Research Paper

Pastoralists' perceptions on the future of cattle farming amidst rangeland degradation: A case study from Namibia's semiarid communal areas

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On the Ground

- The perceptions of Namibian pastoralists on the future of livestock farming amidst land degradation have not been explored.
- We address this gap by following a case study approach, involving semistructured interviews with Ovaherero pastoralists in the Okakarara Constituency, located in the eastern part of Namibia.
- Pastoralists foresee multiple social-ecological challenges for the future of livestock production in their area.
- They plan to employ various strategies to address and overcome the challenges, for instance, engaging more intensively in crop farming and conduct de-bushing.
- Interventions such as training to effectively engage in crop farming, implementation of government-approved de-bushing plans, and introduction of low-cost water technologies for crop irrigation are needed.

Keywords: Livestock farming, Communal areas, Farmer's perceptions, Rangeland degradation.

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Introduction

Over 70% of the world's rural poor (<$1/day USD) derive their income from agriculture and/or agriculture-related activities.[1] One of the most widespread agricultural practices from which the world's rural poor derive their income is pastoralism.[2-4] Pastoralism is a "traditional and extensive form of raising livestock," by guiding and feeding livestock in various landscapes, such as savannas.[2] It plays a significant socioeconomic role in more than 50% of rural communities in developing nations.[1] Pastoralism, hereafter "livestock farming" is therefore critical for food security and poverty reduction across the world.

Land degradation, coupled with climate change, is occurring around the world[3-5] and is threatening the viability of livestock farming in many areas.[6] For example, about 20% of grasslands are degraded or degrading across the world.[2] Land degradation alters plant growth, changes pasture composition and fodder quality, and increases vulnerability of pastoralists (i.e., livestock farmers).[6] Despite these challenges livestock farmers have to overcome daily, their perceptions and general involvement in providing information toward the growing concerns of land degradation and global climatic change are underutilized.[7] Recognizing livestock farmers' perceptions and knowledge may provide important insights into rangelands management practices and challenges, and can help in identifying points of reference to develop sustainable programs in rural areas.[7-11]

In Namibia, livestock farming contributes to approximately two-thirds of agricultural production.[12] Livestock farming is mainly practised in the northern, central, and eastern parts of the country, with cattle, sheep, and goats being the most common.[2] Namibia is, however, a semiarid country, making it more susceptible to land degradation and climate change.[4] Over 60% of the rural population has already experienced progressive loss of the biological and economic productivity in their rangeland.[13,14] The shortage of water is another major threat to livestock farming in the country.[15] Overall, the carrying capacity of the rangeland is expected to decrease, which will further affect the viability of livestock farming in the country. Cumulatively, the economic losses in the Namibian livestock sector are expected to reach US$255 million by 2080.[15]

The communal areas in Okakarara Constituency are some of the rangelands in Namibia most affected by the loss of bi-

ological and economic productivity. In these areas, however, livestock farming, which includes cattle, goats, and sheep, constitutes the main source of income for most homesteads.[16] Other sources of incomes such as wages, remittances, and state pensions only serve as supplementary income sources. The communal areas in Okakarara Constituency are also exposed to various environmental and anthropogenic factors, which are increasingly affecting the local social-ecological processes, and subsequently livestock farming. For instance, the area exhibits low and variable rainfall with frequent droughts resulting in low rangeland productivity.[17] Human population is also increasing,[18] potentially affecting the size of the area available for livestock farming. Essentially, the ability of farmers to generate adequate income and food (e.g., milk) from their livestock is becoming increasingly challenging in this area.[19]

Understanding the views and perception of livestock farmers on the future of livestock farming as well as their anticipated coping mechanisms amidst land (i.e., rangeland) degradation is critical. Unfortunately, the current literature on land degradation in Namibia has mainly focused on historical factors and processes linked to land degradation, its multilayered socioeconomic effects, and policies developed to address these issues.[13,17,20-23] Most of this work has also mainly focused on crop farming, despite livestock farming being one of the most susceptible sectors to land degradation.[24] As a result, our understanding of the views and perceptions of local livestock farmers on the future of livestock farming and their anticipated coping mechanism remains limited. To fill this gap, we assessed the perceptions and attitudes of livestock farmers towards future rangeland changes and uses in the Okakarara Constituency. Our study explored four research questions:

1. What social-ecological changes and challenges do livestock farmers in Okakarara Constituency expect to face in the future?
2. How do livestock farmers think these changes and challenges will affect their livelihoods?
3. What strategies are livestock farmers implementing (or planning to implement) to cope with prospective social-ecological changes?
4. How can livestock farmers be supported to adapt to these future changes?

