Hindawi
International Journal of Ecology
Volume 2022, Article ID 7978744, 14 pages
https://doi.org/10.1155/2022/7978744

*Research Article*

# Rangeland Degradation and Its Impacts Post-1992: Constructing the Perceptions of Boorana Pastoralist, Southern Ethiopia

**Galgalo Dika**,[1] **Degefa Tolossa**,[2] **and Shiferaw Muleta Eyana**[3]

[1]*College of Agriculture and Natural Resources, Gambella University, Gambella, Ethiopia*
[2]*Centre for Rural Development Studies, Addis Ababa University, Addis Ababa, Ethiopia*
[3]*Centre for Environment and Development Studies, Addis Ababa University, Addis Ababa, Ethiopia*

Correspondence should be addressed to Galgalo Dika; galgalo48@yahoo.com

Received 3 March 2022; Revised 14 June 2022; Accepted 16 June 2022; Published 9 July 2022

Academic Editor: Gowhar Meraj



The rangelands of Africa have been subject to substantial changes. The changes in the savanna rangelands ecology were often assessed from different points of view. This study constructs the perceptions of Boorana pastoralists on historic changes in rangelands post-1992 based on the Gadaa timelines. The construction of pastoralist perceptions can make an immense contribution to comprehending the rate, trends, indicators, and impacts of rangeland degradation in Boorana rangelands. This study thus points out that pastoralists can better understand and describe rangeland conditions and factors associated with such changes in the Gadaa periods. The study was based on the data collected from 332 pastoralists using a survey questionnaire and qualitative data, and the results were analyzed using descriptions of responses and narrations of cases. The study revealed that the conditions of the Boorana rangelands have been deteriorating over time and rangeland degradation showed unprecedented growth trends, mainly attributed to vegetation, rangeland production, human, environmental, and climate change-related factors. The study also shows that the progressive degradation of rangeland resources has jeopardized rangeland production, livestock productivity, and human well-being in the Boorana rangeland system. The study suggests that the recognition and promotion of indigenous ecological knowledge of pastoralists could sustain the pastoralist community in arid and semiarid rangelands. It is, therefore, imperative to understand pastoralists' knowledge of rangeland ecology for sustainable management of rangeland resources.

## 1. Introduction

Rangelands cover the world's largest proportions of landscapes and provide several benefits for world pastoralists. Rangelands shelter millions of pastoralists often poor, politically marginalized, and dependent on livestock for survival in developing countries [1]. This is particularly true for African and sub-Saharan African pastoralists. In Africa, destitutions of pastoralists have now become very common, and previously better-off pastoralists have failed into chronic poverty [1–3]. In addition, the political system in many African countries had neglected and marginalized pastoralist groups in the past. There was even a period when pastoralism as a way of living was questioned in Africa [4]. However, several authors [4,5] indicated that pastoralism is one of the most environmentally sustainable and viable systems. The rangelands of developing countries have endured a wide array of challenges including poverty, environmental degradation, social conflicts, displaced people, and climate change [1]. Among these challenges, the degradation of rangeland is a major problem that begs the concern of research, policy, and practice. In the current study, rangeland degradation implies a sequential process of progressive departure from a reference ecological state for a given ecological site (climate, landform, and soil complex), accounting for natural fluctuations in reference conditions [6]. Once it happens, reversing degradation or restoring it to its original state could be difficult and costly at some stages of degradation [7]. Therefore, it is imperative to study the main drivers of changes in rangelands and their impacts and identify rehabilitation methods for degraded rangelands through indigenous community knowledge and ecological

techniques. This study, therefore, answers the basic question of the rate, trends, indicators, and impacts of rangeland degradation.

Similarly, to its other African counterpart, Ethiopian pastoralists are in a perilous precipice due to climate change and associated environmental ills. Several scholars have researched this theme in an Ethiopian context. These previous studies focused on the two regions predominated by pastoralists, namely Afar and Somalia, and some parts of the Oromia region. Tsegaye [8] conducted a study among Afar pastoralists and reported that rangelands in northern Afar have changed noticeably during the past 35 years. In another study conducted by Behnke and Kerven [9], pastoralists along the Awash valley rapidly lost their riverine grazing land in early 1970, the main driver surprisingly being development interventions, particularly the introduction of large-scale farming [10–12]. In the Somali region of Ethiopia, the existence of severe rangeland degradation that occurred since 1944 and which was aggravated after the 1974 drought was documented in the study of Gezahegn [13]. This study revealed that the degradation of rangeland in the Somali region has been severe since the 1974 drought, which has changed the conditions of the rangeland. Another study conducted in the *Rayitu* district of the Bale zone in the Oromia region has revealed poor rangeland conditions resulting from feed, water shortages, and drought [14]. Drought, aridity, and rangeland degradation has increased over time due to environmental degradation and mismanagement of rangeland resources [2].

Boorana rangeland resources have also experienced extensive changes [15]. Boorana rangeland systems were once considered one of the most typical and sustainable production systems in East Africa [16]. Rangeland conditions and traditional land-use patterns in Boorana have changed since the 1960s [17,18]. Dalle et al. [19] indicated that overall rangeland conditions appeared to be in a transitional state from good to bad with an increasing downward trend. Angassa [20] also indicated that the Boorana rangeland was dramatically changed and the application of the state and transition model applies in the analysis of the rangeland ecosystem. In general, the productivity of the Boorana rangeland had been declining with time [21,22]. A comparison of functional land-use units of rangelands indicated that rangeland conditions were better in *Kaloo* (enclosure) and Ranches than in *Warra* (home areas) and *Foora* (mobile herd area) [19]. This is probably due to the difference in management between functional land-use units in rangeland, where *kaloo* and ranches are enclosed and grazing is limited to certain seasons, but grazing within the vicinity of *warra* and *foora* is mostly communal. It was indicated that external interventions and the rapid growth of the human population affected the pastoral land-use system and have reduced the available grazing resources dramatically [18]. This is mainly because the development interventions of the 1970s were designed with the misguided objective of increasing rangeland productivity to exploit pastoral production for the national economy. These development programs and strategies, however, neglected pastoral rangeland management strategies and were guided by the profits the country could gain from livestock sectors. Such kinds of ill-mentioned development interventions did not bring the desired results, rather reduced mobility, triggered conflicts, reduced cooperation, reduced grazing reserves, and led to rangeland degradation [23].

The study on the conversion of savanna rangeland of Boorana indicated that rangelands had undergone substantial changes and have been fragmented [15, 24–26]. Among many factors contributing to the changes in the rangeland system of Boorana, encroachment and proliferation of bushes were the dominant factors [15, 24, 27, 28]. Changes in rangeland condition and degradations of prime rangelands lead to a decline in the productive capacity of livestock [29]. So far, there have been many studies conducted in the Boorana rangeland system for different purposes on several concerns. Many of previous studies extensively treated rangeland ecology [15, 20, 30, 31] and indigenous resource management [18,28,32] extensively. Even though the construction of community perceptions is the main tool for evaluating the impacts of environmental change and this can make crucial methodological contributions [17], the literature available on this topic is limited. The current study argued that the construction of pastoralist perceptions based on Gadaa timelines (Gada system is an indigenous democratic sociopolitical system of Oromo People. UNESCO also recently registers the Gadaa system as an intangible cultural heritage. Gadaa timeline is a period of eight years a Gadaa leader stays in power) can make an immense contribution to comprehending the rate, trends, indicators, and impacts of rangeland degradation in Boorana rangelands. Furthermore, the study believed that the pastoralist could better narrate rangeland conditions and factors responsible for changes by Gadaa timelines. Therefore, the study constructed the perceptions of Boorana pastoralists towards rangeland degradation and its impacts post-1992 (from Gadaa of Boruu Madhaa to Kuraa Jaarsoo).

