rural households [37] [38]. The Borana zone has 1.6 million cattle, 1.2 million small ruminants, 0.1 million equines, 0.2 million camel and 0.2 million poultry with human population of 1.1 million having density of 24 persons per square kilometre [39].

The characterization of Boran pastoralists as 'livestock producers' is arguable because of poor profit and market-orientation of the traditional agriculture. Rather they are classified as 'livestock keepers' because livestock production is

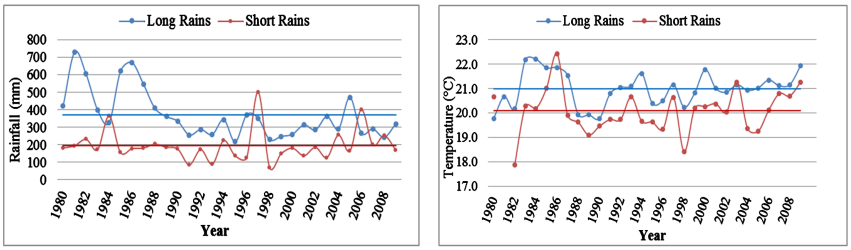

Figure 3. Mean seasonal rainfall and temperature during 1980-2009 in the study area.

seen more as a way of life than a western world style profit oriented agribusiness. Poor access to agricultural input and output market is an important development challenge the rural community face. In the face of climate driven pervasive socio-economic and ecological changes, expanding drought-tolerant maize cultivation, increasingly popular camel and goat husbandry, and shrinking livestock holding per household characterize the dynamics in the farming system [40]. With multiple drivers of change, these dynamic dryland farming systems face rapid evolution of social, economic and biophysical features.

The focus group discussion showed that recurrent drought and resource-based conflicts are the two most critical climate-induced shocks and stressors smallholders face in the study area. Livestock and crop sales make the two most important livelihood activities (Table 1). It is therefore imperative that smallholders pay most attention to respond to recurrent drought conditions perceived as indicators of recent climate change. The smallholders perceive the recurrent droughts as evidence of changes in local climatic conditions which are harming the performance of rainfed agriculture upon which their livelihood depends (Table 1). This view is consistent with a parallel study by Debela *et al.* [11] whereby survey participants identified decreasing rainfall often with extremes to be key feature of changing climate which negatively affected local livelihoods.

2.2. Data Collection and Analysis

The study employed farm household surveys, focus group discussions, expert consultations and secondary data collation to obtain both quantitative and qualitative data. The farm household survey employed a multi-stage sampling technique involving selection of five districts and twenty pastoral/agropastoral associations. Five districts were purposely selected from the ten districts of the Borana lowlands which represent diverse agro-climates and heterogeneous farming systems shaping adaptive responses. Within each district farm households were stratified into pastoral and agropastoral production systems (strata) depending on the predominant production system leading to stratification into pastoral (livestock production) and agropastoral (crop and livestock production) associations or villages. The strata are aligned with pastoral/agropastoral associations which are the lowest administrative units after district.

From each production system or association (stratum), two associations were randomly selected whereby each stratum was again represented by an equal size

Table 1. Ranking of identified major shocks (stressors) and livelihood activities among Borana smallholders (Source: Focus Group Discussion, 2012).

Shocks (Stressors)	Rank	Livelihood activities
Recurrent drought	1	Livestock sell
Resource-based conflict	2	Crop sales
Bush encroachment	3	Off-farm employment
Livestock disease	4	Livestock products
Rangeland degradation	5	Petty trade

of 24 randomly selected farm households. The sampling yielded a total sample size of 480 sampling units with households represented by their respective heads (all male due to local tradition) in the interview. The household interview was held using a semi-structured questionnaire pretested before the formal interview. The survey data, comprising farm and household attributes, was fed into, managed and analysed using an SPSS (Statistical Package for Social Scientists) program [41]. Prior to the interviews, participants' written consent was obtained and ethical consideration for human research was made.

In addition to the household survey, a total of twenty focus group discussions were held representing equally ten pastoral and agropastoral production systems. In each of these focus groups, 6 to 10 farming community members with significant farming experience in the area were randomly selected to take part in the open discussion using a checklist. The focus groups reviewed and reflected on major farming system constraints, adaptation options and barriers identified in the farm household survey. The data obtained through focus group discussions on insights and experiences about adaptation options and their characteristics, and barriers were then summarized and described qualitatively to complement the quantitative data obtained from household interviews. In addition, informal expert consultations and discussions were made at zonal and district levels of agricultural development offices to get broader picture of agricultural adaptation in the study area. The data from consultations and supplement the data obtained from household survey and focus group discussions.