Material and methods

Description of the study area

Our study focused on four communities (Okahitwa, Ovitatu, Ombooronde, and Ozongarangombe) located east of the Okakarara town, within the Okakarara Constituency (Fig. 1). The Okakarara Constituency, situated in the Great Waterberg Landscape Area, is part of the Otjozondjupa Region, which is formerly known as Hereroland. The Great Waterberg Landscape Area is encompassed by two systems of farming land tenure: communal and freehold. The communal land (i.e., state owned) is mainly used for livestock farming, whereas the freehold land (i.e., privately owned) is used for both livestock and game farming mainly for commercial purposes. Our study was conducted in the communal part of the Great Waterberg Area. The four target communities are part of a community-based institution called Ozonahi Conservancy (Fig. 1). Ozonahi Conservancy covers 3,204 km^2 (1,237 square miles) with a population of about 11,399 people.[25] The rainfall of the Ozonahi Conservancy area is typical for a semiarid region in Namibia with a mean rainfall ranging between 350 and 500 mm (~14-20 inches) but displays extreme interannual variation.[26] The average minimum and maximum temperatures are 3°C (37°F) and 35°C (95°F). Our study area is part of Central Kalahari Sandveld and Thornveld Savanna Biome,[27] with woody vegetation dominated by Acacia species on the calcareous soils and *Terminalia sericea* on sand soils. The area is susceptible to various environmental problems such as overgrazing, bush encroachment, and alien species invasion.[25]

Our study area is mainly inhabited by the Otjiherero speaking people, which identify themselves as Ovaherero (lit. Herero people). The Herero people are subsistence livestock farmers who farm under extensive farming systems. Free-range livestock are kept on natural pastures for most of their production cycle. Livestock feeds mostly on grasses and bushes in an open rangeland with few inputs (e.g., supplementary fodders).[28] Livestock are not herded and graze freely. The Herero people live in homesteads ("onganda") with several households occupied by extended families (Fig. 2). We refer to households as a house structure/building, whereas homesteads are premises comprised of a cluster or group of several households. A homestead is comprised of people who share a livestock kraal but do not share a common fire ("omazuko") place to prepare food. A household is comprised of people who use the same cattle kraal and "omazuko" to prepare food. Typically, a homestead consists of the household of the owner—the owner's married son(s) and the owner's younger brothers. More distant relatives and unrelated individuals, such as cattle herders, can also have their households within the homestead. A homestead is mainly made up of two or more households, with individual members ranging from 7 to 20 people. The main livestock owners of each homestead are usually those owning the largest cattle herd (i.e., largest number of cattle). However, survey respondents typically stated the animals belong to everyone living in the homestead, as they provide food and income benefiting the whole family. Hence, ownership and user rights of livestock are not always strictly separated.

The Herero people are traditionally and proudly livestock farmers, mainly, cattle herding. The value of cattle is widely symbolized and strengthened through various ways.[29] For instance, women wear a horn shaped hat called "Otjikaiva," which resembles the importance of cattle farming to the group. A traditional dance called "Outjina," which imitates cattle movements, is often performed by community members.[29] The group has been embracing and cherishing cattle farming for generations. Livestock farming is therefore vital to the cultural beliefs and practices of the Herero people, and it provides a special connection to their forefathers.[30] In addition, the livelihoods of the Herero people are largely dependent on livestock products like meat, milk, hide, and