## 2. Research Methodology

*2.1. Description of the Study Area.* The study was conducted in the Boorana zone (Figure 1) of the Oromia region in Ethiopia. Geographically, the Boorana zone is found between 3°26′ and 6°32′ north latitudes, and 36°43′ and 40°46′ east longitudes. In the south, the Boorana zone shares an international boundary with Kenya. The zone is bordered by the Somali region in the East and Southeast, the Guji zone in the East and Northeast, and the Southern Nations, Nationalities, and People's Region (SNNPR) in the west, northwest, and north. The study area is dominated by a semiarid climate [33] with an altitudinal range of 1,000 to 1,500 meter above sea level (m.a.s.l) [34], and the average mean annual rainfall from 1990 to 2017 measures nearly 520 mm (Figure 2). The Boorana area receives a bimodal pattern of rainfall with the main rains (ganna) falling between March and May and the short rains (hagayya) between September and November [20]. The data for this research were collected from March to June 2019 at different times. Although data collections started during the month of

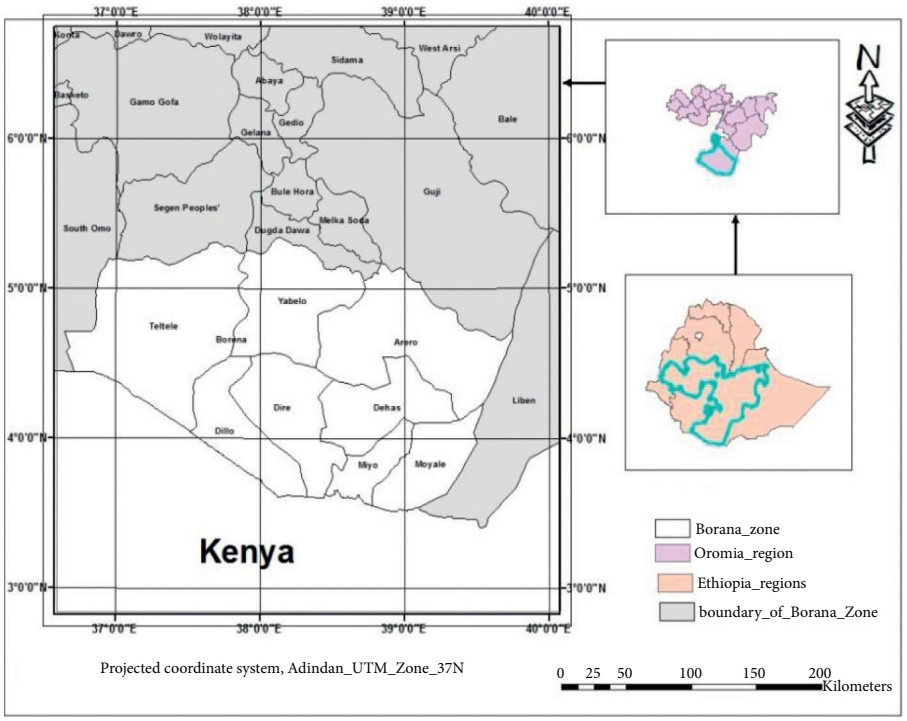


Figure 1: Map of the study area.

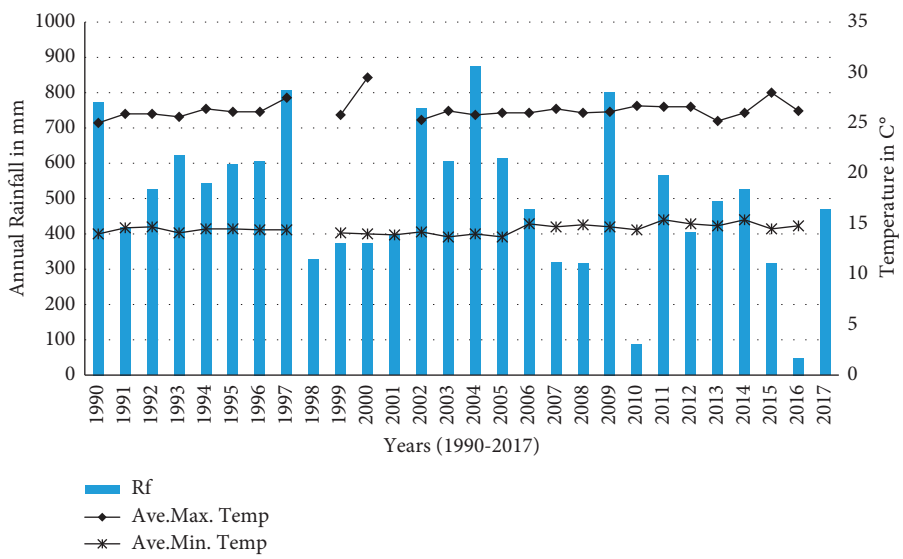


Figure 2: Annual rainfall, annual max, and min temperature at Yaaballo stations.

*ganna,* the *ganna* was late and did not arrive at the expected time. The Boorana zone comprises three traditional agro-climate zones namely, *Kola* (tropical) 56%, *Weyna Dega* (subtropical) 31%, and *dega* (warm temperate) 13% [3]. Based on the traditional ecological zonations of Boorana, the Boorana land is broadly categorized as Liiban and Dirree. The Liiban grazing zone (*dheeda*) is divided into *Golbaa* and *Gubbaa*. Dirree encompasses *goomolee*, *Malbee*, *Golboo*, *Dirree* (Tula wells grazing zone), and *Wayaama* grazing zone [26, 28] and the badda sadeen (the three subhumid zones) [35–37].

Computation of temperature data from 1990 to 2016 indicated that the average mean minimum and maximum temperature of the area ranges from 14.2°C to 25.4°C (Figure 2). Drought is a common hazard that has been occurring frequently every one to two years [33, 38]. Like in other pastoral rangelands of Ethiopia, the fauna in Boorana is mostly characterized by sparse vegetation composed of mainly grasses, bushes, shrubs, small trees, and bare land. Plant communities in Boorana semiarid areas consist of diverse mixtures of woody and herbaceous vegetation [33]. In addition, the woodlands of the Boorana rangelands are

characterized by species from the genera Combretum and Terminalia, while the bushlands and thickets, which cover most of the Boorana lowlands, are dominated by Acacia and Commiphora species [31].

*2.2. Research Method and Design.* This study was based on a mixed research method approach to construct pastoralist perceptions about the degree, trends, indicators, and impacts of rangeland degradation. The mixed method was used to describe the rates and trends of rangeland degradation using qualitative and quantitative methods. The qualitative method was based on the historical narrations of perceptions of participants, whereas the quantitative method was used to systematically summarize the responses. Both methods complement each other through a triangulation strategy. Both data sets were integrated into the analysis phase. Data were collected from pastoralists at one time, so a cross-sectional research design was employed in this study. The study analyzed the conditions of rangeland degradation based on the Gadaa time line, from the Gadaa of Boruu Madhaa (1992–2000) to Gadaa of Kuraa Jaarsoo (2016–2024) as narrated by pastoralists. The conception of time and history is very important in the Gadaa system. In this regard, Boorana Oromos time reckoning and the calendar that is permutation based on lunar rather than solar cycle are unique in East Africa [39]. This study has taken 1992 as a reference point and analyzed the conditions of rangeland for over 28 years. It was in the same year that Boruu Madhaa took office. This study was guided by a pragmatism philosophical underpinning to illuminate pastoralist perceptions of rangeland degradation and its impacts in post-1992. Pragmatism involves the collection, analysis, and integration of quantitative and qualitative data in a single or multiphase study [40]. Many previous studies [41,42] studies had pragmatism as philosophical foundation.

*2.3. Sampling Techniques and Procedures.* This study was conducted in the Boorana zone of the Oromia regional state in Ethiopia. The Boorana zone is further divided into districts, the middle-level administrative unit. Therefore, this study employed multistage purposive sampling where; in the first and second stages, the study districts (*Yaabello* and *Eelwayyee*) and the study *kebeles* (*kebele* is lower-level administrative unit in Ethiopia. It is lower than the district) under each district were selected respectively using purposive sampling techniques based on homogeneity of population and for efficient and timely data acquisition. From *Yaabello* district, the data was generated from *Harweeyyuu* and *Dharriito kebeles*, while from *Eelwayyee* district, the data was collected from *Aadee Galchat* and *Hiddii Aallee kebeles*. In the third stage, the villages in each *kebeles* were selected using simple random sampling techniques. In the fourth stage, the participants were selected using systematic random sampling.

In this study, a survey questionnaire was used as the main data-gathering tool. The survey was carried out to collect information related to the rate and trends of rangeland degradation, indicators, severity of degradation, and impacts of rangeland degradation during the periods of four Abbaa Gadaas. The questionnaire was also used to address the indigenous knowledge of Boorana pastoralists about rangeland management. Data was collected from sampled households during the field survey conducted by the lead researcher from March to June 2019 at different times. A total of 332 households participated in this study. The household questionnaire survey was prepared in English and translated into Afaan Oromoo, the native language of the Boorana pastoralists, to make it easier for the enumerators to gather the necessary information. The questionnaire includes open- and closed-ended questions. A pilot study was conducted before the actual data collection. Eight research assistants were hired to assist in the data collection and were trained by the lead researcher for two days on how the questionnaire survey would be administered, the way they can approach the respondents, and research ethics. These research assistants were selected based on their academic level (i.e., two MA and six Bachelor's degree holders), research experience, and exposure to the local area.

In addition, semistructured interviews, focus group discussions, and observation were also used as tools for gathering data. The observation was also the basic tool used to see the indicators of rangeland degradation in its biophysical settings. The observation allowed the researchers to understand the vegetation structure, forage species, and environmental conditions of the study area. The researchers used the checklist for field observation to observe changes in rangeland ecology.

