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Article

Climate Variability and Household Adaptation Strategies in Southern Ethiopia

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Abstract: This paper examines the determinants and implied economic impacts of climate change adaptation strategies in the context of traditional pastoralism. It is based on econometric analysis of survey data generated from household level interviews in southern Ethiopian rangelands. Pastoralists' perception of climate change in the region is found to be very consistent with the actually recorded trends of increased temperature and the evident secular declines in precipitation. Not only long-term declines, trends in the region's rainfall also appear to have taken a shift towards the direction of more unpredictability. Pastoralist adaptation response strategies broadly involve adjustments in pastoral practices and shifts to non-pastoral livelihoods. Results of the estimated models confirm that pastoral mobility is still quite essential in the present context of climate-induced household vulnerabilities. Increased mobility and diversification of pastoral herd portfolios in favor of a drought-tolerant species (camel) are found to be positively associated with pastoral household net income. A policy stance that ignores the detrimental impacts of the currently pervasive private rangeland enclosures or intends to hasten pastoralist sedentarization in the area is simply untenable in the present context of climate-induced risks and pastoral livelihood vulnerability.

Keywords: climate change; pastoralism; adaptation strategies; Borana; Ethiopia

JEL Classification: O13, Q54, Z13

1. Introduction

This paper explores the determinants and implied economic impacts of climate change adaptation strategies in the context of traditional pastoralism. Pastoralism is a source of livelihoods for millions of inhabitants in developing countries. Pastoral societies inhabit arid and semi-arid environments where climate change is supposed to increase the likelihood of a rise in the frequency and intensity of droughts and floods. The level and nature of their exposure is often believed to be different from those communities living in mixed agricultural systems, which often remain the central focus and policy priority areas of national governments. Pastoralist communities are generally expected to be among the most affected groups, and hence will need access to resources and services that help them cope with impending catastrophic shocks, protect their livelihood assets and increase their resilience [1]. The adverse impact of climate change is thought to be more severe in developing countries because of their heavy dependence on natural resources and constrained capacity to adapt to climate-induced shifts. Climate variability and change is often recognized as a major threatening factor to food security in areas of the world that are largely dependent on rain-fed agricultural production systems [2]. The poorest and marginalized communities are especially the most vulnerable group within these countries due to their very limited ability to embrace adaptive choices [3]. Countries in the Horn of Africa are often considered to be among the most vulnerable, but are also considered to be the least prepared for adverse global environmental change in the word [4]. In the Horn region, Ethiopia has been typically considered as a home of famine, especially beginning from the last three decades of the 20th century, principally as a result of increasing vulnerability to extreme events that relate to changing climatic conditions. The pastoralist peoples, inhibiting the low land areas of the country, with the harsh and precarious conditions of limited livelihood choices in their settings, have particularly become increasingly vulnerable to persistent poverty in recent decades partly due to their recurrent exposure to the adverse effects of climate variability and change.

Climate change is a key issue in any development debate seriously concerned with the future of pastoralism. The likely impact of predicted weather extremes even raises the question of the sustainability of pastoralism as a viable livelihood system. Brooks [5] underlines that views on the impact of climate change on pastoralism are quite simplistic and polarized. The extreme of these is represented by the pessimistic scenario of the collapse of fragile pastoral livelihood systems and consequent massive outmigration of the destitute. Increased temperature and more critical drought conditions would likely erode the natural capital (resource) base of sustainable pastoralism which will be manifested though scarcity of pasture and water resources. This resource scarcity, it is argued, in addition to massive pastoral poverty, is considered to trigger severe resource competition and violent conflicts among pastoralist communities. In contrast, the more general notion is based on the long recognized feature of pastoralism as a system of adaptations. Pastoralists are thought to be natural adaptors provided that they are free from negative external interference and are able to inhabit an enabling policy environment of suitable support services [6–8]. Pastoralist response in this case is based on an adoption of a variety of strategies. Nevertheless, despite this feature of pastoralism as a system of human creative adaptations to hostile climate factors of dryland ecosystems, pastoral livelihoods have rather become increasingly vulnerable to climate change impacts due to the eroded adaptive capacities of pastoralist communities as a result of prolonged marginalization and harmful

external interventions, which are often generally exhibited by superficially imposed dissonant institutions, environmentally unsound programme implementations and bad governance.

Traditional pastoralism typically represents a resilient and unique system of adaptations in a dynamic process of unpredictable climatic variability and continuous human interactions with the natural environment in dryland ecosystems. Pastoral adaptations and climate-induced innovative coping mechanisms are strategically embedded in the indigenous social structures and resource management value systems [1]. However, the case of global climate change, expressed in terms of increased temperature and shifts in patterns of precipitation, is a new challenge to the world of pastoralism. The possible negative welfare effect of global climate change is an added dimension to the already prevailing crisis in the pastoral livelihood system, which is substantially driven by non-climatic factors of internal and external pressures of change such as population growth, bad governance and shrinking rangeland areas lost to competing activities [9–12]. Therefore, the impact of climate change and variability on African pastoral systems could be severe because of the already prevailing exposure of being practiced under marginal environments of considerable water stress [13]. The scale of climate change impacts may differ across regions, but it is quite crucial for research to focus on these fragile dryland environments in order to inform sound policy decisions.

Assessing the economic impacts of changing climatic conditions and their interactions with other driving forces of livelihoods vulnerability has remained a relatively neglected area of research in the context of pastoralist systems [14]. The burgeoning literature on the assessment of the economic impact of climate change in agriculture has almost exclusively focused on crop agriculture and mixed farming systems [15–18]. Nevertheless, the issue of adverse long-term effects and persistent poverty implications of extreme weather shocks and associated multiple drivers has been a subject of recent investigation in our study area [9,19]. Also, Angassa and Oba [20] point to external interventions and induced adaptation strategies, which are indicated to have triggered scarcities by undermining the efficacy of traditional strategies of natural resource management and patterns of land use, as significant drivers of vulnerability to catastrophic assets shocks during drought years. However, there is a need for more systematic inquiry into the nature and economic impacts of adaptation practices, the challenges of local adaptive responses, and long-term welfare implications of specific adaptation options in the context of traditional pastoralism. In addition to individual adaptation options ascertained at household level, there are several public measures and scattered efforts that can be identified in the context of the need to enhance pastoralist adaptive capacity to climate change. Not all individual adaptation measures to climate variability and public actions in pastoral areas are constructive and sustainable. Some can be destructive to the extent that they may increase pastoralist vulnerability. Therefore, a critical and systematic appraisal of current individual adaptive behavior and public measures in pastoral areas is essentially justifiable in view of the need to design policies and selectively promote innovative practices that can enhance pastoralist adaptive capacities. The focus of this paper is on the empirical analysis of individual household adaptation behavior and the implied impacts of embraced adaptation measures on household income in southern Ethiopian rangelands.

The rest of this paper is organized as follows. The next section introduces the study area and data sources. Section 3 presents the extent of climate variability and pastoralist perception about long-term climate change in the Borana pastoral area of southern Ethiopia. Section 4 provides a descriptive account of identified climate-induced pastoralist core adaptive strategies. Section 5 is devoted to

econometric analysis of the determinants and implications of selected adaptation strategies embraced by pastoral households in the study area. Concluding remarks are given in Section 6.