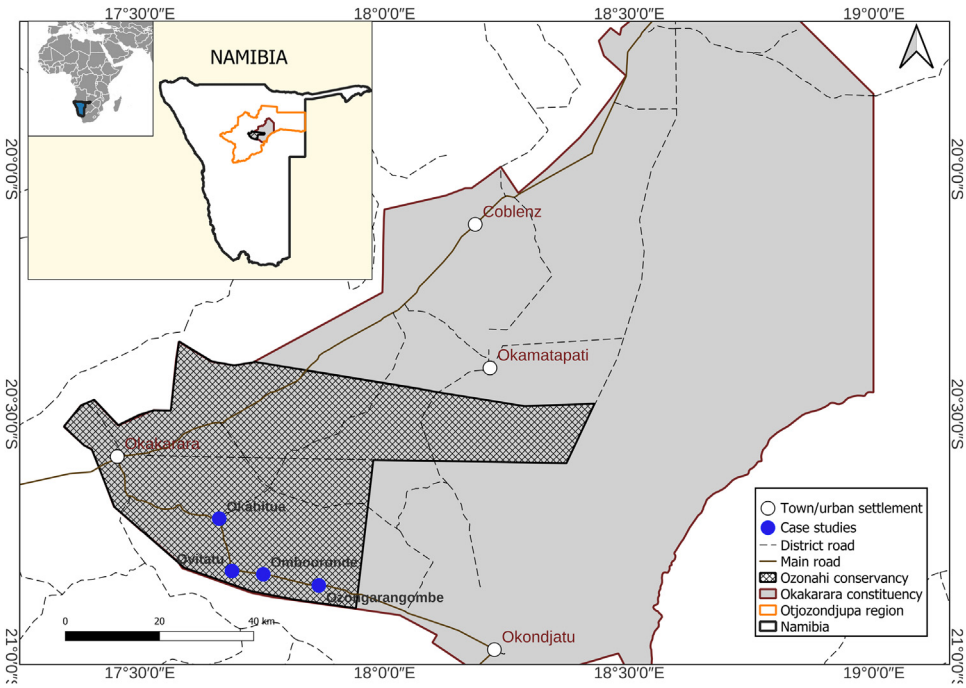

Figure 1. The location of the four communal communities (i.e., Okahitwa, Ovitatu, Ombooronde, and Ozongarangombe) within the Ozonahi Conservancy in the Okakarara Area, Namibia.

Figure 2. Aerial photograph of typical Herero Community homestead in the Okakarara area of the Okahitwa village located in the eastern communal areas of Namibia. Photo courtesy of Vistorina Amputu.

horns. Farming activities contribute up to 33% of income in our study area, and wages and state pension contributed 27% and 19% of income, respectively.[16] Most of the wages come from temporary employment at various infrastructural development projects, such as road construction, conservancies' projects, and farmers associations.[16]

Sampling procedure

Our study employed semistructured interviews at the homestead level and focus group discussions at the community level in the four communal settlements. In total, 41 of 171 (24%) homesteads from the four communities (Okahitwa, n = 10 [23%]; Ozongarangombe, n =11 [20%]; Ombooronde, n =10 [28%]; and Ovitatu, n =10 [26%]) were interviewed. A homestead was the sampling unit, and members from all households in the homestead were free to participate. In most cases, however, the head of the homestead was the main responder. For instance, if there were differences among the homestead members on the response to a particular question and/or additional information was needed, each participant was allowed to participate in the discussions before the head of the homestead confirms the final answer. To obtain information from household members of different ages, participants were asked individually. Therefore, the head of the homestead had no influence on individual responses from household members of different ages.

The homesteads were selected using "preselected criteria relevant to a particular group cohesion".[31] This implies that the target group had similarities, which in our case were the village homesteads with vast experience in livestock farming (e.g., the long-term residents of the area). We asked the headmen/women of each settlement (*otj. sing. orata*) to provide us with a list of farmers with vast experience. Most the homesteads in the area were headed by males. As a result, we interviewed all female-headed homesteads present at the time of the survey.

Data collection and analysis

Presetup interview questions (see Appendix 1) grouped into 14 different categories (water, soil, vegetation, etc.) were asked, followed by probing questions aligned to the farmers' (i.e., participants') responses. Our questions included "how farmers foresee changes to their soil productivity, water availability, vegetation changes," etc. "Challenges and strategies farmers may experience and employ to adapt to the changes" were also included in the survey. After the interviews at the

homestead level, a group discussion comprised of all participating homesteads was conducted at a community level. In total, four focus group discussions (one per community), were conducted. The group discussions were to reaffirm responses provided at the homestead level and to document participants' collective opinions on alternative farming practices they may employ to overcome future cattle farming challenges. The group discussions allowed sufficient time per participant to gather detailed information.