A semi-structured interview was conducted with local elders, village heads, case households, *jaarsa argaa-dhageettii*, development agents, and leader of *ganda* to apprehend and illuminate pastoralist understanding of conditions of rangeland post-1992. The interviewees were selected based on their knowledge of the problem under investigation, referral from the community to those who are knowledgeable about resource management. The case study households were selected randomly from each study site. This study conducted 26 semi-structured interviews with respondents. A total of 18 semi-structured interviews were conducted with local elders, village heads, development agents, and leader of *kebele*. In addition, interviews were also conducted with 4 case study households and 4 *jaarsa argaa-dhageettii*. Through interviews, researchers were able to understand how the rangelands have changed over time. The participants were encouraged to narrate the main changes they have observed in the rangeland conditions by referring to their traditional Gadaa timelines besides its impacts and how changes in climatic conditions affected the potentials of rangeland resources under each Gadaa period.

Further focus group discussions (FGD) were also conducted with four groups to corroborate the degree and trends of rangeland degradation. FGD also enabled the researchers to comprehend how climatic conditions have been affecting rangeland resources and how pastoralist indigenous ecological knowledge is functioning. The discussants were selected based on their knowledge of the problem under investigation, popularity, and position in the community. Heterogeneous and homogeneous groups of elders,

women, village heads, and other community members were contacted. The number of participants in each group ranges from 6 to 8 individuals.

*2.4. Data Analysis.* The study employed the Gadaa timeline to elucidate pastoralist perceptions of rangeland degradation. Status and trends of rangeland post-1992 were analyzed through qualitative exploratory analysis and systematic descriptions of data obtained from a cross-sectional survey. In addition, indicators and impacts of rangeland degradation, impacts of climate change on rangeland conditions, and indigenous knowledge of pastoralists in rangeland management were analyzed through the narration of cases and summarization of quantitative data. Data were descriptively analyzed and presented using tables and graphs. Qualitative data were rephrased and put in a verbatim form and were analyzed by explorative analysis, which includes descriptions of response, content analysis, and narratives of case studies.

## 3. Results and Discussion

*3.1. The Rates and Trends of Rangeland Degradation.* "Let alone by the Gadaa period, deterioration of the rangeland occurs yearly. This year is not equal to last year and the coming year will also not be equal to this year" (discussant in FGD).

Based on community expert knowledge, the study found that rangelands were degraded. Angassa and Oba [17] attested that the perception of the community makes the most crucial methodological contributions. Almost all of the respondents (98.19%) noticed rangeland degradation in the Boorana rangeland system. In the discussion, the respondents reached the consensus that rangeland degradation was very severe in Boorana rangelands. Participants indicated that people usually wonder about the abundances during Gadaa Gobbaa Bulee (1968–1976); however, the conditions of rangeland resources have been decreasing from time to time. Similar studies also attested that the Afar rangeland [9,12,43] and Somali [13] were degraded severely.

The study revealed that across time, during the 30 years trends, the conditions of rangeland are deteriorating. Discussants added that from 2000 to 2016, for nearly two decades, the conditions of grasses have deteriorated. "In Gadaa of Guyyoo Gobbaa, even though *oolaa* (severe drought) affected livestock, there was a patch of grass that remained for the livestock," said one of the discussants. Participants further indicated that from 2016 (the year current Kuraa Jaarsoo assumed office), there were no grass reserves due to failure of *haggayya* (short rainy season) rain and late coming of *gannaa* (long rainy season). The participants further stressed that "let alone by the Gadaa period, deterioration of rangeland occurs yearly." "This year is not equal to last year and the coming year will also not be equal to this year," they said. This is consistent with the study of [6], which sees rangeland degradation as a sequential process of departure from ecological states. Many previous studies [17, 20, 24, 31] also confirmed that the Boorana rangeland has experienced extensive changes. Figure 3 below presents the rate of degradation of rangelands.

The study revealed that from 1992, the condition of the rangeland was improved nearly for a decade (33.43%). This indicates good rangeland conditions during Gadaa of Boruu Madhaa. Later on, from 2000 to 2008, rangelands were slightly degraded (47.11%). Furthermore, for more than a decade, the conditions of the rangelands showed high degradation, particularly during Gadaa of Guyyoo Gobbaa (60.18%) and Kuraa Jaarsoo (79.94%). This is consistent with the view of the respondents in interviews and discussions that indicated that the conditions of the rangeland were dwindling from time to time. During the early 1990s, the conditions of the rangeland were relatively good. The study indicated that the improvement in conditions of rangeland decreases from Gadaa of Boruu Madhaa to Kuraa Jaarsoo (1992 to 2021; Figure 3). Most of the respondents indicated that the Boorana rangelands after 1992 were severely degraded under each consecutive Gadaa period. Only 15.5% of respondents indicated that rangelands were highly degraded during Boruu Madhaa. However, during Gadaa of Liiban Jaldeessaa, Guyyoo Gobbaa and Kuraa Jaarsoo 16.72%, 60.18%, and 79.94% of respondents indicated that rangelands were highly degraded, respectively. A similar study [44] in northern China's rangeland also indicated that the rangelands were highly degraded. This indicates that rangeland degradation increases over time.

In the past 30 years, the degradation of the rangeland showed increasing trends in the Boorana rangeland systems. Respondents indicated that the trends of rangeland degradation in the Boorana rangelands have increased after 1992, the year Gadaa of Boruu Madhaa assumed Gadaa power. This is also consistent with the view of *jaarsa-argaa-dhageettii* (elders knowledgeable in what was seen and told), who indicated that the trends of degradation had been increasing from time to time since Gadaa of Jiloo Aagaa (1976–1984). However, before Gadaa of Jiloo Aagaa, Boorana had also experienced rangeland degradation. The rate and trends of rangeland degradation have been worsening with time. This means that the Boorana rangelands are degrading with an increasing trend. This dynamic change in the potential resource base of pastoralists and resultant degradation is related to sociopolitical dynamics, climate change, and underlying factors. An elder indicated that since the 1970s pastoralists had overwhelming threats of rangeland degradation, droughts, and conflict. "These days the condition of rangeland has been severely changing. You are asking the right things," he said. In the past, rangeland conditions were relatively good. However, respondents indicated that currently, the rate and trends of rangeland degradation have increased more than ever.

*3.2. Indicators and Severity of Rangeland Degradation*

*3.2.1. Vegetation and Biodiversity Related Indicators.* In an interview, an elder said, "let alone grass, even trees are thinned in our area." There are highly sparse trees and severe encroachment of thorny bushes in the area. It can be

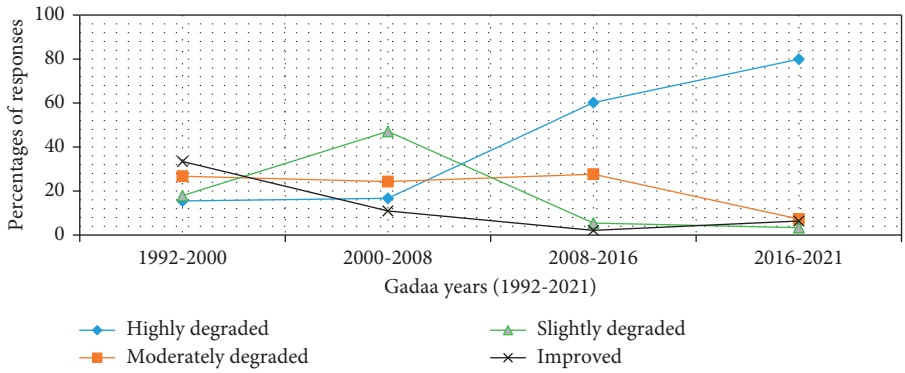


Figure 3: Rate of rangeland degradation in Boorana rangeland.

understood that the loss of grass species and vegetation is severe in the area. Pastoralists perceived that loss of palatable plants, proliferation of unpalatable species, loss of vegetation, loss of litter, decline in plant density, and bush encroachment were the main indicators of rangeland degradation in Boorana rangelands. Previous studies [12, 15,17, 29, 31, 45] have indicated that vegetation indicators, particularly bush encroachment, were the main indicators of rangeland degradation.

As shown in Table 1, the respondents perceive that from 1992, during the Gadaa of Boruu Madhaa, the main indicators of rangeland degradation were loss of palatable plants (60.84%) followed by decline in plant density (57.53%) and bush encroachment (54.22%). During Gadaa of Liiban Jaldeessaa (2000–2008), the loss of palatable plants (92.17%), bush encroachment (90.36%), and the decline in plant density (87.65%) were the three main indicators of rangeland degradation related to vegetation and biodiversity. Similarly, during the Gadaa of Guyyoo Gobbaa (2008–2016), the loss of palatable species (96.08%), bush encroachment (95.78%), and the proliferation of unpalatable species (94.88%) were the main indicators of rangeland degradation. Since 2016 (Gadaa of Kuraa Jaarsoo), bush encroachment (91.87%) has become the main indicators of rangeland degradation followed by proliferation of unpalatable species (90.96%) and loss of palatable plants (90.66%). The study indicated that for more than two decades (from 1992 to 2016), loss of palatable plant species was the main indicator of rangeland degradation, whereas, after 2016, bush encroachments were the main indicator of rangeland degradation. Therefore, this study is different from the study of [24], which observed a decrease in bushland cover.