2. The Study Area and Source of Data

2.1. The Study Area

The study is based on primary data generated through a household survey undertaken in Borana pastoral area, southern Ethiopia. The Borana are one of the well-known East African pastoral groups who inhabit southern Ethiopia and northern Kenya. The Borana pastoralist grazing territory in Ethiopia accounts for about 9% of the country's total landmass [21]. The area is agro-ecologically comprised of arid and semi-arid ecological zones with bi-modal rainfall pattern of average range of 400–700 mm. The annual cycle of precipitation is comprised of the *ganna* main rainy season from mid-March to May and the short *Hagaya* rains of September to November. The arid and semi-arid agro-climatic characteristics of the Borana region rather clearly suggest the importance of pastoralism as the single most important livelihood source to the growing human population in the area [22]. Borana pastoralism is predominantly characterized by milk-dependent cattle herding. The Borana also keep small stock and camel. The household pastoral herds are divided into *warra* and *fora* herd units. The *warra* unit is comprised of milking cows and weak animals kept in semi-settled encampments with women, children, and the elderly. The *fora* splits are mobile herd units that migrate to remote territories with able male herders [22].

2.2. Source of Data

The primary data for this study were collected through household interviews, community level focused group discussions, key informant interviews, and field observations. The pastoral household interviews were conducted in selected sites of the Borana pastoral area using standard verbatim and tabular questionnaires. Data on adaptation strategies were generated using closed questionnaires prepared based on extensive reference to the relevant literature and our experience of the survey area. A total of 281 households were randomly selected from six pastoral village sites of different grazing territories of the Borana rangelands for a weekly repeated-visit enumeration. The weekly repeated-visit enumeration was thought to be very essential in the context of the survey area in order to build trust and generate more accurate information. The process of site identification and selection was based on a key consideration of differences in range ecology with the aim to attain sufficient variations and representativeness in the selected sample. The selected six sites fall into the traditional Borana ecologically based classification. They fall in Malbe, Tula, Golbo, and Wayyama grazing territories. The six sites are Haraweyu, Dubuluk, Dokole, Dilo, Dhas, and Bokola site in Moyyale (see Appendix for location map of the study area and survey sites). Respondent households were randomly selected from established lists of surveyed village residents stratified based on wealth status differentials. The survey was conducted from mid-November to mid-December in 2012.

A unique recall interview technique was used to acquire information on the number of browsers (camels) added to pastoral herds over the years as an adjustment mechanism to climate-induced changes. The same technique was applied to generate data on climate-induced shock survival in terms

of experienced climatic risk exposure and sustained wealth losses. This distinctive recall technique especially relies on the Borana *Gada* calendar for generating longitudinal data in a cross-sectional pastoral household survey. The *Gada* system is a unique traditional system of Borana self-governance that has been there for many centuries and practically governs all the socio-political and economic life of Borana pastoralists. It is a traditional democratic system in which Borana leaders (*Abba Gadas*) are elected only for a single period of eight years (Gada period). The current Abba Gada (Borana leader) is, for example, Guyyo Gobba and his term is for the period of 2009–2017. The Borana pastoralists can fairly easily recall past events, including their age, by referring to *Gada* periods.

The secondary data used in this study are obtained from the Ethiopian Meteorological Service Agency, some unpublished records of the previously well-known but currently dismantled Southern Rangelands Development Unit (SORDU) and the dataset created by the Climate Prediction Centre of the National Oceanic and Atmospheric Association (NOAA) [23]. The Ethiopian Meteorological Service Agency currently operates five (Mega, Moyale, Negelle, Teltele, and Yabello) major stations in southern Ethiopian rangelands. We used the fairly regularly kept records of the older stations of Moyale, Negelle, and Yabello in our analysis because of the serious irregularity of recording and enormous missing data points of Mega and Teltele stations.

3. General Trends of Climate Variability in Borana Rangelands

The general trends and pastoralist perception of climate variability in the study area are broadly assessed in this section. This is based on the important consideration that pastoralist adaptation choice is largely influenced by changing climatic conditions and underlying local perceptions. We start with the presentation of the nature and extent of climate variability based on the last four decades' climatic data records of three major meteorological stations currently managed by the Ethiopian Meteorological Service Agency in the Borana region. Table 1 shows a summary of the average annual rate of change in temperature trends recorded at the Negelle station. Very regular and consistent temperature records are available only for Negelle, which is the oldest and fairly consistently managed station in the region. Other stations have significant periodic interruptions and irregular temperature records of considerably missing data points. Therefore, based on Negelle station temperature records, the average temperature in the area has significantly followed an upward trend with an average annual rate of increase of 0.3% in the last 50 years. With an estimated annual rate of increase of 0.35% in the 1980–2012 period, this long-term change in average temperature appears to have been more pronounced in the recent decades (these growth rate figures, estimated by using the semi-long transformation model, are statistically significant at a 1% level). A further general picture of long-term trend in the average temperature is additionally provided in Figure 1.

Table 1. Average annual rate of change in temperature trends in Borana area.

Station	Period	Average Annual Growth Rate (%) *
Negelle	1964–2012	0.3 $^{\Psi}$
	1980–2012	0.35 $^{\Psi}$

Note: ***** Estimated based on semi-log transformation model $LnYt = \beta_1 + \beta_2 T + \varepsilon_t$; $^{\Psi}$ coefficient is significant at 1%. Source: Calculated from Ethiopian Meteorological Service Agency records (unpublished raw data).

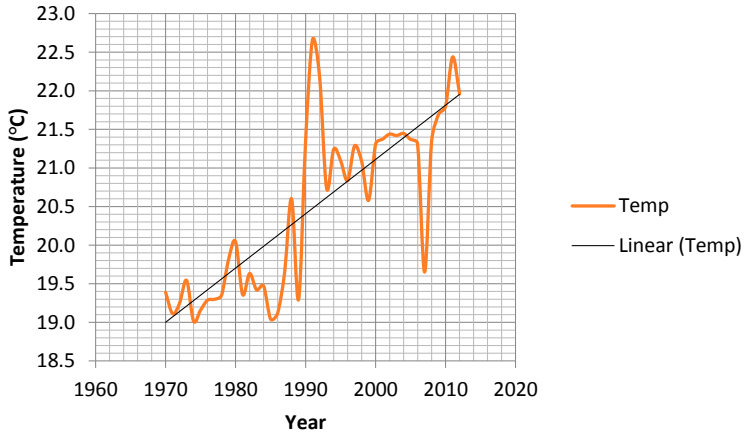

Figure 1. Negelle station long-term average annual temperature trends. Source: Created based on Ethiopian Meteorological Service Agency records (unpublished raw data).

Figure 2 shows the erratic nature of rainfall in the Borana rangelands. All the three stations keep both temperature and precipitation records. The rainfall records are more regular and consistent than the observed irregular and scanty temperature data points particularly observed at Moyale and Yabello stations. It can be seen, especially from trends in the Moyale and Negelle station records, that the area has on the average experienced a long-term declining trend in mean annual rainfall in the last several decades. The highest rainfall record for the last four decades was 1382 mm in 1972 which was recorded at Negelle station. It was a year of the second highest (913 mm) record for Yabello station (the highest record for Yabello station in the last 30 years was 986 mm in 2012). The second highest rainfall record was observed a decade later in the early 1980s, which was 1309 mm for Negelle station in 1981 and 1171 mm for Moyale in 1982. The 1972 recorded rainfall level appears to have never been attained at the three stations for the past 40 years. The Borana pastoral area in the last four decades has on the average experienced rather a long-term decline in rainfall with increasing incidence of periodic droughts. The lowest rainfall at the three stations was in 1999, which was 309, 359, and 372 mm for Moyale, Negelle, and Yabello, respectively. It was a period of the catastrophic drought that ravaged the entire Borana region at the turn of the century.