The study explored the perceptions of livestock farmers on the future of cattle farming. We interpreted the future as the time after the current period, which can be evaluated differently depending on the perspective of the livestock farmer.[32] We set a point of departure of 5 to 25 years for our future time frame, adapted from a similar study.[32] The study indicated that future-oriented studies can be constructed with chronological horizon breadth, which means studies can be framed in short-, medium-, and/or long-term periods.[32] We have chosen this mid-range (up to 25 years' time) horizon because it gave the participants the opportunity to think in a broad way, yet still within the scope of their own lifetimes.[33] On this basis, we were able to record the farmers' own planned strategies for coping with the changes and challenges they perceived to be occurring in the next 25 years at the most. Shorter time periods (<5 years) usually do not provide a clear future perspective; longer time horizons (e.g., future generations) may have become more abstract and impersonal for the participants and not contribute directly to our research questions. Nonetheless, responses from participants from before and after the specified period were recorded with the exact time specification. The interviews were conducted in English and Otjiherero (depending on the participants' preference). We used a translator, who was a native Otjiherero speaker, to translate between Otjiherero and English during the interviews. Thematic coding was used to analyze the interview data.

Results

Socio-economic characteristics of the homesteads

The majority (71%) of the assessed households had men as the heads (Table 1). Only 12% of them were run by people under the age of 40 (i.e., youth), and about 46% were headed by persons above the age of 60 (Table 1). Several sources of livelihood/income were reported, but livestock, specifically cattle farming (93%) and old age pension (46%), were the most common (Table 1). Only a few homesteads (7%) had wages as a source of income. A small number of homesteads were practising other livestock farming activities such as goat and sheep farming (17%) and gardening (9%) in addition to cattle farming.

When individual homesteads were asked to indicate the source of their livelihood, 16 homesteads (39%) reported one source of livelihood, with most of these homesteads (87.5%) indicating livestock farming, as the source of livelihood. Another 20 homesteads (49%) reported two sources of livelihood, of which 95% included livestock farming. For homesteads that indicated two sources of livelihood, the combination of livestock farming and old age pensions was the most common (Table 2). A few homesteads reported three or four sources of livelihoods, centered on livestock farming (i.e., cattle and small stock farming), old age pension, and gardening.

Future social-ecological changes perceived by the livestock farmers

Most of the farmers were pessimistic about the prospects of livestock farming in the area. Over 90% of the homesteads surveyed indicated that a decline in the number of cattle will occur over time, with some perceiving a general decrease in interest in livestock farming among community members. Five percent of respondents, on the other hand, noted that an increase in cattle numbers will happen, and 2% were neutral about their livestock farming prospects (Table 3). The main reasons for the perceived decline in livestock farming, especially cattle, in descending order, were droughts, less availability of palatable grasses/forage, bush encroachment, livestock theft, and increased numbers of predators such as jackals (*Canis mesomelas*) and cheetahs (*Acinonyx jubatus*). Conversely, the main reasons for the perceived increase in livestock, especially cattle were high rainfall seasons, higher interest in livestock farming among young people (i.e., who would purchase more animals), and the increase in human population, which may imply an increase in numbers of livestock. Participants who indicated a "neutral" response stressed that the wealthy farmers may purchase animals from disadvantaged homesteads, which may increase or decrease livestock numbers for some farmers.

Future social-ecological challenges perceived by livestock farmers

Survey participants were asked if they agreed or disagreed with perceived future challenges that may affect livestock farming in the Okakarara Constituency (Fig. 3). Most participants agreed that drought (92%), human population growth (90%), bush encroachment (87 %), and theft and predators (73%) were the most important future challenges. Furthermore, most participants (90%) did not agree that the youth will lose interest in cattle farming in the future. Most participants (95%) were unsure of whether poor management (i.e., overstocking) or an increase in invasive herbaceous species (e.g., *Tribulus terrestris*; 90%) would become future challenges in their area.

Livestock farmers implemented and planned strategies to cope with perceived changes and challenges

Given the various changes and challenges affecting, or expected to affect, livestock farming in the Okakarara Constituency, participants indicated several strategies to deal with

Table 1
The socio-economic characteristics of participant homesteads (n = 41) in the eastern communal areas of Namibia.

Socio-economic characteristics	Category*	Number of homesteads	Percentage of homesteads
Homestead Head	Female headed	12	29
	Male headed	29	71
	Homestead head by Pensioners (>59 years)	19	46
	Homestead head by Youth (<40 years)	5	12
Livelihood	Livestock farming (cattle)	38	93
	Livestock farming (goat and sheep)	7	17
	Wages	3	7
	Old age pension	19	46
	Gardening (home use)	4	9
	Poultry (home use)	2	5

Note: The number of homesteads headed by pensioners and youth are also part of the male and female headed homesteads and livestock farming includes cattle, goat and sheep unless otherwise is specified.
* Sex is self-reported.