In this study, we triangulate between qualitative and quantitative data obtained from different social research data collection methods—individual and household interviews, focus group discussions and expert consultations. Triangulating information from different data collection methods allows for the validation and explanation of options and barriers to adapt, and development of a typology of adaptation responses. The classification assumes that, in the extreme, these strategies are different in terms of their adaptation vision or goal, timing of adaptation in relation to a risk to manifest itself into a hazard (phasing), degree of collaboration among actors and its immediate impact on the adaptation unit. The task was developed based on a framework of adaptation typology by Pelling [18] which provides a sound analytical framework to analyse and understand key characteristics of adaptation options.

3. Results and Discussion

3.1. Adaptation Options

The study has shown that smallholders in the Borana farming systems adopted a wide range of adaptation measures and tried to remain flexible to overcome what they perceived as changing climatic conditions. Supplementary feeding, off-farm employment and herd mobility to remote areas are the three most commonly used adaptive strategies smallholders and their communities pursued as responses to climate change (**Figure 4**). Declining seasonal rainfall with often

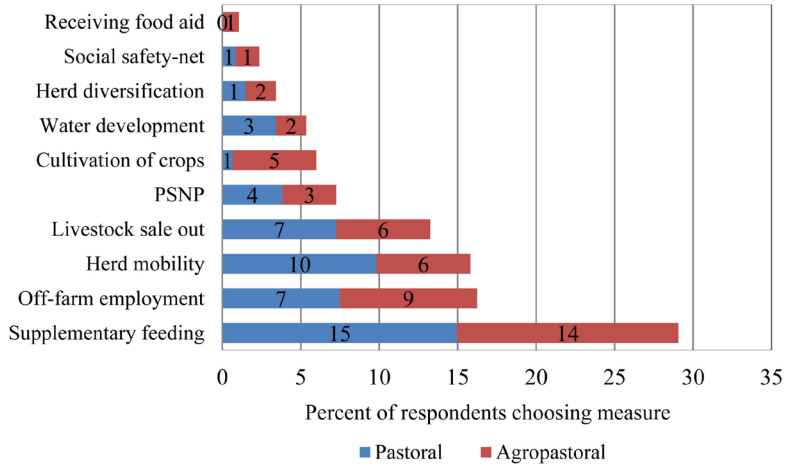

Figure 4. Percentage of pastoral (n = 240) and agropastoral (n = 240) household interviewees identifying the most common adaptive measures adopted across production systems. (PSNP = Productive Safety Net Programs.)

below average extreme lows, its uneven seasonal distribution and increased temperature are key features of perceived climate change they responded to. Particularly, increasingly frequent as well as intense drought conditions continue resulting in scarcity of pasture and water resources challenging the sustainability of traditional pastoralism. Broadly, speaking, amid constraining barriers, smallholders responded to climate change mainly through adjustment of farming practices and shifting into non-pastoral livelihoods.

While adaptation options stated as most commonly used measures were closely similar across pastoral and agropastoral systems, there are few differences. More households are engaged in cultivation of food crops (e.g. maize and sorghum) and off-farm employment (e.g. petty trade) in predominantly agropastoral systems as compared to pastoral ones (**Figure 4**). Agropastoral households obtain more percentage of non-farm income and less of farm income as compared to pastoral households (**Table 2**). Whereas herd mobility to remote areas and supplementary feeding of animals are identified as the most commonly used option by more households in pastoral systems than agropastoral counterparts. The variation can be attributed to the fact that livestock rearing is a primary source of livelihood which makes an important source of income in pastoral systems. Subsequently, average livestock holding is relatively larger (**Table 2**) among pastoral households than their agropastoral counterparts.

Adaptation options taken up were mostly reactive rather than proactive (**Table 3**) implying that adaptation in the study area was a response to pressures. This, therefore, confirms that the PSR model is a suitable framework for analysing adaptation to climate change in the study area. While most of the measures target to deal with current pressures from climate change, few, such as moving from cattle-only herd to mixed-herd (with camel and goats added), water development (such as well and pond maintenance and construction), and cultivation

Table 2. Key household and farm characteristics of interviewed households in the study area.