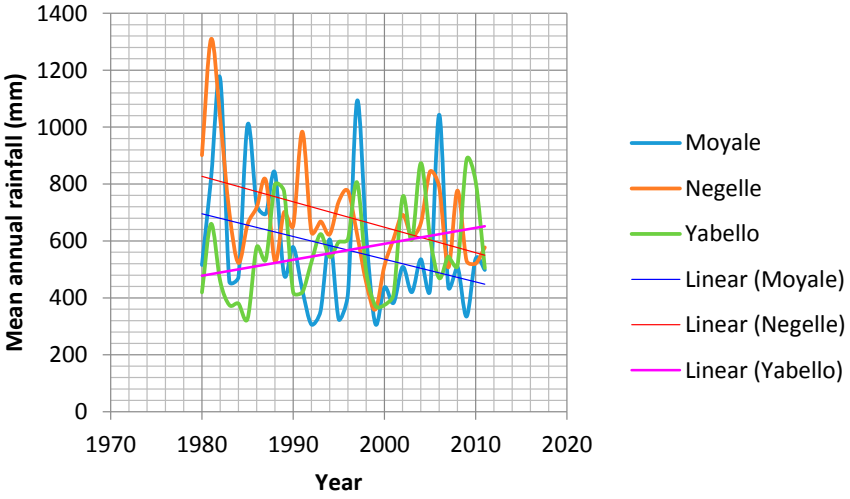

Figure 2. Trends in mean annual rainfall in three major stations. Source: Created based on Ethiopian Meteorological Service Agency records (unpublished raw data).

The trends and long-term seasonal variability of rainfall conditions in the area are summarized in Table 2. The region to a great extent appears to have experienced substantial declines in the main (*ganna*) season rainfall over the last three decades. However, despite the general long-term declines in the region's annual precipitations, the average rate of change for the short (*hagaya*) season was positive in the 2000 decade as compared to the previous periods. The average increase in *hagaya* rainfall has been particularly considerable to compensate for the average declines in the main season rainfalls at Yabello station. This apparently minor movement might have motivated a comment by one of our elder informants: "*hagaya* and *ganna* rains recently seemed to have moved in a direction of swapping their positions". However, the feeble apparent gains in *hagaya* rainfall have never been enough to sufficiently and reliably compensate for the considerable absolute declines in the *region's* main (*ganna*) rainfalls.

With the observed rate of increases in the estimated coefficients of variations (CV), the general trends in the region's average rainfalls rather appear to indicate a condition of shifts towards more unpredictability. Quite considerably, the variability of short (*hagaya*) rainfalls has generally increased over the decades, which indicates their expected conventional unpredictability. The level of this variability is apparently higher at Yabello and Moyale stations, which have exhibited considerable average gains in their short season precipitations (Table 2). Therefore, this monitorable general movement apparently signals that, in addition to the overall secular decline, the trends in annual rainfall in Borana rangelands might have taken a shift towards the direction of even more unpredictability. Table 3 indicates that the ratio of short (*hagaya)* rainfalls in the total annual precipitations has considerably increased in recent decades. The ratio of *hagaya* rainfall in the total annual precipitation in the 2000s was 37%, and this was an increase from a decade average of 27% in the 1980s with an average rate of change of 17%. The upward trend in these ratios seemingly indicate the increasing significance of *hagaya* season in the Borana rangelands though it is in fact largely a result of substantial declines in the main (*ganna*) season rainfalls.

Table 2. Trends in seasonal rainfall variability in Borana rangelands.

Station	Averages and Coefficients of Variation (CV)				Rate of Change (%)	
	1970s	1980s	1990s	2000s	2000s/1970s	2000s/1980s
Negelle Station						
Annual						
Average (mm)	899	788	651	654	−10.1	−4.5
Main season						
Average (mm)	486	515	393	380	−8.0	−7.3
CV	0.32	0.38	0.39	0.34	2.0	−2.7
Short season						
Average (mm)	316	241	197	224	−10.8	−1.8
CV	0.36	0.30	0.46	0.42	5.3	8.8
Moyale Station						
Annual						
Average (mm)	*	719	503	504	*	−8.5
Main season						

Table 2. *Cont.*

Station	Averages and Coefficients of Variation (CV)				Rate of Change (%)	
	1970s	1980s	1990s	2000s	2000s/1970s	2000s/1980s
Average (mm)	*	478	223	246	*	−15.3
CV	*	0.45	0.34	0.38	*	−4.1
Short season						
Average (mm)	*	171	190	195	*	3.3
CV	*	0.48	1.2	0.69	*	9.5
Yabello Station						
Annual						
Average (mm)	*	530	541	604	*	3.3
Main season						
Average (mm)	*	314	299	301	*	−1.1
CV	*	0.39	0.24	0.45	*	3.6
Short season						
Average (mm)	*	133	158	195	*	10.0
CV	*	0.48	0.70	0.58	*	4.8

Note: * Incomplete data. Source: Calculated from Ethiopian Meteorological Service Agency records.

Table 3. Trends in the ratios of short (*hagaya*) rainfalls by decade.

Station	Mid to late 1960s Average	1970s Average	1980s Average	1990s Average	2000s Average	% Change 2000s/1980s
Negelle	0.35	0.36	0.31	0.31	0.38	10
Moyale	na	*	0.25	0.34	0.38	24
Yabello	*	*	0.25	0.27	0.35	18
Average	*	*	0.27	0.31	0.37	17

Note: na = not available; * incomplete data. Source: Calculated from Ethiopian Meteorological Service Agency records (unpublished raw data).

The foregoing analysis broadly reveals that, except for the recorded trends at Yabello station, there is an observed tendency of long-term declines in the region's average annual rainfalls with increasing sign of unpredictability. Here, it may be important take up an important issue of ascertaining whether pastoralist perceptions of climate change correspond with the actually recorded climate variability in the region. Pastoral households were asked whether or not they have noticed any change in the climatic conditions in terms of changing trends in temperature and rainfall in the last two decades. Nearly 95% of the interviewed pastoral households (N = 281) perceived that the average temperature in the area has increased, while the average rainfall has reportedly decreased, in the last several decades. A clear deviation, however, was observed between local perception and recorded rainfall trends at Yabello station.

4. Descriptive Analysis of Climate-induced Household Adaptation Strategies

The observed climate variability and associated pastoralist perceptions, along with other drivers of socio-economic and political origins, are generally considered to have essentially generated a variety of local adaptation response mechanisms among the pastoralist community. A number of adaptive response strategies can be identified in the context of traditional pastoralism. Two major categories of

adaptation choices, adjustment in pastoral practices, and shifts to non-pastoral livelihoods, are identified in the case of dynamic response mechanisms and adaptive strategies recently embraced by Borana pastoralists in southern Ethiopia. These adjustment responses are partly supported by external inducements generated by pastoralist prolonged exposure to the increasing wave of activities of both governmental and non-governmental agents. Our survey results of the extent of these pastoral household adjustment responses are summarized in Table 4.

Table 4. Pastoral household adaptation choices (N = 281).

No	Adaptation Choice	Response %
1	Adjustment of pastoral practices	
(a)	Increased mobility (distance & frequency)	53.7
(b)	Increased adoption of drought-tolerant livestock species	
	(i) Camel	29.2
	(ii) Goats	55.7
(c)	Have resorted to purchase of hay	37.0
(d)	Private enclosure for fodder production	16.1
(e)	Strategic private range enclosure for double purpose	33.4
2	Partial shift to other livelihoods	
(a)	Private range enclosure for opportunistic cereal cultivation	61.2
(b)	Conversion of livestock capital into physical capital	10.0
(c)	Banking livestock assets (bank saving)	5.7
(d)	Petty trade/business	21.9
(c)	Low return activity participation	
	Charcoal making	12.2
	Fuel wood selling	15.7
	Casual labor	30.0

Source: Household survey data.