As shown in Table 1, during the 2000–2016 period, there was a high loss of palatable plants. There were also high proliferation of unpalatable species during Gadaa of Guyyoo Gobbaa and Kuraa Jaarsoo. The participants perceived that both vegetation loss and litter were higher during Gadaa of Guyyoo Gobbaa and Kuraa Jaarsoo. In an interview, an elder consistently stated that "even the trees had dropped the leaf with exception of *Canaa* (haplocoelum foliolosum)." There was a high decline in plant density during Gadaa of Liiban Jaldeessaa. During the Gadaa of Boruu Madhaa, there were the lowest percentages for all indicators compared to other Gadaa periods. This indicates that degradation proceeds over time. It is also imaginable that the loss of palatable species and resultants proliferation of unpalatable species has created conducive environments for widespread bush encroachments. In the discussions, participants also attested that currently, the area grows more exotic species, forbs, and shrubs. Respondents indicated that there are many fulleensa (*Acacia drepanolobium*), saphansa (*Acacia mellifera*), dhaddacha (*Acacia tortilis*), gurbii (*Abutilon hirtum*), and adaa (*Aspilia mossambicensis*) species in the area. "These bushes and shrubs suppress the growth of grasses," they said. However, these are not the only encroachers there are too many encroaching plant species in the area. The percentages of responses for vegetation indicators were higher for Gadaa of Guyyoo Gobbaa than for the current Gadaa (Kuraa Jaarsoo).

The study area is covered with highly invasive species (Figure 4). Figure 4(a) depicts the growth of *cakkee* (*sansevieria robusta*) under other bushes. *Sansevieria robusta* grows very close to each other. It has large stiff leaves, which has needle-like sharp hard point. Since it grows very close to each other, the passages of both livestock and human are very limited. In addition, S*ansevieria robusta* suppresses the growth of grasses. Figure 4(b) also depicts the densely grown bushes, particularly *Acacia mellifera* and other bush species. In such dense and thickly dressed bushes let alone, the growth of grass, livestock, and humans cannot pass through it. Figure 4(c) portrays the growth of new *Acacia tortilis* in a very thick and dense manner, whereas, in Figure 4(d), it can be observed that the growth of bushes suppressed the grasses. The study area was subjected to widespread encroachment of different species of bushes [45]. It consistently indicated that bush encroachment contributes to the degradation of the pastoral environment. The proliferation of these bushes has become very severe than ever. In some cases, even clearing by hand may not be possible.

The study observed an increase in the severity of vegetation and biodiversity indicators of rangeland degradation during the past 30 years. Respondents indicated that between 1992 and 2000, the severity of loss of palatable species decreased (45.48%). In addition to the decrease in the severity of palatable species, respondents indicated that the severity of proliferation of unpalatable species, loss of vegetation, loss of litter, decline in plant density, and bush

Table 1: Vegetation and biodiversity indicators of rangeland degradation.

| Indicators | Boruu Madhaa Freq. (%) | Liiban Jaldeessaa Freq. (%) | Guyyoo Gobbaa Freq. (%) | Kuraa Jaarsoo Freq. (%) |
|---|---|---|---|---|
| Loss of palatable plant | 202 (60.84) | 306 (92.17) | 319 (96.08) | 301 (90.66) |
| Proliferation of unpalatable species | 179 (53.92) | 290 (87.35) | 315 (94.88) | 302 (90.96) |
| Loss of vegetation | 165 (49.70) | 288 (86.75) | 295 (88.86) | 290 (87.35) |
| Loss of litter | 172 (51.81) | 285 (85.84) | 297 (89.46) | 290 (87.35) |
| Decline in plant density | 191 (57.53) | 291 (87.65) | 289 (87.05) | 270 (81.33) |
| Bush encroachment | 180 (54.22) | 300 (90.36) | 318 (95.78) | 305 (91.87) |


Figure 4: Encroachment conditions of different bushes: (a) growth of *sansevieria robusta* and other bushes, (b) densely grown bushes, (c) growth forms of new *Acacia tortilis*, and (d) grass suppressed under *Acacia tortilis*.

encroachment have increased. The largest increase was observed for bush encroachment and loss of litter both accounting for 52.71%. During 2000–2008, the respondents perceived that the level of severity for all indicators was increased. There was the largest increase in bush encroachment (86.45%), loss of litter (85.84%), and proliferation of unpalatable species (85.54%). Additionally, from 2008, the severities of all indicators increased. The highest proportion of the respondents indicated that the severity of loss of palatable species (91.27%) and proliferation of unpalatable species (90.06%) increased during Gadaa of Guyyoo Gobbaa. In Gadaa of Kuraa Jaarsoo, there was an increased severity of vegetation loss (91.54%) and a decline in plant density (91.57%).

*3.2.2. Rangeland Production-Related Indicators.* The losses and decline in rangeland production capacity was the main indicator of rangeland degradation. This finding is in line with [12] that found a decline in the production capacity of the rangelands in the Afar region. The study found that the decrease in forage production, the low grazing capacity of rangelands, overgrazing, the increased distance to grazing lands, and the pressure on the livestock population were the main indicators of rangeland production, which in turn affects the overall productivity of rangelands. Other studies also consistently showed that overgrazing [45], forage scarcity [17, 46], and livestock population pressure [18, 46] as the main causes of rangeland degradation. From 1992, for nearly a decade, the low grazing capacity of rangeland

(54.22%) was the main indicator of rangeland degradation followed by an increased distance to the grazing lands (54.5%) and livestock population pressure (53.92%). From 2000 to 2008, there was a high decline in forage production (92.77%), high livestock population pressure (90.66%), and overgrazing (89.46%), whereas, during the Gadaa of Guyyoo Gobbaa, the decline in forage production (96.39%) and livestock population pressure (93.98%) has increased with increased distance to grazing land (95.78%) from the previous Gadaa period. Furthermore, during Gadaa of Kuraa Jaarsoo overgrazing (90.06%), the increased distance to grazing land (93.98%) and livestock population pressure (90.96%) were the main indicators of rangeland degradation related to rangeland production. The result also indicated that during the rainy and dry seasons, the mean walking distance time from home to the pastureland was 53.6 and 118.08 minutes, respectively.

The study indicated that the decline of the forage base of livestock was highest during the Gadaa of Guyyoo Gobbaa followed by Liiban Jaldeessaa. However, the participants perceived that other indicators were more visible in Gadaa of Guyyoo Gobbaa and Kuraa Jaarsoo. During the Gadaa of Boruu Madhaa, the lowest percentages of respondents observed these indicators compared to other Gadaa periods. During the past 30 years, the severity of rangeland degradation indicators related to rangeland production has increased. Respondents indicated that from 1992, for almost a decade, the largest increase was observed for the increased distance to grazing land (55.12%) and the livestock population pressure (53.61%). From 2000 to 2008, respondents perceived that the level of severity for all indicators increased. There was the largest increase in overgrazing and livestock population pressure both accounting for 87.35%. In addition, there was also an increased distance to grazing land (87.05%). Likewise, during the Gadaa of Guyyoo Gobbaa, the severity of overgrazing (92.77%) and livestock population pressure (92.47%) was increased. In Gadaa of Kuraa Jaarsoo, there were increased severity of low grazing capacity and livestock population pressure both accounting for 92.77%.

*3.2.3. Human-Related Indicators of Rangeland Degradation.* Human-related indicators are related to human exploitation of resources that leads to the degradation of rangeland resources. The study found that increase in privatization of grazing land, human population pressure, deterioration of water points and conversion of pastureland to farmland were the main indicators of rangeland degradation related to human exploitation. Previous studies consistently found that human activities such as deforestation, charcoal production, unwise use of resources, population growth [45], increased cultivation [24, 46], and privatization [46–48] contributed to rangeland degradation. As shown in Table 2, during Gadaa of Boruu Madhaa, water points deteriorated (60.24%). The respondents also indicated that there was high population pressure during this period (53.92%). Respondents indicated that from 2000 to 2008, there was high human population pressure (88.25%), followed by conversion of pastureland to farmland (86.75%) and deterioration of water points (85.84%). During 2008–2016, the main human-related indicators of rangeland degradation were the conversion of pastureland to farmland (96.69%), human population pressure (94.58%), and privatization of pastureland (91.27%). Since 2016 (in the Gadaa of Kuraa Jaarsoo), 94.58% of the respondents indicated that human population pressure was the main indicator of rangeland degradation. In addition, the respondents indicated that the deterioration of the water points (93.98%) and the conversion of pastureland to farmland (91.57%) were the main indicators of the degradation of the rangeland. The result also revealed that the privatization of pasturelands and the conversion of pasturelands to farmlands were highest during Gadaa of Guyyoo Gobbaa (2008–2016), while population pressure and deterioration of water points became highest in Gadaa of Kuraa Jaarsoo.