Characteristics	Production system		Overall mean
	Pastoral	Agropastoral	
Age of household head (years)	48.3	51.5	49.9
Household size (number)	7.6	7.3	7.4
Farming experience (years)	21.6	24.1	22.8
Education level (school years)	1.2	1.0	1.1
Livestock holding (TLU*)	9.8	6.3	8.1
Private farm size (ha)	0.9	1.9	1.5
Annual farm income ($US)	500.4	423.4	461.9
Annual non-farm income ($US)	229.5	209.8	219.7
Perception of climate change (%)	98.0	96.0	97.0

*TLU = Tropical Livestock Unit.

Table 3. Summary and classification of adaptation options identified by the Borana pastoralists and agropastoralists in interviews and focus group discussions.

Adaptation option	Adaptation vision	Phasing	*Degree of collaboration	Function	Origin or Source
Livestock supplementary feeding	Resilience	Proactive/Reactive	Individual	Pools risk across space/time	Indigenous/Introduced
Herd mobility to remote areas	Resilience	Proactive/Reactive	Individual/Collective	Pools risks across space/time	Indigenous
Herd diversification	Transitional	Proactive	Individual	Spreads risk across animal groups	Introduced/Indigenous
Livestock sell out (destocking)	Resilience/ Transitional	Reactive	Individual	Transfers risk across food chains	Indigenous/Introduced
Cultivation of crops	Transitional	Proactive	Individual	Spreads risk across farm enterprises	Indigenous
Water point maintenance and development	Resilience/ Transitional	Proactive/ Reactive	Collective	Pools risk across space/time	Indigenous/Introduced
Get support from social safety-net	Resilience	Reactive	Collective	Pools risk across households	Indigenous
Take part in Productive Safety Net Program	Resilience	Reactive	Individual/ Collective	Pools risk across livelihood options	Introduced
Off-farm employment	Resilience	Reactive	Individual	Spreads risk across livelihood options	Indigenous
Receive food aid from NGOs or government	Resilience	Reactive	Individual/ Collective	Reduces risk across households	Introduced

*Individual refers to Individual farm households whereas Collective refers to group of households or communities.

of food crops (mainly maize and sorghum) envisage proactive adaptation to anticipated climate change as they get implemented before the next hazard manifests itself.

We also found that locally adopted options featured two important features: 1) inherently resilience or transitional modes of adaptation, and 2) reliance on indigenous knowledge and local resources (**Table 3**). Adaptation options adopted in the study area reflect a strong preference for resilience or transitional within existing institutional and cultural arrangements. Most of the adaptation options identified among the Borana envisage the goal of maintaining stability or marginal changes that utilise elasticity in farming systems and local livelihoods (**Table 3**). In other words, buffering or coping against shocks, which represents often autonomous resilience approach to adaptation, is a favourable response to moderate negative effects of climate variability which is an essential element of dealing with climate change among resource poor farmers [23]. For example, the use of supplementary feed and increased herd mobility to remote areas are means by which livestock can be taken through the dry spells when drought-induced feed shortage is critical and would result in massive die-offs if no action is taken [29] [42]. The approach is no more than an attempt to maintain the status quo and allow unsustainable systems to persist. In other words, it keeps the system on its pre-existing trajectory through maintaining the essence and integrity of the system [43] which underpins the elasticity of the system.

In view of current level of vulnerability, it appears that a predominantly resilience approach to adaptation involves low degree of intervention and does little to adequately reduce vulnerability to current and anticipated climate change and ensure co-benefit of improving rural livelihoods. Further to that, it possibly undermines long term adaptation suggesting temporal trade-off with short term resilience approaches, and increases the risk of maladaptation as these resilience measures are often autonomous and ad hoc. The strong preference for resilience can be partly attributed to the weak adaptive capacity of households and communities subject to recurrent climate stresses that eroded resources available for future adaptation. Studies noted that the high costs and risks (economic, social, cultural, etc.) associated with transformative actions tend to make it difficult for resource-poor farmers to pursue transformational adaptation [44] [45]. But note that transformational adaptation poses great risks as well as gains.