4.1. Adjustment of Pastoral Practices

This category is comprised of a number of adaptation choices. These are increased mobility, more adoption of drought-tolerant livestock species, increasing resort to purchased hay, and competitive individual household land grabs for strategic private range enclosures for the double purpose of cereal cultivation and fodder production. Mobility is a survival and resource management strategy commonly practiced by herder societies for efficient use of meagre and scattered rangeland resources for sustainable livelihoods in the face of climate fluctuations in dryland ecosystems. It is a good practical instance of locally adapted livelihood strategies in dryland areas [24]. Flexible and responsive mobility is a vital strategy of livelihood sustenance in dryland pastoralism. The scale (distance) and frequency of pastoral mobility depends on spatial and temporal variations in resource availability which, in addition to the nature of range ecology, is also often influenced by accidental shocks [25]. Long distance movements are mainly caused by scarcity of rangeland resources triggered by severe droughts and range degradation. Changing climatic conditions such as reduced annual precipitation and rainfall variability are often recognized to be important factors of rangeland productivity declines. Therefore, higher aridity may imply increased pastoral mobility for household livelihood sustenance [24].

In general, the threatening impacts of global climate change would rather imply a further need for increased mobility as inescapable adaptation option, albeit one is increasingly constrained by the pressure of shrinking boundaries of pastoral rangelands. Despite the increasing problem of shrinking rangelands and restricted mobility due to the rising pressure of human settlement, internally driven by recent population growth in the area and loss of grazing territories, about 54% of our survey respondents indicated that the growing strain of climate-induced difficulties have pressed them to increase their mobility in terms of distance and frequency. The Borana pastoralists have been quite squeezed but they apparently still continue to wiggle.

Herd diversification in favor of browsers (camel and goats) is another important strategy of pastoralist adaptive response to climate-induced shifts in rangeland ecosystems. Traditionally, Borana pastoralism is predominantly a cattle-specialized pastoral system. A person without a head of cattle in the Borana custom is considered as *qolle* (destitute) and "incomplete" because of the comprehensive social functions bestowed upon cattle in the indigenous constitution. The camel has never gained this status of traditional completeness in its functions, in that it has in no way been valuably recognized for use in social and religious rituals, local wealth redistributions, dowry and ceremonial gifts, and payment of fines. Therefore, Borana herders, especially in the past, always remained hesitant to uphold camel in their traditional herd management decisions perhaps except for as a beast of burden. However, recent studies [26,27] have pointed to some observed trends of growing Borana interest in camel pastoralism as a result of mounting pressures of climate-induced difficulties. In the present case, the proportion of camel holders in our total survey sample is found to be 35.6%. Nearly 60% of them reported to have initially acquired the "seed" stock through purchases (Figure 3). The rest acquired it through inheritance (23%), NGO restocking (9%), and inter-ethnic conflicts (this is a form of booty seized by Borana pastoralists in their occasional clash with other neighboring pastoral groups). Only 29.2% of the sampled Borana households reportedly embraced camel pastoralism as an adaptive response (or strategy) to changing conditions (Table 4).

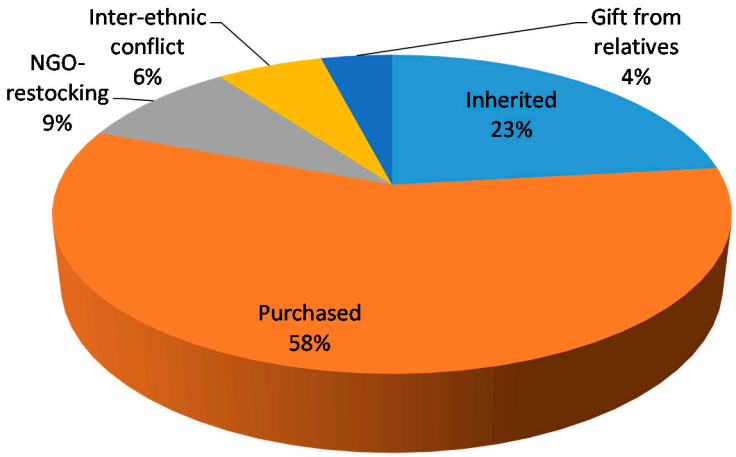

Figure 3. Reported initial way of camel acquisition. Source: Household survey data.

In order to get an approximate idea about quantitative trends in Borana households' camel adoption, our respondents were asked to recall their camel holdings in the last six *Gada* periods (each with a period of eight years in the Borana *Gada* system) beginning from the period of Abba Gada (leader)

Jaldessa Liban (1960). The result, as indicated in Figure 4, is considerable, which shows the recent fairly increasing trend of camel keeping by Borana pastoralists, especially and strikingly since the 1990s. The trend is significantly vivid and yet the level of camel keeping is still far from being very extensive.

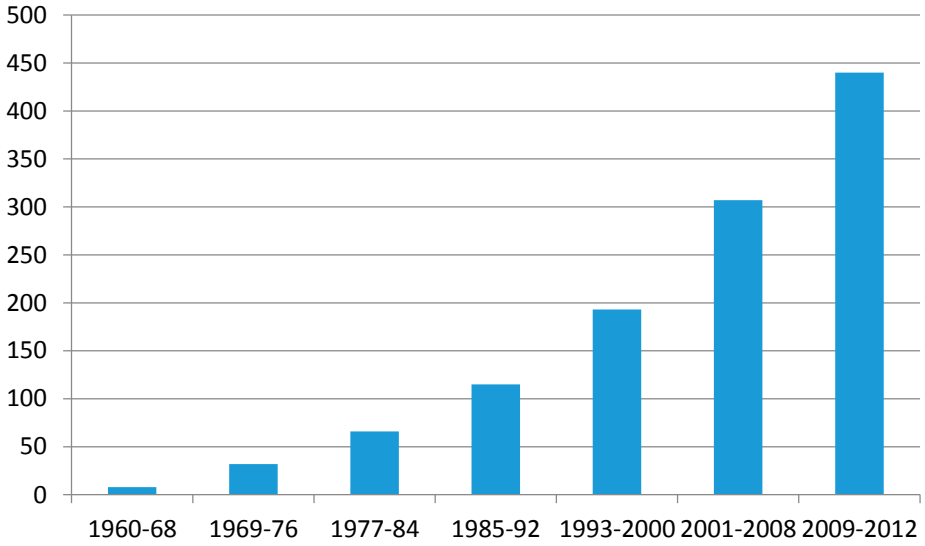

Figure 4. Approximated trend in total camel holdings (numbers) as reported by respondents. Source: Household survey data.

Milk is the most important product in subsistence pastoralism. The attractiveness of camel herds in herder households' animal species portfolio is that many camel breeds produce more milk than cows [28]. However, despite the recent significant signs of change, many Borana pastoralists may still remain far from an unreserved rush to wholly embrace camel as a superior asset in their herd portfolios. It is not only that the tradition, unlike cattle, has considered the camel a "beast" with incomplete function. The community also to a great extent considers camel milk as relatively inferior. All the same, despite these traditional restrictions and the Borana limited experience and skill in camel management, nearly 85% of our survey respondents maintain that the current high cost of camel is a key constraint to desired adaptations. Only 6% of our respondents wholly reject camel keeping as a result of cultural restriction of not eating camel products. The current prohibitive cost of more camel adoption in the Borana pastoral area is strangely unprecedented. It perhaps took a few young animals for the pastoral Borana to acquire a female breeding camel in the 1980s when people frowned at the camel to substantially ignore its introduction into their pastoral herds. The current Borana moderately welcoming interest in camel acquisition is, however, apparently strangled by the recently climbing camel prices evidently driven by competitive pressures of unexpected demand for camel in Ethiopia's export markets.