The respondents indicated that during past 30 years, the severity of human-related indicators of rangeland degradation has increased for all Gadaa periods. During Gadaa of Boruu Madhaa, the largest increase was observed for deterioration of water points and conversion of pastureland to farmland both accounting for 54.22%. The respondents also indicated that the severity of privatization of pasture land and the pressure on the human population has also increased. Similarly, during the Gadaa of Liiban Jaldeessaa respondents perceived that the largest increase was observed in the deterioration of water points (87.95%) and conversion of pastureland to farmland (87.35%). Between 20008 and 2016, the severity of privatization of pastureland (91.57%) and conversion of pastureland to farmland (91.87%) increased. Similarly, during the Gadaa of Kuraa Jaarsoo, there was an increase in the severity of privatization of pastureland (91.87%) and conversion of pastureland to farmland (92.47%). The percentages of responses for human-related indicators were higher for Gadaa of Guyyoo Gobbaa than for current Gadaa (Kuraa Jaarsoo) for some indicators.

*3.2.4. Environmental and Climatic-Related Indicators.* Boorana rangelands are under pressure from multifaceted climatic and environmental factors. This study found that the main causes of rangeland degradation related with climatic and environmental conditions are rise in temperature, drying up of wells and ponds, lack of water for livestock, changes in average rainfall, increase of soil erosion, runoff, and bare land (Table 3). In line with these findings, studies confirmed that increased dryness [45], bareness of the land [24], and aridity [2] were the main factors associated with rangeland degradations. Respondents also confirmed that lack of pastures, recurrent drought, increased bareness, and lack of water were the main characteristics of rangeland degradation. Participants perceived that during 1992, for nearly a decade, lack of water for livestock (59.64%), drying up of wells and ponds (58.13%), and increased bareness of land (56.02%) were the main indicators of rangeland degradation under this category.

Further participants perceived that during Gadaa of Liiban Jaldeessaa (2000–2008), the main indicators of rangeland degradation were changes in the average rainfall (87.05%), increased bareness of land (86.14%), and increase

Table 2: Human related indicators of rangeland degradation.

| Indicators | Boruu Madhaa Freq. (%) | Liiban Jaldeessaa Freq. (%) | Guyyoo Gobbaa Freq. (%) | Kuraa Jaarsoo Freq. (%) |
|---|---|---|---|---|
| Privatization of grazing land | 162 (48.80) | 274 (82.53) | 303 (91.27) | 297 (89.46) |
| Human population pressure | 179 (53.92) | 293 (88.25) | 314 (94.58) | 314 (94.58) |
| Deterioration of water points | 200 (60.24) | 285 (85.84) | 301 (90.66) | 312 (93.98) |
| Conversion of pastureland to farmland | 159 (47.89) | 288 (86.75) | 321 (96.69) | 304 (91.57) |

in soil erosion and runoff (85.54%). Likewise, respondents indicated that between 2008 and 2016, the bareness of the land (97.29%) has increased, and in some way, increase in soil erosion and runoff (97.28%) and changes in average rainfall (96.08%) were the main indicators. In 2016, respondents indicated that lack of water for livestock and increased bareness of land were the main indicators of rangeland degradation, both accounting for 96.69%. Furthermore, it was indicated that the increase in soil erosion and runoff (96.08%) in rangelands were the main indicators of rangeland degradation. Respondents indicated that there was an increase in the occurrence of rangeland degradation indicators from one Gadaa period to another. Compared to the other Gadaa periods, the percentages of climatic and environmental indicators were lower during the Gadaa of Boruu Madhaa. During Gadaa of Guyyoo Gobbaa and Kuraa Jaarsoo, there were high percentages of responses for all indicators. The percentages of responses for environmental and climatic-related indicators were higher for Gadaa of Guyyoo Gobbaa than current Gadaa (Kuraa Jaarsoo) for some indicators.

During the past 30 years, the respondents indicated that there was a high increase in the severity of environmental and climatic indicators of rangeland degradation. There was the largest increase in drying up of wells and ponds (55.12%) and changes in the average rainfall (55.72%) during 1992–2000. The respondents also indicated that the severity of other indicators has also increased. During Gadaa of Liiban Jaldeessaa, respondents perceived that there were the largest changes in the average rainfall (88.55%). In addition, the largest proportion of respondents (88.25%) observed an increase in soil erosion and runoff and increased bareness. During Gadaa of Guyyoo Gobbaa, there was the largest increase in the severity of changes in the average rainfall (93.67%) followed by an increase in the severity of extreme temperature and soil erosion and runoff both accounting for 92.17%. In the Gadaa of Kuraa Jaarsoo, there was an increased severity of the change in average rainfall (94.58%) and soil erosion and runoff (93.05%).

### 3.3. Impacts of Rangeland Degradation

*3.3.1. Impacts on Rangeland Productivity.* The participants perceived that the progressive deterioration in the conditions of the rangeland resources has adversely affected the productivity of the rangelands. The main impacts of rangeland degradation related to rangeland productivity were the reduction of rangeland productivity and grass cover. This is consistent with previous studies [46, 49]. From 1992, for nearly a decade, the largest proportions of respondents perceived that rangeland degradation has resulted in the reduction of rangeland productivity. In addition, since 2000, for more than two decades, rangeland degradation has resulted in the reduction of grass cover. Comparing all Gadaa periods, it was indicated that the largest decline in rangeland productivity and grass cover was observed during Gadaa of Guyyoo Gobbaa (2008–2016). This is probably due to the severe drought that stuck Boorana during his term. The participants in the focus groups consistently agreed that degradation of the rangeland leads to reductions in the productivity of the rangeland and grass cover. In an interview, an elder stated that there was no adequate pasture for their livestock. "There is no grass, grass has now been lost from the area," he said. Additionally, the participants believed that the grass is not nutritious for livestock. Thus, it can be understood that rangeland degradation resulted in the reduction and loss of grass cover, which in turn reduces the *finna* (nutritiousness), and productivity of the pasture. Boorana pastoralists usually say *laftii finna hin qabdu* (the land/pasture is not nutritious). Generally, pastoralists believed that despite the abundance and plenty of pasture and water, the *finna* (nutritiousness) of the resources is very important. Sometimes despite the abundance of pastures, there are no *finna*, whereas in some cases very few resources have *finna* for livestock.

The respondents confirmed that there is no grass. In an interview, a young woman indicated that there was no pasture. "Yes, there is no grass. Livestock have nothing to grass from the land," she said. Angassa and Beyene [46] consistently reported a reduction in rangeland production and grasses. There was limited grass growth during the rainy season. Thus, livestock depend on small grasses and different leafy vegetation after rain. After running out of the available pastures, pastoralists usually collect grasses from nearby rangelands and also use the advantages of crop residue during the harvest and keep livestock around the farm. Participants believed that recurrent droughts, erratic rainfall, and degradation of rangelands are inextricable. Lack of rain over a long period of time results in the protracted drought that together leads to the progressive degradation of rangeland and reduction of rangeland productivity. Besides erratic rainfall and prolonged drought, several factors contribute to the reduction in grass cover. In the discussion, one of the participants stated that "the pasture land was highly covered with encroaching species." Another participant also stated that "the other issues were erratic rainfall and rapid expansion of bush cover." At all study sites, the respondents consistently attested that bushes prohibit the growth of

Table 3: Environmental and climatic-related indicators.

| Indicators | Boruu Madhaa Freq. (%) | Liiban Jaldeessaa Freq. (%) | Guyyoo Gobbaa Freq. (%) | Kuraa Jaarsoo Freq. (%) |
|---|---|---|---|---|
| Extreme temperature | 167 (50.30) | 279 (84.04) | 320 (96.39) | 317 (95.48) |
| Drying up of wells and ponds | 193 (58.13) | 280 (84.34) | 316 (95.18) | 298 (89.76) |
| Lack of water for livestock | 198 (59.64) | 281 (84.64) | 316 (95.18) | 321 (96.69) |
| Changes in average rainfall | 178 (53.61) | 289 (87.05) | 322 (96.99) | 304 (91.57) |
| Increase of soil erosion and runoff | 181 (54.52) | 284 (85.54) | 322 (97.28) | 319 (96.08) |
| Increased bareness of land | 186 (56.02) | 286 (86.14) | 323 (97.29) | 321 (96.69) |

grasses, suppress the available grasses, and "thus, it is not possible for new grass to grow under dense bush cover."