On the other hand, few adaptation options such as cultivation of moisture-stress tolerant food crops (such as maize and sorghum) and herd diversification with addition of drought-tolerant species (such as goats and camels), adopted in turn would lead to transitional goals resulting in incremental changes through minimal reconfiguration of the system. Such measures go beyond an attempt to maintain functional persistence, and involve moderate reform, restructuring of activities and incumbent livelihood systems [18] [44]. Combining cultivation and herd diversification into existing livelihood systems represents an incremental adaptation envisaging transitional approaches. Cultivation, in particular, is expanding rapidly though there exists little evidence that cultivation of small and fragmented plots enabled food self-sufficiency among the Borana [26] [46]. Addition of cultivation as a risk spreading mechanism is often a desperate measure and low-external input production system. The extension

support system that potentially increases production and productivity is weak and annexation of plots for private use from the communal land is against the traditional tenure system and culturally discouraged.

Moving into diversified livelihood systems however has become a necessity and not a free choice to moderate harm from both climatic and non-climatic stresses. Diversification of livelihood activities includes the shift into non-farm employment areas such as traditional mining and charcoal production. Though such practices are temporary measures taken to overcome critical drought impacts such as food insecurity, diversification of livelihoods should be an adaptation strategy that needs to be explored further as a long term response to anticipated climate-induced risk. It is difficult to accurately decouple the effects of climate change and non-climatic factors (e.g. population pressure) in the Borana but the effects of climatic stresses such as droughts is perceived to be far more significant for participants in triggering adaptive action as indicated on the ranking of stressors in **Table 1**.

On the other hand, climate change adaptation measures identified in the Borana lowlands primarily draw on indigenous knowledge and local resources. Our study indicates that indigenous measures play key role in responding to climate change especially as external support for local adaptation is limited. Measures such as herd mobility, social safety-net, cultivation and sale of livestock (destocking) are key examples (**Table 3**). In particular, herd mobility to remote regions is a complex adaptation activity which pools local knowledge and collective resources to spread risk across space and time with the help of indigenous resource governing institutions. This highlights that pastoral adaptation to climate change is strategically embedded into indigenous social and resource governing structures which indicates the importance of social capital and citizen participation [19] [47]. Despite government's policy move to privatize land contrary to the traditional tenure, the traditional laws and indigenous institutions of the Borana primarily govern access to collective water and pasture resources that support adaptation [5] [29]. However, conflicting interests over divergent land tenure systems between state and indigenous institutions remain to hinder the role of local institutions in supporting collective action to manage natural resources and adapt.

While adaptation is intended to reduce or avoid vulnerability, the study indicates that some measures tend to result in unintended outcomes and increase vulnerability across time and/or space. Given the spatial and temporal complexity of climate change problems and responses, adaptive actions that bring successful results in one instance may increase vulnerability elsewhere and/or at another time [20] [32]. Current coping or resilience actions may unintentionally affect the future adaptive capacity of individuals and communities resulting in maladaptation. Maladaptation is often attributed to path-dependency and adaptive measures that are autonomous and ad hoc which often raises the risk of maladaptation [20]. In our study, it is possible that the practice of moving herd onto congested remote areas during drought periods may provide relief in the

short term but may be maladaptive in the medium to long terms. Participants emphasised that concentration of mobile herds in a given remote fall back region during severe droughts caused resource overexploitation. The high stocking density results in degradation of resources which may be acceptable adaptation option in the short-term but may increase vulnerability to future droughts as these fall back areas become degraded undermining future local adaptive capacity. Our study shows that there is an urgent need for policy makers to consider maladaptation and subsequent negative externalities that may be the outcome of the current resilient approach to climate change adaptation in the Borana.

Although traditional pastoralism has been a preferred and major livelihood source, the study has shown that smallholders have demonstrated the tendency to increasingly get involved in non-pastoral livelihoods as means of livelihood diversification. For example, many pastoralists who previously specialized in livestock keeping are now combining cultivation of crops into agricultural practice which is also the case for many African dryland systems [25] [48]. But cultivation of crops involves annexation of the communal land as there is no so called private land which also competes with livestock production causing fragmentation and reduction of the grazing land. This transition into more diversified production systems allows livelihood risk to be distributed over a number of enterprises. The transition into agropastoralism marks the growing need to spread risk through diversifying household income and livelihood sources in the face of rapid socioeconomic, biophysical and policy changes. Moreover, pastoralists in the study area were increasingly involved in non-farm income generating activities such as off-farm employment and Productive Safety Net Programs, joint initiative involving the Ethiopian Government, World Food Program, the World Bank and development partners. Consistent with similar findings from other pastoral systems across East Africa, pastoralists in the Borana who practiced pastoralism for generations while increasingly involved in non-farm income generating activities are not completely detaching themselves from the culturally preferred transhumant lifestyle.