4.2. Other Adjustments in Pastoral Practices

The use of purchased hay and growing private fencing of communal rangelands for fodder production and hay making are among some of the recent adaptive pastoral practices increasingly embraced in the Borana rangelands. About 37% of our survey respondents have reportedly resorted to hay purchases in recent times (Table 4). The local communal rule prohibits private enclosures for fodder production but allows it for cereal cultivation. This may have motivated stock owners to fence

communal rangelands for fodder production in the name of cereal cultivation via the strategic stance of having it for a twin purpose. The well-known adopted practice in the area is to keep village communal fodder banks (*kallo*) used to feed calves, weak animals, and milking cows during feed-deficit dry months. Neither "imported" hay purchases nor large local production and stockpiling of hay were known in the past traditional pastoral practice of Borana pastoralism. Climate-induced distress and local hardships, according to Desta [27], has induced Borana pastoralists to change their range management practices and stocking up of hay for use during dry periods, which is claimed to be partly promoted by the government and some NGOs operating in the area. This may have considerably triggered competitive pressures of mushrooming illegitimate private enclosures for fodder production and hay making in communal rangelands. Only 16.1% of our interviewed households reported to have privately fenced communal rangelands for fodder production alone. Since private enclosures for fodder production are not allowed, the most convenient way to have one is through a calculated stance in pastoral household decision by fencing the communal land for the double purpose of cereal cultivation and dry season hay-making. It is found that 33.4% of the interviewed Borana households have adopted private rangeland enclosures for the twin purpose of cereal cultivation and fodder production (Table 4). Pastoralism by design is naturally an extensive system of adaptation. Private rangeland holding mainly by large stockowners is apparently quite ironic and unsustainable in the present context of increasing difficulty of climate variability and rangeland degradation.

4.3. Shifts to Non-Pastoral Livelihoods

The most non-pastoral adaptation strategy embraced by Borana pastoralists in the last two decades of the 20th century is cereal cultivation. The pastoral Borana in their past tradition frowned upon land tilling as an act of evil and disgrace [21]. The pastoralist massive rush to the act of having private enclosures for cereal cultivation largely began in the mid-1990s and perhaps culminated in the first decade of this century. Farming was originally adopted by shock victims and the destitute. Climate-induced recurrent pressures later made it a common experiment among Borana pastoralists primarily to avoid livestock selling required for supplementary cereal purchases in the widely pressing circumstances of declining milk yields. As can be seen in Table 4, 61.2% of the surveyed households reportedly hold private enclosures, which are opportunistically held for cereal cultivation in this unpredictable rangeland environment of erratic climatic conditions. For example, only 30% of the current holders of fenced grounds for cereal cultivation in our sample reported to have produced some kilograms of grain in the last cropping season. Therefore, it is quite ironic to consider dryland farming as a sustainable adaptation option in the current trend of secular rainfall declines in southern Ethiopian rangelands.

Different non-pastoral livelihoods have been embraced by pastoral households in response to climate-induced risks and subsequent failures of subsistence pastoralism. Livestock commercialization and monetization of the pastoral economy was the central focus of internationally financed massive rangeland development interventions of the mid-1970s to early 1990s. Perhaps the abysmal underachievement of these efforts is reflected in the increasing dominance of the previously disparaged low-return non-pastoral pursuits embraced by pastoral households as a result of recurrent vulnerability to exogenous shocks and growing pastoralist destitution [9,21]. As can be seen in Table 4, only 10% of the respondent households have managed to convert part of their livestock capital into relatively high

return urban-based investments, which are predominantly made on rental house construction in small rangeland towns or market centers and livestock trade business. A considerable proportion (about 22%) of the sample households have participated in petty trade activities such as selling assorted goods and brokerage in local livestock markets. The largest (nearly 60%) part of non-farm-non-pastoral adaptation measures are in low return activities such as fuel wood selling, charcoal making, and casual labor engagements. Perhaps the transient nature of the recently growing household casual labor participation, though partly contributed by flourishing rangeland towns and market centers, is that a considerable part of it is induced by public adaptation measures such as social protection public works and small rural infrastructure projects (of unpredictable sustainability) currently implemented in the area both by the government and NGOs.

5. Analysis of Determinants and Impacts of Pastoralist Adaptation Choices

5.1. The Model

Our simple theoretical departure for the analysis of pastoralist response to long-term climatic variability and change is the notion of pastoral household utility maximization. Here pastoral households are assumed to make rational decision of choosing adaptation measure "m" over adaptation strategy "n" if the expected utility from the former option is greater than that of the latter adaptation option. That is if:

$$E\,[U\,(m)] > E\,[U\,(n)] \quad (1)$$

The empirical strategy is based on a range of major pastoral household adaptation choices identified and quantified during the field survey. Using a similar empirical approach to Di Falco *et al.* [18], here pastoralist adaptation to climatic variability is explored by adopting a framework of two-stages setting. (An alternative statistical approach to this specification is to consider those adaptation measures as polytomous choice categories [17,21] most commonly analyzed by using Multinomial Logit Models. However, the simple approach we have adopted here is recognized as being more useful in broadly assessing the impacts of adaptation choices in the next step). The pastoralist decision to implement an adaptation strategy (based on the assumption that it generates benefits) is modeled as a binary response outcome. The underlying response behavior in this case can be represented by unobserved (latent) variable (A_i*) capturing the expected benefits from adaptation choice with respect to not adopting, and specified as:

$$A_i^* = \mathbf{X}\beta + \varepsilon,\ Ai = 1\ [A_i^* > 0) \quad (2)$$

The observed adaptation option $A_i = 1$ if $A_i^* > 1$, and 0 otherwise. The vector X broadly represents different groups of explanatory factors corresponding to household socio-economic characteristics, climatic variables and other factors such as institutional support services. Therefore, in the adopted first step, factors that significantly play a role in determining the probability of pastoral household adoption of specific adaptation strategies are examined using probit model estimation.

The next associated step roughly explores the effects of climate change adaptation measures on pastoral household income. This is applied by considering selected adaptation strategies of fairly strong connections with major sources of pastoral household revenues, the latter including milk and

meat production and non-pastoral adaptations such as cereal cultivation and asset diversification. Predicted values of probit estimates in the first step are generated as a measure of probability of adoption and are included as a dummy variable (A_i = 1 if the identified measure is adopted by household i, and 0 otherwise) in the applied ordinary least square (OLS) model estimation.

Definition and descriptive statistics of the empirical model variables are provided in Table 5. Selected major pastoral adaptation choices are dependent variables in the first stage estimation. The first category of variables in Table 5 is associated with a vector of variables of household socio-economic characteristics embraced in Equation (2). These include age of household head (AGE), gender of household head (GENDER), household size (HHSIZE), level of educational (EDUCATION), and livestock size (LVSTKSIZE).

The second category refers to elements of a vector of climate variables represented by locality based approximations of temperature (MAXTEMP) and rainfall (RAINFALL) conditions. Here, in addition to the usual cross-sectional analysis problem of specifically entering individual household level rainfall and temperature observations, our case is found to be quite tricky and more daunting due to the mobile nature of traditional pastoralism. In order to clear this hurdle in the Borana case, we resorted to the unique traditional characterization of *warra* (semi-settled) *versus fora* (mobile) herd management system in Borana pastoralism. The Borana *warra* herd unit is a core division of subsistence herds which is of limited (10–20 km radius) circular movement in the surroundings of semi-settled pastoralist encampments [26,29]. Individual household level temperature observations by site were then approximated by average recent records of relatively closer currently operating meteorological stations. The Moyale meteorological station, for example, is within 20 km distance of our Bokola survey site in the area. In other cases, extrapolated records of the fairly widely spread previous (now abandoned) substations of the Southern Rangelands Development Unit (SORDU) were additionally used. The rainfall data used in the empirical model estimation come from the dataset constructed by the Climate Prediction Centre of the National Oceanic and Atmospheric Association (NOAA), which are extracted based on grid measures of the surveyed sites.