*3.3.2. Impacts on Livestock Production.* Respondents perceived that rangeland degradation has adversely affected livestock productivity. The largest proportion of the participants indicated that progressive degradation in rangeland resources has reduced animal production, resulting in the outbreak of livestock disease, death of livestock, livestock emaciation, and rapid fall in the livestock price. Previous studies consistently indicated that rangeland degradation reduces livestock production through reduction of animal production [2], outbreak of livestock disease [2, 50], death of livestock [46], emaciation [45], and rapid fall in livestock price [51]. As shown in Table 4, during the early and late 1990s, rangeland degradation has resulted in a rapid fall in livestock price (84.94%), livestock death (83.43%), and a reduction in animal production (82.83%). From 2000 to 2008, the deterioration of rangeland resources was associated with a rapid fall in livestock price (94.88%), the reduction in animal production (91.87%), and the outbreak of livestock disease (91.27%).

The respondents also indicated that reduction in animal production (95.48%), livestock emaciations (94.58%), and livestock death (94.26%) were the main impacts of rangeland degradation during Gadaa of Guyyoo Gobbaa (2008–2016). Furthermore, before *gadaamojjii* (the seventh and last grade in the Gadaa system) of Gadaa of Kuraa Jaarsoo cattle were emaciated (90.36%), animal production was reduced (88.86%), and a rapid fall in the price of livestock (86.14%) was observed. These all happened due to the late coming of *gannaa* (main rainy season) rain, which affected the rangeland production in *adoolessaa* (small dry season), and the late coming of *haggayya* (short rainy season) rain, though sufficient amount of rain occurred throughout Boorana land later. Participants perceived that the largest reduction in animal production was observed during Gadaa of Guyyoo Gobbaa and outbreaks of livestock diseases were noticed during Gadaa of Liiban Jaldeessaa. In addition, the highest proportion of respondents also indicated that emaciation and livestock death were highest during the Gadaa of Guyyoo Gobbaa. Furthermore, participants indicated that the price of livestock was not good during the Gadaa of Liiban Jaldeessaa (2000–2008). The percentages of responses to impacts on livestock production were higher for Gadaa of Guyyoo Gobbaa than for current Gadaa (Kuraa Jaarsoo).

Participants reported that due to their dependency on livestock, their life is difficult, vulnerable, and worrisome. During the rainy time, the conditions of livestock is good because they look fat; they breed and make pastoralists happier. However, in an interview, an elder said that "we wilt like a dying leaf of cabbage if drought comes." It can be understood that pastoral livestock production is highly vulnerable to shocks. Several factors contributed to the vulnerability of the livestock sector. Respondents indicated that rangeland degradation was severe and that pasture was not enough to feed livestock. The grazing land was not sufficient because many areas were taken by settlement and cultivation. Furthermore, pastoralists perceived that crop residues were not adequately collected and were wasted in the rain and sun. The participants reported that in addition to pasture, the main problem of pastoralists is the lack of sufficient water. Thus, prolonged drought together with very low availability of grasses and erratic rainfall affected livestock production. In line with this, [46] indicated that rangeland degradation reduced mitigation of risks of livestock loss during drought. The participants felt that the prime grazing lands were already degraded and threatened the production of livestock. Many of the respondents confirmed that though emaciated, the condition of livestock was generally good except of camels, goats, and sheep. Some of the respondents' perceptions of the impacts of rangeland degradation on livestock production were put in verbatim form as follows:

> *"Since there is no enough pasture livestock are emaciated and dying. The condition of goat and sheep is very bad"* (an elder from Hiddii Aallee, Eelwayyee district).
>
> *"Goats and camels are in very bad conditions. Camels and goats are dying"* (an elder from Dharriito, Yaabello district).
>
> *". . .due to lack of plenty of grasses and prolonged drought, the conditions of livestock are very poor. You keep them well they die; you water them well they die and also you cut and carry fodder for them they die"* (an elder from Aadee Galchat, Eelwayyee district).

The respondents reported that the lack of resources, especially pastures and water, had significantly affected the productivity of the livestock. It can be understood that generally, livestock were emaciated; however, particularly, the conditions of goats, sheep, and camels were not good. Participants indicated that *bona haggayya* (severe dry

Table 4: Impacts on livestock production.

| Impacts on livestock production | Boruu Madhaa Freq. (%) | Liiban Jaldeessaa Freq. (%) | Guyyoo Gobbaa Freq. (%) | Kuraa Jaarsoo Freq. (%) |
|---|---|---|---|---|
| Reduced animal production | 275 (82.83) | 305 (91.87) | 317 (95.48) | 295 (88.86) |
| Outbreak of livestock disease | 271 (81.63) | 303 (91.27) | 299 (90.06) | 282 (84.94) |
| Death of livestock | 277 (83.43) | 290 (87.35) | 312 (94.26) | 283 (85.24) |
| Livestock emaciation | 270 (81.33) | 296 (89.16) | 314 (94.58) | 300 (90.36) |
| Rapid fall in livestock price | 282 (84.94) | 315 (94.88) | 304 (91.57) | 286 (86.14) |

season) and the late arrival of *gannaa* have resulted in severe feed shortages and livestock emaciation. All respondents consistently stressed that the conditions of cattle were relatively good; however, goats, sheep, and camels were severely emaciated and dying. "Sheep and goats were starving and dying in kraal and on the way to home," many of the respondents said. In addition, the respondents reported that camels were sitting everywhere. Most of the respondents consistently stated that "currently livestock are never full up." The responses of the participants were different from the orthodox view that camels, goats, and sheep are more resilient [45,50,52] due to the disease condition for camels, goats, and sheep during data collection. Respondents have an understanding that in the past sheep, goats and camels were more resilient to drought and harsh environmental conditions. However, the respondents indicated that the reason for this, in addition to feed shortages and droughts, was that goats, sheep, and camels have diseases. Though feed shortages, droughts, and associated diseases might have reduced the resilience of these livestock species, the study is still optimistic that camels, goats, and sheep are more resilient than cattle. The paragraph below narrates the view of an elder from *Aade Galchat* on the impacts of rangeland degradation and prolonged drought on livestock production:

According to the Boorana age-set, I am *Dambala Diidaa* (*Dambala Diidaa* is one of the age-set (*Harriyya*) in Boorana. In Boorana age of individuals is counted from the Gadaa period in which he was born. *Dambala Diidaa* was born in Gadaa of Guyyoo Boruu Galma (1944–1952). At the time of interview, *Dambala Diidaa* is an elder at the age of late 70s.). In the past, the death of livestock during drought was very rare. There were plenty of grasses, which were sufficient to feed our livestock. We freely use mobility and grass our livestock in the garaacha kootichaa (garaacha kootichaa means the midst of the land of black cotton soil where adequate pasture is available.) and water them by sadeen (each third day) at Eela Araarii, Eela Galchat, Carii, Burqaa, and Galaana konsoo (Segen river) that are the main sources of water for livestock for Boorana in gaara-garjaloo (below mountain, including Eelwayyee, Carii, and its environs)), and livestock were not dead from drought because the pastures were abundant and plentiful. In this drought in Aade Galchat, livestock are emaciated, and people are holding a tail of cattle to support them stand. The conditions of goats, sheep, and camels are bad. Goats consume few remaining leafy trees such as Canaa (*haplocoelum foliolosum*). Sheep cannot consume trees like goats, and since there are no grasses, sheep are starving. Camels have nothing to consume and fall into large gullies trying to consume from the trees on the edge of the gullies. Therefore, due to the lack of plenty of grasses and prolonged drought, the conditions for livestock are very bad. Though we take care of them well, water them properly, and cut and carry fodder for them, they may not survive.

*3.3.3. Human Impacts of Rangeland Degradation.* Rangeland degradation affects not only rangeland and livestock production but also human aspects. Pastoralists perceived that rangeland degradation is associated with weakening of social networks, decline of traditional coping mechanisms, escalation of conflicts, food insecurity, increased poverty, and dependency on food aid (Table 5). In line with this finding, rangeland research found weakening of social networks [45], decline of traditional coping mechanisms [2, 46], escalation of conflicts [1], food insecurity, increased poverty, and dependence on food aid [2] as impacts of rangeland degradation.

Respondents indicated that during the early and late 1990s, rangeland degradation has resulted in the weakening of the traditional coping mechanisms (85.84%) and food insecurity (81.63%). Progressive degradation of rangeland resources and underlying factors was associated with decline in traditional coping mechanisms (93.67%), weakened social networks (92.47%), and escalation of conflicts (92.17%) from 2000 to 2008. During the Gadaa of Guyyoo Gobbaa, the highest proportion of respondents indicated a weakened social network (94.88%), dependency on food aid (94.56%), and food insecurity (94.28%) were the main impacts of rangeland degradation. Participants confirmed that due to rangeland degradation and feed shortages, there was increased poverty (93.98%) from the year 2016. In addition, respondents also perceived that dependency on food aid (92.17%) and food insecurity (91.27%) were other human-related impacts of rangeland degradation. In general, the respondents indicated that the greatest decline in the traditional coping mechanism was observed during Gadaa of Liiban Jaldeessaa. Additionally, the highest proportion of respondents perceived the weakening of the social network, escalation of conflicts, food insecurity, and dependency on food aid was highest during Gadaa of Guyyoo Gobbaa. The level of poverty increased in an unacceptable way during Gadaa of Kuraa Jaarsoo. The percentages of responses for human impacts of rangeland degradation were higher for Gadaa of Guyyoo Gobbaa than for current Gadaa (Kuraa Jaarsoo).