3.2. Barriers to Adaptation

The majority (87%) of the farmers felt that barriers to adapt to climate change exist. The other smallholders (13%) consider that there is no compelling reason that prevents adaptation. The impediments cited by the majority of farmers are extremely diverse, including natural, economic, social and institutional factors. Adaptation barriers were in descending order of the percentages of respondents that identified each barrier; limited finance, expertise and weather/climate information, shortage of labour and land, poor government support, access to market and irrigation and finally conflict among neighbours (**Figure 5**). The three key barriers identified (by approximately half of the participants, **Figure 5**) to limit adaptive capacity and successful adaptation were limited finance, expertise and access to weather/climate information. These barriers in general either stop, delay or divert the adaptation strategies and processes shown in **Figure 4**.

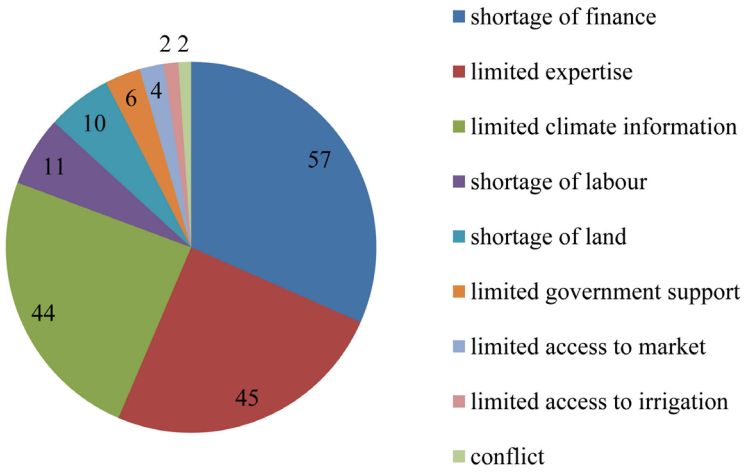

Figure 5. Percentage of respondents (out of 480) that mentioned specific adaptation barriers as key challenge(s) for their household.

A range of socio-cultural, institutional, financial, technological and natural factors play restricting roles that may limit adaptive capacity, prescribe adaptation pathways and may lead to undesired outcomes [49] [50]. The range of barriers to adaptation in Borana is no different, and that partly explains why the Borana smallholders envisage resilience rather than transformational adaptation. The coexistence and interaction of different types of barriers brings additive negative effects and further erodes the ability to adapt in the future. Among the different group of barriers, financial and institutional barriers were identified by the Borana as significant and interrelated challenges to adapt confounding the effects of one another (**Figure 6**).

Participants underlined that there is limited government support to facilitate local adaptation. For instance, there have been divergent views between state and indigenous institutions on land tenure systems. The state promotes the privatization of user rights, a stance which contravenes the traditional rules of collective resource governance in the study area. The divergence has weakened the capacity of indigenous resource governing institutions that regulate access to resources which have traditionally supported collective action to adapt at the local level [47]. Jones and Boyd [50] and Upton [51] argue that institutional factors play important roles in prescribing options and shaping adaptation pathways at different scales. In a related observation, Watson [36] reported that, in Borana, the involvement of state and non-state agencies in water resource management through a top-down interventionist approach is seen as interfering rather than helpful to the local adaptation process. In this view, there has been a biased approach towards the development of modern agriculture, a negative attitude towards pastoralism and development policies which have focused on the role of indigenous culture have been deliberately overlooked or ignored [24] [29].

In general, the challenge now for policy is to overcome these barriers, and successfully integrate local needs and priorities with external interventions in

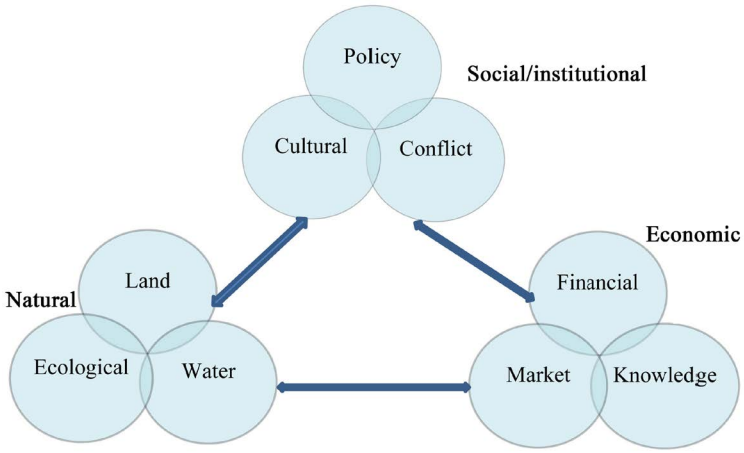

Figure 6. Barriers and limits to adaptation and their inter relationships.