Table 2
The main sources of income per homestead in the eastern communal areas of Namibia.

Sources of income in categories	Source of income	Number of homesteads	Percentage of homesteads
One source of income	Livestock farming (cattle)	14	34%
	Livestock farming (goats and sheep)	1	2.4%
	Poultry	1	2.4%
	Livestock farming (cattle, goat, and sheep)	2	4.9%
Two sources of income	Livestock farming and wages	3	7.3%
	Livestock farming and old age pension	13	32%
	Livestock and poultry farming	1	2.4%
	Gardening and old age pension	1	2.4%
Three sources of income	Livestock, poultry, and old age pension	2	4.9%
	Livestock farming, gardening, and old age pension	1	2.4%
Four sources of income	Livestock farming, poultry farming, gardening, and old age pension	2	4.9%
Total		41	100%

Note: Livestock farming includes cattle, goat, and sheep unless otherwise specified.

Table 3
Perceptions of livestock farmers on changes in livestock numbers and their associated reasons.

Perceived changes	Reasons (numbered from most to least often mentioned)
Livestock numbers will decrease	1. Droughts 2. Less palatable grasses 3. Bush encroachment 4. Theft and predators 5. Costly as it depends on supplementary feeding 6. Loss of reproductive male cattle (i.e., bulls)
Livestock numbers will increase	7. Numbers will increase during high rainfall 8. Young people may procure more livestock 9. Human population increase may increase livestock numbers in communities
Others (neutral)	10. Wealthy people will buy more livestock, especially, cattle, from poor farmers 11. Livestock numbers may pick up during a high rainfall, but still decrease during droughts

Note: Based on homestead surveys in the eastern communal areas of Namibia.

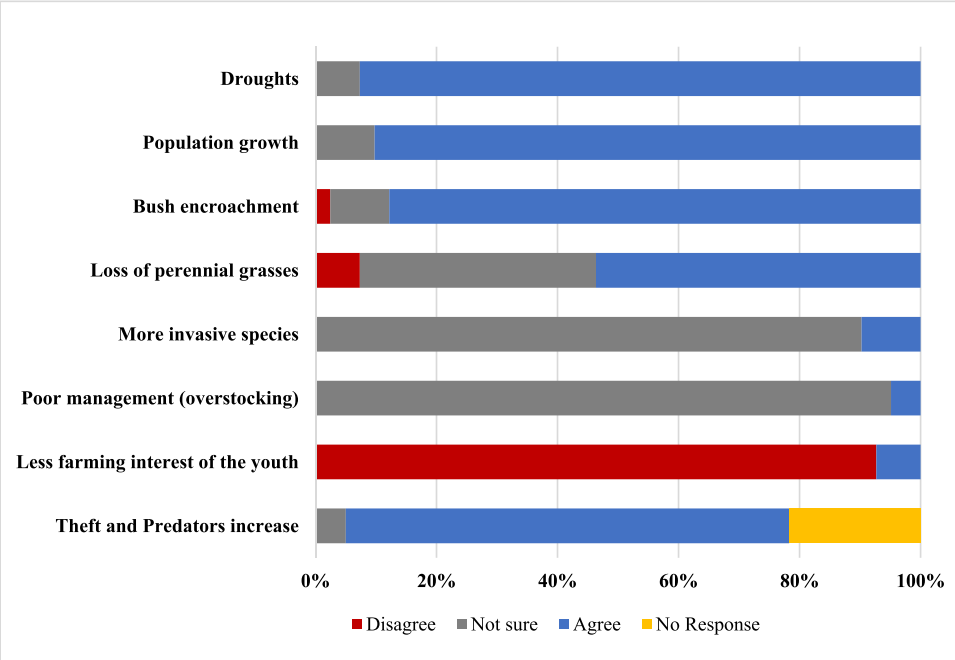

Figure 3. Perceived livestock farming challenges by farmers in the eastern communal areas of Namibia. Note: No response means this is not a perceived challenge.