Table 5. Definition and descriptive statistics of model variables.

Variable	Description	Mean	SD
AGE	Age of household head	54	16.7
GENDER	Dummy for gender of household head, 1 if male; 0 otherwise	0.86	0.40
HHSIZE	Household size	6	
EDUCATION	Household head level of education in years	0.28	1.1
LVSTKSIZE	Livestock size in a standardized unit (TLU) *	12	17
SHKSURINDEX	Shock survival index (see text for explanation)	1.12	1.02
EXTENVIST	Dummy for regular visit by government extension agent, 1 if yes; 0 otherwise	0.71	0.46
FREQUTRAINP	Frequency of participation in government or NGO training & orientation programs (0 = none; 1 = a few times; 3 = frequently)	1.2	1.1
CREDITACESS	Dummy for access to formal credit, 1 if yes; 0 otherwise	0.16	0.36
MLOCALEADER	Dummy for membership in local government leadership structure, 1 if yes; 0 otherwise	0.17	0.38
DISTDISTCAP	Distance from district capital (km)	23	14.4
RAINFALL	Average annual rainfall (mm) based on NOAA dataset	301.7	39.4

Table 5. *Cont.*

Variable	Description	Mean	SD
MAXTEMP	Maximum temperature based on extrapolated recorded temperature at stations closer to sample site	29	2.65
PRANGESTATUS	Dummy for perceived range status in the locality, 1 if degraded; 0 otherwise	91	29
AREACULTVD	Area cultivated in *sangas* (4 *sangas* = 1 hectare)	2.3	3.3
WCRATIO	Workers-Consumers ratio in the household (household composition)	0.5	0.2

* Conversion factors are not uniform; here we have adopted the following: cows (0.7), heifers (0.65), calves (0.34), young male (0.54), bull/steer (1), small stock (0.1), camel (1.1), horse and mule (0.8), donkey (0.6). Source: computed from survey data.

The variable SHKSURINDEX (shock survival index) is included here in order to capture the effects of past recurrent exposure to climate-induced shocks in addition to the usual variables of current rainfall and temperature conditions. It is a ratio of current stock size to the highest reportedly attained pre-shock livestock holding multiplied by frequency of exposure to catastrophic shocks [9]. The frequency of exposure is measured by the reported number of times the respondent pastoral household experienced drought-related substantial livestock losses in the past.

The other set of variables included in the empirical model are institutional support variables represented by access to regular extension visit (EXTENVIST), frequency of participation in organized government and NGO training and orientation programmes (FREQUTRAINP), and access to formal credit (CREDITACESS). Other included explanatory variables are household head membership in local government leadership structure (MLOCALEADER), distance from district capital (DISTDISTCAP) and perceived range status of most frequently used local range ecology (PRANGESTATUS).

5.2. Empirical Results and Discussion

Probit regression results of the determinants of pastoral household selected adaptation choices are presented in Table 6. These are estimated functions of pastoral household adaptation choice decisions represented by the relationship specified in Equation (2). The estimated results generally indicate that the likelihood of pastoral household adoption of the selected major adaptation options is significantly explained by age, gender, wealth status, degree of pastoral household shock resilience, and climatic variables. It is found that the probability of adjustment in pastoral practices of increased mobility and adoption of more camels significantly decreases with age. This clearly signifies that it is the younger pastoral households that have more of the energy to move around the rangelands in the event of shock and climatic risks, and that the older generations of Borana pastoralists are likely to be more hesitant in embracing camel pastoralism than the recent cohorts. The strategy of asset diversification in the form of conversion of livestock assets into urban-based physical investments is, as expected, significantly explained by the size of livestock ownership. The likelihood of adoption of high-return adaptation measure is also found to be positively and significantly related to household head membership in local government leadership structure.

Table 6. Probit regression results of pastoral household selected adaptation choices.

Explanatory Variables	Mobility	Drought-Tolerant Species (Camel)	Private Enclosures		Asset Diversification
			Cereal Cultivation	Cereals & Fodder	
AGE	−0.0152 ***	−0.0263 ***	−0.0122 *	−0.0131 **	−0.0125
	(0.0053)	(0.0064)	(0.0070)	(0.0062)	(0.0088)
GENDER	−0.0752	0.0236	0.8017 ***	0.2979	−0.7543**
	(0.1935)	(0.2256)	(0.3049)	(0.2785)	(0.3404)
HHSIZE	0.0556	0.1141 **	0.0434	0.0513	−0.0505
	(0.0435)	(0.0461)	(0.0458)	(0.0411)	(0.0615)
EDUCATION	0.0041	0.0548	−0.1241	−0.0632	0.1078
	(0.0679)	(0.0785)	(0.0978)	(0.0791)	(0.0930)
LVSTKSIZE	0.0359 **	0.0203 ***	0.0020	0.0185 ***	0.0910 ***
	(0.0155)	(0.0078)	(0.0080)	(0.0069)	(0.0189)
SHKSURINDEX	0.3279 ***	0.4314 ***	0.1835	0.2048**	0.0197
	(0.1122)	(0.1018)	(0.1188)	(0.1032)	(0.1330)
EXTENVISIT	−0.3608	−0.3852	0.4796	0.2595	−0.2859
	(0.2276)	(0.2718)	(0.3597)	(0.3250)	(0.4433)
FREQTRAINP	0.1397	0.0121	0.2354 *	0.2431 **	0.1290
	(0.0897)	(0.1046)	(0.1207)	(0.1060)	(0.1639)
CREDITACCESS	−0.4384	−0.5139 *	0.5495	0.0708	−0.7191
	(0.2718)	(0.2705)	(0.3425)	(0.2833)	(0.4654)
MLOCALEADER	0.1059	−0.1941	−0.3080	0.1301	0.7236 **
	(0.2589)	(0.2679)	(0.2996)	(0.2605)	(0.3341)
DISTDISTCAP	−0.0156	−0.0318 **	−0.0241 *	−0.0269 **	−0.0244
	(0.0111)	(0.0129)	(0.0142)	(0.0128)	(0.0227)
RAINFALL	0.0117 ***	0.0238 ***	0.0276 ***	0.0208 ***	0.0012
	(0.0037)	(0.0041)	(0.0044)	(0.0041)	(0.0069)
MAXTEMP	0.2901 ***	−0.0804	−0.7609***	−0.4560 ***	−0.3075 *
	(0.1109)	(0.1182)	(0.1352)	(0.1069)	(0.1791)
PRANGESTATUS	0.0719	0.4131	−0.7115 *	−0.5864 *	0.2983
	(0.2852)	(0.3332)	(0.4228)	(0.3302)	(0.4653)
CONSTANT	−11.389 ***	−4.961	13.306 ***	6.183	7.301
	(4.199)	(4.288)	(4.641)	(3.979)	(7.038)
Wald $\chi^2(14)$	67.91	81.17	122.42	107.26	71.08
N	281	281	281	281	281
Pseudo R^2	0.22	0.31	0.56	0.32	0.56

Note: Numbers in parenthesis are robust standard errors; *** significant at 1% level; ** significant at 5% level; * significant at 10% level. Source: computed from survey data.