both adaptation and development planning. Particularly, abovementioned barriers are putting significant limits to adaptation leading to adaptation deficits in the area which necessitate interventions that appropriately target and address each barrier. Improving access to credit services to overcome financial barriers, provision of technical support to overcome knowledge gap and putting in place downscaled climate information services can be important areas of immediate focus to enhance local adaptive capacity. In this regard, governments, the private sector, NGOs and community organizations have different roles to play in addressing these barriers, improving adaptive capacity, narrowing adaptation deficit and reducing vulnerability to climate induced risks.

4. Conclusions

Smallholders in the Borana lowlands, at least in the foreseeable future, will continue to depend on rainfed agriculture as a primary source of livelihood for which they face considerable uncertainty due to prevalent climate perturbations and eroded ability to adapt. The dependency presents the need to urgently and successfully deal with multiple internal and external pressures to significantly reduce vulnerability to changing climate manifesting itself through increased temperature and more frequent/intense droughts already felt by participants. In this study, we explored smallholder climate change adaptation options and barriers, using combination of PSR model and Pelling's [18] typological framework of adaptation (**Table 3**). The study found that for the pastoralists of the Borana: 1) climate change adaptation is intrinsically resilient or transitional, 2) indigenous knowledge and resources play a crucial role in adaptation, and 3) there exist a wide range of barriers to adaptation and these barriers are limiting adaptive capacity and shape routes for adaptation.

Smallholders generally responded to climatic stresses through adaptation by adjusting farming practices and shifting into non-pastoral livelihoods. Adaptation envisioned resilience and transitional goals while transformational approaches that bring deeper changes that meaningfully address vulnerability are

virtually non-existent. They preferred to emphasize reducing or avoiding system disruptions, and ensuring continuity of pre-existing production and livelihood systems. Such an approach potentially undermines long term adaptation by diverting efforts and resources needed for future adaptation. Adaptation also featured transitional approach embracing incremental modes of adaptation resulting in minor, non-major changes which could be attributed to limited adaptive capacity. Despite efforts to adapt, there is little or no evidence that adaptation significantly contributed to vulnerability reduction and livelihood improvement. This suggests the need to change course and transform the current coping capacity of smallholders into longer term sustainable adaptive capacity and integrate adaptation into development planning. There were also experiences where adaptive measures implemented in one location were likely to increase vulnerability in another resulting in maladaptation underlining the importance of considering to proactively addressing risk of maladaptation in future adaptation efforts.

Our study indicates that vulnerabilities of smallholder agriculture and livelihoods in Borana are sizeable. Adaptation approaches that envisage resilience and transitional approaches do not seem to robustly address the vulnerability challenge that uncertain climate poses. The focus on these two approaches also undermines long term adaptation and sustainable development in the study area. Detrimental impacts of recurrent and severe droughts witnessed in recent decades suggest that the Borana may not be able to continue with the *status quo* in highly variable environment to achieve significant vulnerability reduction and livelihood improvement goals. Along with shrinking recovery periods, the complex and interacting set of barriers are responsible for already low and eroding adaptive capacity. In the face of climate uncertainty and weak adaptive capacity of smallholders, responses can explore low-cost and no-regret adaptation options and pathways that can potentially deal with wide range of future climate scenarios and associated climate-induced risk in the medium to long terms.

Adaptive responses in agriculture should encourage major and purposeful proactive actions that successfully respond to potential impacts of climate change while ensuring co-benefit of livelihood improvement. Beyond reducing vulnerability and risk, adaptation should also seek opportunities and build the future adaptive capacity of actors. Climate change adaptation responses must be integrated into policies and development programs to actively promote local livelihoods and help reduce vulnerability addressing the shortcomings of conventional adaptation and development pathways. Further research is required to identify innovative adaptation pathways that promote locally relevant transformational change to significantly reduce vulnerability and improve livelihoods while upholding the needs and priorities of the local community.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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