Table 5: Human impacts of rangeland degradation.

| Impacts | Boruu Madhaa Freq. (%) | Liiban Jaldeessaa Freq. (%) | Guyyoo Gobbaa Freq. (%) | Kuraa Jaarsoo Freq. (%) |
|---|---|---|---|---|
| Social network weakened | 268 (80.72) | 307 (92.47) | 315 (94.88) | 297 (89.73) |
| Decline in traditional coping mechanism | 285 (85.84) | 311 (93.67) | 308 (92.77) | 286 (86.14) |
| Conflicts | 262 (78.92) | 306 (92.17) | 309 (93.35) | 293 (88.25) |
| Food insecurity | 271 (81.63) | 301 (90.94) | 313 (94.28) | 303 (91.27) |
| Increased poverty | 270 (81.33) | 304 (91.57) | 308 (92.77) | 312 (93.98) |
| Dependency on food aid | 268 (80.72) | 302 (91.24) | 313 (94.56) | 306 (92.17) |

Shortages of rainfall have also reduced the productivity of livestock and crops. As a result, *Hiddii Aallee* informants stressed that people were starving. In the discussion, discussants at *Hiddii Aallee* consistently stated that "people are starving." "Before coming of the drought we have some food to eat," discussants clearly said. One of the discussants expressed his sincere confirmation to us by stating, "you might have observed the situation in the villages." In fact, the *Hiddii Aallee* communities were known for their poverty, and the productive safety net program supported the largest proportion of the community. Therefore, if it did not rain soon, "we are in a big fear," they said. Likewise, respondents attested that even for those people who engaged in the livestock trade, the price for livestock was not good. "It is declining," they said. These conditions have led to the high vulnerability of pastoralists to the impacts of progressive rangeland degradation and recurrent droughts. When asked about their coping mechanisms and resilience, the *Hiddii Aallee* community discussants consistently stated, "we have no other hope other than *Waaqaa* (God), because no one has ever cut hope from God."

## 4. Conclusions and Policy Recommendations

The study constructed perceptions of pastoralists on the rates, trends, indicators, and impacts of rangeland degradation based on Gadaa timeline. Perceptions of community experts post-1992 (the year Boruu Madhaa took office) to the current Gadaa period were assessed. It was found that in the late 1960s, rangeland resources were abundant and the conditions of rangelands were good. However, the conditions of rangeland resources have been worsening over time. The degradation of rangeland has shown increasing trends. Therefore, it can be concluded that Boorana rangeland is in a state of worst degradation unless serious management options that incorporate indigenous and ecological techniques of restorations that are undertaken.

The study underscored that vegetation, rangeland production, human, environmental, and climate change-related indicators were the main indicators of rangeland health. Rangeland degradation is associated with factors that reduce rangeland productivity. Thus, addressing these factors can minimize the process of degradation. Boorana rangelands are more clearly characterized by the loss of palatable plants and proliferation of unpalatable species and bush encroachments. It is therefore evident that Boorana rangeland could be totally converted to a bush-dominated landscape over time. The study suggests that much effort should be put into reducing the adverse impacts of bush encroachments on rangeland production. In addition to human exploitation of rangeland resources through privatization of grazing land, population pressure and expansion of crop cultivation into communal rangelands are the main drivers of rangeland degradation. This has distorted the functioning of indigenous knowledge of pastoralists and become a source of persistent disputes in the community. Thus, privatization must be strictly prohibited, and community-based zonation and mapping of traditional land-use types should be maintained. Furthermore, it can be concluded that community knowledge provides the foundation for understanding the key indicators of rangeland degradation.

The progressive degradation of rangeland resources has jeopardized rangeland production, livestock productivity, and human well-being in the Boorana rangeland system. Prolonged drought and water scarcity were the main climatic factor that has been affecting Boorana pastoralist production. Thus, much effort must be given to how to minimize the adverse effects of drought through pre-drought destocking and reserving of grain and post-drought recovery and restocking where needed. The government and stakeholders involved should further focus their efforts on the development of water projects that can sustain pastoralist needs. The study underscored that although all livestock were emaciated, the conditions of goats, sheep, and camels were not good due to *bona haggayya* (severe dry season) and the late arrival of *gannaa*, which resulted in severe feed shortages. This is different from the orthodox view that states that camels, goats, and sheep are more resilient due to the fact that they have diseases in addition to week-body conditions. Despite the bad conditions experienced, this study is still optimistic about the promotion of drought-resistant livestock species in peripheral pastoralist areas. It is therefore evident that reliance on livestock continues to make life much more difficult, vulnerable, worrisome, and hopeless for pastoralists. However, recognition and promotion of indigenous ecological knowledge of pastoralists can sustain pastoralist communities in arid and semiarid rangelands. Therefore, understanding Boorana pastoralist knowledge in constructions of trends, indicators, and impacts of rangeland degradations is crucial for understanding the dynamics of the rangeland ecosystem in East Africa.

## Data Availability

The data used for the study will be available upon request.

## Disclosure

The authors would also want to acknowledge that this manuscript is part of PhD dissertation entitled "Poverty, Rangeland Degradation and Livelihoods of Pastoralists in Boorana Rangeland System, Southern Ethiopia" by Dr. Galgalo Dika submitted to Ababa University in 2021.

## Conflicts of Interest

The authors declare that there are no conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Acknowledgments

This study is funded by Addis Ababa University. The authors would like to thank the data collection teams for devoting themselves to collecting the necessary data. The authors are very much grateful to local communities who were willing to participate in the study. The authors have immensely benefited from their knowledge of their environment.

## References

[1] D. L. Coppock, M. Fernández-giménez, P. Hiernaux et al., "Rangeland systems in developing Nations: conceptual advances and societal implications," *Rangeland Systems*, Springer, Berlin, Germany, 2017.

[2] A. Kassahun, H. A. Snyman, and G. N. Smit, "Impact of rangeland degradation on the pastoral production systems, livelihoods and perceptions of the Somali pastoralists in Eastern Ethiopia," *Journal of Arid Environments*, vol. 72, no. 7, pp. 1265–1281, 2008.

[3] D. Tolossa, "Pathways of livelihood transformation among borana of southern Ethiopia," *Eastern Africa Social Science Research Review*, vol. 34, no. 1, pp. 137–169, 2018.

[4] R. Hogg, "Should pastoralism continue as a way of life," *Disasters*, vol. 16, no. 2, pp. 131–137, 1992.

[5] B. A. Gebeye, "Unsustain the sustainable: an evaluation of the legal and policy interventions for pastoral development in Ethiopia," *Pastoralism*, vol. 6, no. 1, 2016.

[6] C. Jamsranjav, R. S. Reid, M. E. Fernández-Giménez, A. Tsevlee, B. Yadamsuren, and M. Heiner, "Applying a dryland degradation framework for rangelands: the case of Mongolia," *Ecological Applications*, vol. 28, no. 3, pp. 622–642, 2018.

[7] S. J. Milton, W. R. J. Dean, M. A Plessis, and W. Siegfried, "A conceptual model of arid rangeland degradation," *BioScience*, vol. 44, no. 2, pp. 70–76, 1994.

[8] B. Tsegaye, *Assessment of Land Degradation Using Gis Based Model and Remote Sensing in Bishan Guracha-Adilo Subcatchments, Southern Ethiopia*, Addis Ababa University, Addis Ababa, Ethiopia, 2007.

[9] R. Behnke and C. Kerven, "Replacing pastoralism with irrigated agriculture in the awash valley, north-eastern Ethiopia: counting the costs," *Paper Presented at the International Conference on Future of Pastoralism*, 2011.

[10] R. Hailu, *Water Security In the Awash Basin of Ethiopia: An Institutional Analysis (Issue June)*, Addis Ababa University, Addis Ababa, Ethiopia, 2018.

[11] B. Hundie and M. Padmanabhan, *The Transformation of the Afar Commons in Ethiopia: State Coercion, Diversification and Property Rights Change among Pastoralists*, University of Pennsylvania Press, Philadelphia, PA, USA, 2008.

[12] M. Tilahun, A. Angassa, A. Abebe, and A. Mengistu, "Perception and attitude of pastoralists on the use and conservation of rangeland resources in Afar Region, Ethiopia," *Ecological Processes*, vol. 5, no. 1, p. 18, 2016.

[13] A. K. Gezahegn, *Characterization of rangeland resources and dynamics of the pastoral production systems in the Somali region of eastern Ethiopia*, PhD Thesis, University of the Free State, Bloemfontein, South Africa, 2006.