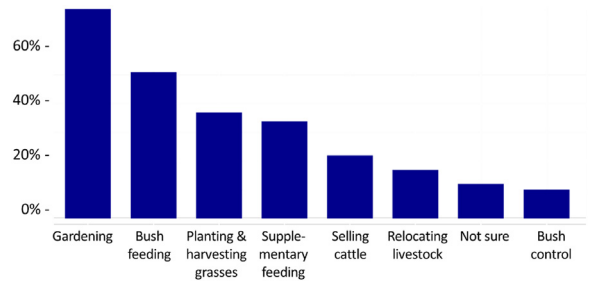

Figure 4. Potential alternative farming practices livestock farmers will use to overcome future livestock farming challenges in the eastern communal areas of Namibia. Note: Bush Feed refers to the production of animal fodder from encroacher bush and supplements.[55] Bush Control refers to actions targeted at controlling the density and composition of bushes and shrubs in a given area affected by bush encroachment.[56]

them. Our results showed >70% of the livestock farmers plan to start or invest more work in gardening in the next 5 to 25 years (Fig. 4). However, these respondents expect assistance from the government because they lack the resources to intensify their field cultivation activities, including the installation of new boreholes for the introduction of irrigation systems. More than 50% of farmers indicated they would use encroaching bush species to feed their livestock as a strategy to respond to the decline of palatable grasses in the area (Fig. 4). Farmers also envisaged planting and harvesting grass (39%) to feed their animals during future droughts, whereas others intended to resort to buying supplementary feed (35%) and selling the livestock, specifically cattle (25%). Farmers also planned to relocate the livestock as well as to control the expansion of bush as other strategies to cope with future land degradation (Fig. 4). Participants indicated several ways to diversify their livelihoods as a strategy to overcome future challenges associated with livestock production. In particular, some farmers planned to focus more on small stock production, especially goats, start poultry farming and engage on off-farm activities such as baking and selling bread (Table 4).

The level of interest in diversifying farming practices in the future among participants was assessed across age groups (Fig. 5). All age groups between 31 and 70 were willing to diversify their farming practices, but the greatest interest in diversification was in the 31 to 40-age category (100%), followed by the 41 to 50 (86%) and the 51 to 60 (70%) age groups (Fig. 5). Overall, our results showed that farmers' willingness to diversify decreased with increasing age. Younger livestock farmers were more willing to diversify than older livestock farmers. No livestock farmer aged >70 years was willing to diversify (Fig. 5).

Discussion

Most of the livestock farmers interviewed were aware of current and future changes and challenges facing the livestock farming in the communal areas of Okakarara Constituency. The changes and challenges were mainly related to droughts, rangeland degradation (i.e., decrease of palatable grasses/forage and bush encroachment), increased theft and predators, decline in land available for grazing due to increased human population, increased costs, and increased loss of reproductive male cattle (i.e., bulls). The farmers emphasized that these changes and challenges were already causing them problems, and they perceive that the situation will worsen in the future. Livestock production, especially cattle farming, in many Namibian communal areas is facing challenges caused by anthropogenic and climatic factors.[34]

Drought occurs in most arid and semiarid regions.[35-37] Droughts understood as the "prolonged absence or marked

Table 4
Perceived potential diversification options in the future by livestock farmers and their reasons in the eastern communal areas of Namibia.

Diversification options	Reasons for diversification
1. Livestock farming (goats and sheep)	Land is transforming from grassland to bushes, we need browsers
	Small stocks are easy and affordable to farm
2. Horticulture	Plant lucerne and crops for cattle and food because gardening is easier than grazing
	Use earthen dam to hold water in the area
	Home bound during Covid pandemic promoted interest
3. Poultry (e.g., chicken) farming	Create quick income
	Poultry need less water unlike livestock, which need more water and increases water bill
4. Bread making	Easy to make and provide immediate income (common in female farmers)

Note: Lucerne (*Medicago sativa* L.) "is one of the important cultivated forage crops in the world." It is nutritional and can prevent erosion and increase nitrogen fixation among other benefits.[54]