The probability of adoption of increased mobility as a survival strategy in the growing circumstances of recurrent climatic shocks is very significantly explained by wealth status and level of climatic shocks survival. The poor and the stockless generally tend to settle for opportunistic cereal cultivation or move to peri-urban location in search of relief assistance and other non-pastoral opportunities than moving in the rangelands. It also appears that adaptation choice and capacity is rather more significantly explained by dynamically exhibited degree of pastoral household shock resilience, which is rather measured here by considering the degree of survival in recurrent exposure to climate-induced shocks

as an alternative to using the levels of current temperature and rainfall conditions alone. This is quite important in the context of mobile pastoralism because in our case current temperature and rainfall conditions are rather found to be more logical and consistent in explaining the pastoralist recent involvements in dryland cropping than modification of traditional pastoral practices. It is quite logical to observe from the estimated relationship that increased mobility is significantly associated with high temperature. However, the apparently positive relationship between mobility and annual rainfall conditions in a specific locality is perhaps quite inconsistent with common expectations. Some of the respondents may have rather experienced inter-locality shifts in their current encampments while their response to the question of increased mobility considerably signifies their dynamic perception of relative trends in the recent past. The status of local range ecology and associated sustained availability of pasture are crucial factors for pastoral mobility rather than only current level of local rainfall conditions in specific localities.

In addition to the significance of age, the decision to adopt more camel is very significantly explained by the size of livestock ownership and degree of climate-induced shock survival. The recently increasing prohibitive cost of adoption of drought-tolerant species (camel) implies that it is only the wealthy households that can more productively diversify the composition of their herd species portfolios as a hedge against the current condition of increasing climate-induced risks of livelihood deteriorations. The estimated positive relationship between local rainfall conditions and the level of household camel holding rather largely indicates the observed less dominance of this species in the pastoral herd portfolio of sampled households from the more arid *Dilo* district predominantly characterized by small ruminant production in addition to cattle. The expected future trend is that the prevailing long-term declines in average rainfalls in Borana rangelands would generally imply the adoption of drought-tolerant livestock species such as camel, albeit the increasing restrictive pressure of soaring adaptation costs. However, the current status in camel holding is partly influenced by the experience of past tradition and the often observed location-specific predominance of camel adoption, which, in addition to the particular case of suitability of existing range ecology, is substantially shaped by the degree of Borana exposure to the breeding practices and experience of other adjacent camel rearing pastoral groups in the area.

The probability of practicing the recently growing pervasive strategy of private enclosures for cereal cultivation is negatively related to age, and positively associated with gender. The older household heads rather either stick to their conservative feelings about dryland tilling or significantly lack the required labor power for land preparations. Cereal cultivation in the Borana rangelands, as detailed elsewhere, is generally a gender-biased operation [30]. The estimated results, as commonly expected, also indicate that pastoralist adoption of the practice of cereal cultivation decreases with level of aridity and increasing temperature. Correspondingly, in addition to level of aridity and temperature conditions, household range enclosure for the double purpose of cereal cultivation and fodder production is significantly explained by the size of stock ownership.

An important result in Table 6 is that institutional support mechanisms such as rural credit access and regular extension visits appear to have no effect on pastoral household choice of the selected adaptation measures. This suggests, at least, the partial ineffectiveness of these institutions in southern Ethiopian rangelands. Perhaps, except for the health programs, the existing extension services are largely less development-oriented at the household level. About 39% of our survey respondents indicated to have received visits by government agents but a significant component of these contacts

are largely for tax collection and for local political and security matters rather than effective developmental advice. The frequency of participation in organized orientation programs is significantly associated with private land enclosures for dryland farming, and for the double purpose of cereal cultivation and fodder production. This result is consistent with the fairly observed recent recommendations by some governmental and non-governmental agents for household stockpiling of hay required to minimize the problem of feed shortages encountered during dry periods. However, private rangeland enclosures for this purpose may significantly imply negative repercussions due to the inbuilt incompatibility of this measure with the more ecologically sound broad strategy of extensive pastoralism on communal pasturelands in dryland ecosystems.

The estimated model results in Table 7 are presented in accordance with our further aim of the need to roughly explore the effects of selected adaptation strategies well associated with pastoral production and household income. Quite notably, the previously discussed remaining strategies of pastoralists increasingly resorting to low-return activity engagements are generally related to the tendency of dropping out of pastoralism [31]. As it can be seen, the results indicate that, except for the strategy of private land enclosures for cereal cultivation, all other adaptation measures are found to be significantly positive for the achievement of increased net household income in Borana rangelands. Therefore, the strategies of increased pastoral mobility, preference for more drought-tolerant species (camel) and conversion of livestock capital assets into urban-based physical capital investments have considerable positive implications for sustainable household food security in the region. The estimated model results interestingly reveal the apparent incompatibility of the implications of these findings and current negative views on pastoral mobility and corresponding vigorous stance of planned pastoralist sedentarization. The estimated results rather suggest that increased mobility has more significantly positive food security implication for an average Borana household than sedentarized cereal cultivation. The relationship between household income and climate variables of increasing temperature and precipitation in the rangelands is found to be significantly negative. The estimated result of a negative relationship between precipitation and pastoral household income may well appear quite inconceivable. But it might be partly explained by the general tendency of a shift towards increasing use of fragile rangeland soils for a relatively low-return cereal cultivation, which could involve a negative repercussion of rangeland degradation and reduced livestock productivity [20,24]. However, for drawing a strong and valid inference, the predictions with respect to these variables of current temperature and rainfall conditions in a cross-sectional context may be fairly mooted. This is partly due to the possible complex productivity influences of the diverse range of ecological conditions of the Borana mobile pastoral mode of production, but it remains to be a matter of further investigation.

Table 7. The relationship between net income and selected adaptation choices.

Explanatory Variables	Dependent Variable: Net Household Income				
	Mobility	Drought Tolerant Species (Camel)	Private Enclosures		Asset Diversification
			Cereal Cultivation	Fodder & Cereal	
Adaptation Choice	4311.3 **	4838.9 **	2630.5	7932.1 ***	13986.8 ***
	(1711.5)	(1933.3)	(1838)	(2073.6)	(3936.1)
LVSTKSIZE	874.9 ***	886.3 ***	910.7 ***	869.5 ***	776.2 ***
	(34.1)	(32.3)	(30.6)	(32.1)	(49.0)

Table 7. *Cont*.

Explanatory Variables	Dependent Variable: Net Household Income				
	Mobility	Drought Tolerant Species (Camel)	Private Enclosures		Asset Diversification
			Cereal Cultivation	Fodder & Cereal	
AREACULTVD	330.8*	338.5*	292.7	165.7	371.5 **
	(172.9)	(172.5)	(186.9)	(178.9)	(169.1)
HHSIZE	38.6	−2.9	71.9	8.6	153.5
	(215.5)	(218.8)	(217.5)	(211.9)	210.7
WCRATIO	7758.9***	6695.3 **	7190.8 ***	7123.6 ***	6979.9 ***
	(2571.6)	(2578.2)	(2587.3)	(2529.0)	(2539.2)
RAINFALL	−68.9 ***	−73.2 ***	−67.7 ***	−76.9 ***	−54.2 ***
	(20.9)	(21.3)	(21.5)	(20.8)	(20.4)
MAXTEMP	−1894 ***	−1452.5 ***	−1104.2 **	−1405.4 ***	−1210.4 **
	(520.7)	(471.8)	(496.9)	(462.6)	(464.8)
CONSTATNT	72,850.7 ***	62,911.5 ***	49,909.7 ***	62,312 ***	50,477.6 ***
	(19,985.9)	(18,911.5)	(19,017.9)	(18,449.7)	(18,433.6)
F(7, 273)	150.81	150.75	147.89	156.44	155.08
P-value	0.000	0.000	0.000	0.000	0.000
N	281	281	281	281	281
R^2	0.79	0.79	0.79	0.80	0.80

Note: Numbers in parenthesis are standard errors; *** significant at 1% level; ** significant at 5% level; * significant at 10% level. Source: computed from survey data.