[14] T. Abate, A. Ebro, and L. Nigatu, "Traditional rangeland resource utilisation practices and pastoralists' perceptions on land degradation in south-east Ethiopia," *Tropical Grasslands*, vol. 44, pp. 202–212, 2010.

[15] T. Abate and A. Angassa, "Conversion of savanna rangelands to bush dominated landscape in Borana, Southern Ethiopia," *Ecological Processes*, vol. 5, no. 1, p. 6, 2016.

[16] N. J. Cossins and M. Upton, "The Borana pastoral system of Southern Ethiopia," *Agricultural Systems*, vol. 25, no. 3, pp. 199–218, 1987.

[17] A. Angassa and G. Oba, "Herder perceptions on impacts of range enclosures, crop farming, fire ban and bush encroachment on the rangelands of Borana, Southern Ethiopia," *Human Ecology*, vol. 36, no. 2, pp. 201–215, 2008.

[18] S. Homann, B. Rischkowsky, J. Steinbach, M. Kirk, and E. Mathias, "Towards endogenous livestock development: borana pastoralists' responses to environmental and institutional changes," *Human Ecology*, vol. 36, no. 4, pp. 503–520, 2008.

[19] G. Dalle, B. L. Maass, and J. Isselstein, "Rangeland condition and trend in the semi-arid Borana lowlands, southern Oromia, Ethiopia," *African Journal of Range and Forage Science*, vol. 23, no. 1, pp. 49–58, 2006.

[20] A. Angassa, *The Dynamics of Savanna Ecosystems and Management in Borana, Southern Ethiopia*, Norwegian University of Life Sciences (UMB), As, Norway, 2007.

[21] G. Dika, *The Role of Indigenous Knowledge in Rangeland Management and Pastoralist Perception on Factors Affecting its Productivity in Yabello Woreda, Southern Oromia, Ethiopia*, Adama Science and Technology University, Adama, Ethiopia, 2013.

[22] J. Doyo, *Indigenous Practices of Rangeland Management: Constraints and Prospects in Borana Pastoralists of Southern Ethiopia, Oromia Regional State*, Addis Ababa University, Addis Ababa, Ethiopia, 2011.

[23] B. Demissie, *State Development Interventions versus Indigenous Resource Management Institutions: Whose Reality Count? Evidence from Borana Pastoral System of Southern Ethiopia*, 2016, https://mpra.ub.uni-muenchen.de/id/eprint/70780.

[24] M. Elias, O. Hensel, U. Richter, C. Hülsebusch, B. Kaufmann, and O. Wasonga, "Land conversion dynamics in the borana rangelands of southern Ethiopia: an integrated assessment using remote sensing techniques and field survey data," *Environments*, vol. 2, no. 4, pp. 1–31, 2015.

[25] N. McCarthy, A. Kamara, and M. Kirk, "The effect of environmental variability on livestock and land-use management: the Borana Plateau," *Southern Ethiopia EPTD Discussion Paper*, vol. 75, 2001.

[26] G. Oba and D. G. Kotile, "Assessments of landscape level degradation in Southern Ethiopia: pastoralists versus ecologists," *Land Degradation & Development*, vol. 12, no. 5, pp. 461–475, 2001.

[27] S. A. Asongu and S. Le Roux, "Understanding sub-saharan africa's extreme poverty tragedy," *International Journal of Public Administration*, vol. 42, no. 6, pp. 457–467, 2019.

[28] D. Godana G, "The role of indigenous knowledge in rangeland management in yabello woreda, southern Oromia, Ethiopia," *Arts and Social Sciences Journal*, vol. 07, no. 02, 2016.

[29] T. B. Solomon, H. A. Snyman, and G. N. Smit, "Cattle-rangeland management practices and perceptions of pastoralists towards rangeland degradation in the Borana zone of southern Ethiopia," *Journal of Environmental Management*, vol. 82, no. 4, pp. 481–494, 2007.

[30] A. Angassa, "The ecological impact of bush encroachment on the yield of grasses in Borana rangeland ecosystem," *African Journal of Ecology*, vol. 43, no. 1, pp. 14–20, 2005.

[31] G. Dalle, B. L. Maass, and J. Isselstein, "Encroachment of woody plants and its impact on pastoral livestock production in the Borana lowlands, southern Oromia, Ethiopia," *African Journal of Ecology*, vol. 44, no. 2, pp. 237–246, 2006.

[32] S. Homann, *Indigenous Knowledge of Borana Pastoralists in Natural Resource Management: A Case Study from Southern Ethiopia*, Cuvillier Verlag Göttingen, Göttingen, Germany, 2004.

[33] D. L. Coppock, *The Borana Plateau of Southern Ethiopia: Synthesis of Pastoral Research, Development and Change, 1980-91*, ILCA (International Livestock Centre for Africa), Nairobi, Kenya, 1994.

[34] B. Tache, "Pastoralism under stress: resources, institutions and poverty among the borana Oromo in southern Ethiopia," PhD Thesis, Norwegian University of Life Sciences, As, Norway, 2008.

[35] G. Dika, D. Tolossa, and S. M. Eyana, "Looking for alternatives: the determinants of livelihood strategy of pastoralists in Boorana rangeland system, Southern Ethiopia," *Geojournal*, 2021.

[36] G. Dika, D. Tolossa, and S. M. Eyana, "Multidimensional poverty of pastoralists and implications for policy in Boorana rangeland system, Southern Ethiopia," *World Development Perspectives*, vol. 21, Article ID 100293, 2021.

[37] G. Dika, D. Tolossa, and S. M. Eyana, "Understanding poverty and survival strategy among Ethiopian pastoralists: the Boorana pastoralists perspectives," *International Journal of Rural Management*, vol. 1, Article ID 097300522110731, 2022.

[38] B. Riché, E. Hachileka, C. B. Awuor, and A. Hammill, "Climate-related vulnerability and adaptive-capacity in Ethiopia's Borana and Somali communities," *IISD Report*, 2009.

[39] A. Legesse, *Gada: Three Appraches to the Study of African Society*, Free Press, Nariman Point, Mumbai, 1973.

[40] J. W. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, Sage, Thousand Oaks, CA, USA, 2014.

[41] H. van Griensven, A. P. Moore, and V. Hall, "Mixed methods research—the best of both worlds," *Manual Therapy*, vol. 19, no. 5, pp. 367–371, 2014.

[42] D. Tolossa, *Rural Livelihoods, Poverty and Food Insecurity in Ethiopia: A Case Study at Erenssa and Garbi Communities in Oromiya Zone, Amhara National Regional State*, Norwegian University of Science and Technology, Trondheim, Norway, 2005.

[43] D. Tsegaye, *Afar Pastoralists in a Changing Rangeland Environment*, Norwegian University of Life Sciences, As, Norway, 2010.

[44] P. Ho and H. Azadi, "Rangeland degradation in north China: perceptions of pastoralists," *Environmental Research*, vol. 110, no. 3, pp. 302–307, 2010.

[45] Z. Birhanu, A. Ambelu, N. Berhanu, A. Tesfaye, and K. Woldemichael, "Understanding resilience dimensions and adaptive strategies to the impact of recurrent droughts in Borana Zone, Oromia Region, Ethiopia: a grounded theory approach," *International Journal of Environmental Research and Public Health*, vol. 14, no. 2, p. 118, 2017.

[46] A. Angassa and F. Beyene, "Current range condition in southern Ethiopia in relation to traditional management strategies: the perceptions of Borana pastoralists," *Tropical Grasslands*, vol. 37, no. 1, pp. 53–59, 2003.

[47] A. Napier and S. Desta, *Review of Pastoral Rangeland Enclosures in Ethiopia*, Tufts University, Medford, MA, USA, 2011.

[48] B. Tache, "Range Enclosures in Southern Oromia, Ethiopia: an innovative response or erosion in the common property resource tenure?" *International Conference on the Future of Pastoralism*, vol. 17, 2011.

[49] X. Wu, X. Zhang, S. Dong et al., "Local perceptions of rangeland degradation and climate change in the pastoral society of Qinghai-Tibetan Plateau," *The Rangeland Journal*, vol. 37, no. 1, p. 11, 2015.

[50] T. Tolera and F. Senbeta, "Pastoral system in the face of climate variability: household adaptation strategies in borana rangelands, southern ethiopia," *Environment, Development and Sustainability*, vol. 22, 2019.

[51] A. Le Sage and N. Majid, "The livelihoods gap: responding to the economic dynamics of vulnerability in Somalia," *Disasters*, vol. 26, no. 1, pp. 10–27, 2002.

[52] B. Megersa, A. Markemann, A. Angassa, and A. Valle Zárate, "The role of livestock diversification in ensuring household food security under a changing climate in Borana, Ethiopia," *Food Security*, vol. 6, no. 1, pp. 15–28, 2014.