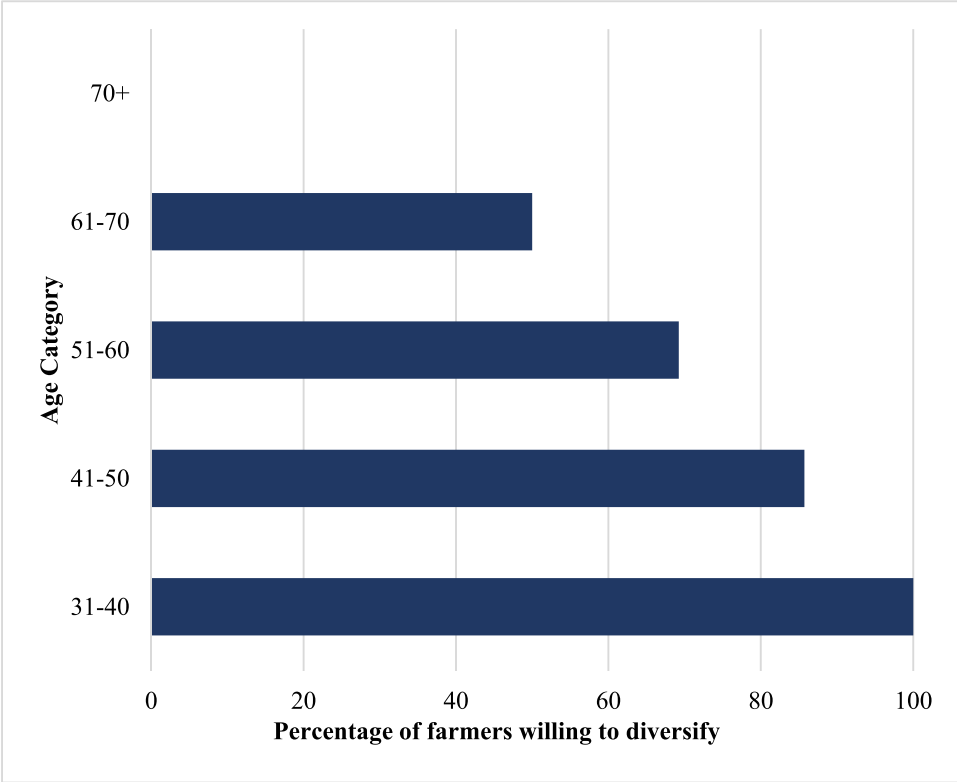

Figure 5. Proportion of participants willing to diversify livestock farming activities in the eastern communal areas of Namibia. Participants are grouped by age categories.

deficiency of precipitation."[38] This leads to soil water deficit, which affects grass growth, and reduces the water availability for livestock and humans. Many areas in Namibia have experienced a decrease in precipitation since the middle of the 20th century, and the mean annual rainfall is projected to decrease further.[39] In northwestern Namibia, for instance, Himba pastoralists have experienced multiyear droughts that have caused large losses of livestock, putting their livelihoods at risk.[30] In Okakarara Constituency, farmers have recently experienced the worst drought in the last 40 years, many of them losing the half of their herds.[40] In our study, farmers indicated that these processes are leading to an increase in invasive shrub species and a decrease in perennial grasses that are beneficial to cattle and also prevent soil erosion. They pointed out that drought has caused a decline in mature adult male cattle (i.e., bulls) within their communities. Losing bulls resulted in a lower reproductive rate within the cattle herds. Although participants are aware of the effects of drought and foresee continued problems, they feel powerless and appeal to the government for help.

Human population growth was perceived to have an effect on livestock farming in our study area. The population in the Otjozondjupa Region grew on average 0.6%/year during 2001 to 2011 with 54% of the population living in rural areas, contributing to the overutilization of grazing land and its fragmentation through fencing.[18,41,42] The population of the Otjozondjupa Region is projected to continue increasing.[43] Our participants are fully aware of this population

growth trend and the resulting loss of grazing land. Participants worry that reduced land will likely lead to overutilization of vegetation, especially palatable grasses—the preferred forage for livestock. Furthermore, participants indicated that human population growth has led to more land being fenced off into private camps, which has caused land disputes and conflicts among communities. The remaining communal land available for grazing does not have time to rest and recover under these circumstances, which promotes soil erosion and species extinction in the area.