6. Concluding Remarks

This paper examines household climate adaptation strategies and their implied impacts on pastoral household income in southern Ethiopian rangelands. The recorded trend of climate variability in the last four decades is found to correspond with pastoralist perception of climate change in the region. The average temperature fairly followed a general upward trend in recent decades while the existing rainfall records, in accordance with the pastoralist perception, substantially signify that the region has experienced secular declines in average rainfall with significant signs of more unpredictability.

It is quite naive to attribute the pastoral crisis in southern Ethiopian rangelands, and consequent pastoralist adaptation response mechanisms, entirely to a factor of climate variability and change. However, as discussed elsewhere [9], the influences of climate-induced recurrent shocks have been profoundly sharp to aggravate the effects of a host of internal and external factors, including government interventions, which have dynamically implied shifts in pastoralist livelihood strategies. The pastoralist adaptive response mechanisms have generally involved the strategies of adjustment in pastoral practices and shifts to non-pastoral livelihoods. Despite the existing restrictive pressures, increased pastoral mobility still remains to be a viable strategy of sustainable pastoralism in the present context of climate-induced risks and pastoral livelihood vulnerability. In a related front, the Borana pastoralists appear to have gradually modified their traditional stance against camel pastoralism in recent decades as a result of the increasing need to diversify their herd portfolios in favor of drought-tolerant species. These adjustments in pastoral practices are apparently quite helpful in the sense that they are found to exhibit statistically significant positive implications for increased pastoral household income. However,

the recent pastoralist growing interest to embrace drought-tolerant species (camel), in the prevailing circumstance of climate-induced growing local food insecurity, is evidently faced with the problem of soaring camel prices driven by competitive international market pressures. It is a critical trade-off which should be fairly considered by policy makers in designing regional food security strategies and current programme interventions.

The pastoralist non-pastoral adaptation strategies in recent decades are found to be highly dominated by the less rewarding competitive pressures of private rangeland enclosures for opportunistic cereal cultivation and growing involvement of the poor in low-return activities. Only a small percentage of the surveyed pastoral households have managed to convert their livestock assets into relatively high-return non-pastoral undertakings as an adaptive risk management response. The strategy of asset diversification, in the form of transfer of surplus from the pastoral economy to urban-based non-pastoral investment ventures, in the face of currently increasing challenges of climate-induced co-variate shocks, is a significantly desirable risk management and developmental option in the area. All the same, a serious gap in the present state of institutional services provided by external agents in the area is their critical inadequacy of offering commercially-oriented skill training and related rigorous capacity building assistance at the household level. The conventional wisdom is arguably inclined to present a case for existing support actions by external agents to be substantially directed to target the poor. However, it is also crucial to refocus attention to strongly emphasize wealthy and medium stock owners in core support interventions, given the existing reality of catastrophic co-variate shocks which could typically eat into the entire capital asset base of the pastoral mode of production and subsequent rise in the likelihood of widespread pastoralist destitution.

The predominant strategy of private land enclosures for cereal cultivation is seemingly consistent with the ill-informed government stance of pastoralist sedentarization though it is found to have potentially insignificant contribution to average pastoral household food security. However, government strategies that discourage pastoral mobility but promote range privatization for cereal cultivation in the present context of climate-induced recurrent shocks in southern Ethiopian rangelands would ironically negate the goal of achieving sustainable livelihoods in this naturally susceptible environment. Local administrators and community leaders should rather discourage opportunistic and harmful individual adaptation measures such as private rangeland enclosures by wealthy stock owners, an act that is quite inconsistent with the naturally extensive system of adaptation of traditional pastoralism.

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Author Contributions

Wassie Berhanu designed the research project, prepared survey questionnaires, administered the field survey, organized and analyzed the data, and wrote the paper. Fekadu Beyene helped in the design, advised on field data collection, contributed to the introduction section, and reviewed the paper.

Appendix

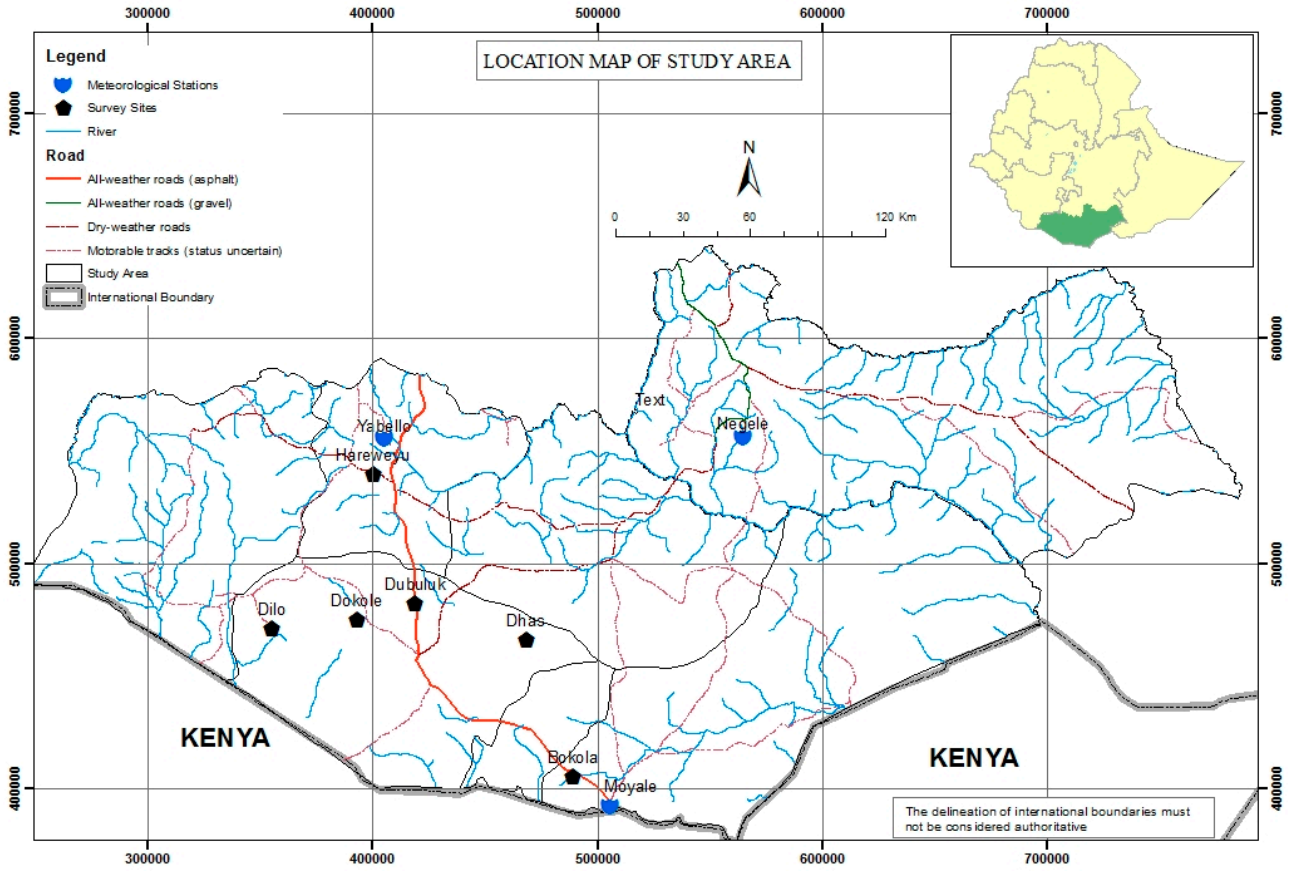

Figure A1. Location map of the study area and survey sites.

Conflicts of Interest

The authors declare no conflict of interest.

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