Participants identified bush encroachment as the third most important factor affecting livestock farming in the area. Many farmers, both communal and commercial, face bush encroachment problems in Namibia.[44] Bush encroachment refers to the "invasion and/or thickening of aggressive undesired woody species resulting in an imbalance in woody plant-grass cover"[44] and is estimated to affect up to 45 million hectares (111 million acres) of Namibian land.[45] Bush encroachment decreased the productivity of Namibian agriculture by two-thirds in recent decades.[46] The most common encroaching woody species reported by our participants were *Terminalia sericea* and *Senegalia mellifera*. Participants also mentioned an increase in nonwoody and less palatable and/or poisonous plants such as *Argemone ochroleuca*, *Sida cordifolia*, and *Tribulus terrestris*. Bush encroachment has resulted in loss of rangeland productivity, including reduced grass germination and soil compaction. The encroaching species are competing with grasses for water through their extensive root systems, displacing grass from the soil.

Other challenges that livestock farmers foresee include the loss of large numbers of animals to theft and predation. Regarding the former, livestock theft has been reported to be one of the main causes of livestock loss in the region, comparable to drought.[47] In the last 10 years, 55 households in the Ozongarangombe, Omblooronde, and Ovitatu settlements have lost 642 heads of cattle to theft (authors' unpublished data). Livestock theft continues, but the perpetrators are rarely charged because they are both arrested and released on bail or never get arrested because family members protect them.[48,49] Most participants attributed livestock theft to high unemployment in the area.[49] By 2009, over 25% of rural population in the Otjozondjupa region were illiterate and 37.7% over the age of 15 were unemployed.[50]

Drought contributes to livestock theft because it reduces the livestock population, which increases the market demand. High market demand for livestock motivates livestock thieves as an opportunity to make more money through stealing and selling livestock. Recently, a local newspaper reported that the theft of livestock in Namibia continues unabated.[48] Despite efforts such as livestock task forces, arrests of suspects, and police to patrol the situation, farmers across the region continue to report the theft of livestock. A communal livestock farmer of the Otjozondjupa Region comments, "Our livestock, which is our livelihood, are being stolen at an alarming rate and it appears the police are not taking this seriously."[49] In addition, predators, such as jackals and cheetahs, pose a challenge to livestock farming in the area. The annual number of cattle lost because of predators in the eastern communal conservancies is reported to range between 0 and 35 cattle per farmer.[51]

Although most of the participants were highly pessimistic about the future of livestock farming in the area, a small number of participants were optimistic. Optimistic farmers were elderly (70-83 years old), who foresee an increase in livestock numbers despite negative changes and challenges in the future (i.e., droughts, bush encroachment). Their optimism was linked to their belief that the number of young people who could afford to buy livestock would increase. Moreover, although the elderly were aware droughts could occur, they were convinced droughts were unlikely to happen in the next 5 years, which would lead to an increase in livestock numbers, at least in the midterm. When asked why they did not foresee droughts in the next few years, the elderly indicated a severe drought usually occurs every 5 to 10 years. Therefore, given the last severe drought was in 2018 to 2019, the next severe drought was only expected in 2024 to 2025 or later.

Overall, the anticipated changes and challenges are expected to mostly have a negative effect on livestock farming, thus affecting the livelihood of the livestock farmers. Drought conditions reduce land available for grazing and increase the costs of livestock farming because of the increased reliance on supplementary feeding.

To overcome livestock farming challenges, farmers are keen to diversify their livelihoods, for instance, by starting or intensifying horticultural activities and placing more emphasis on farming with small livestock such as goats, which are less susceptible to drought and feed on bush. Our participants indicated gardening would promote the production of palatable grasses for livestock like lucerne (*Medicago sativa*) as well as fruits and vegetables for home consumption and marketing. How an intensification or expansion of field cultivation will influence Herero culture, especially in terms of their symbolic associations with livestock, can be an interesting future research topic. The Herero people have always been livestock farmers and they settled in the plains of Central Namibia for its grass pastures needed for livestock.[31]

Remarkably, many participants disagreed that the invasion of unpalatable herbaceous species (90%) and poor land management (95%; i.e., overstocking) can negatively affect livestock farming. Participants perceived the occurrence of invasive species, such as *Sida cordiflora* and *Tribulus terrestris*, as seasonal and mostly dependent on the time and amount of rainfall. In addition, they pointed out that these plants tend to grow in heavily grazed areas, such as near boreholes, and therefore have little effect on the wider rangeland. They also indicated goats can feed on invasive species, such as *Tribulus terrestris*.

Regarding poor land management, elderly participants stated they had >50 herds of cattle per homestead in the past (around the 1970s), but never had the problems of overgrazing they have today. Rangeland productivity in Namibia is primarily affected by rainfall rather than grazing pressure.[3,52] This may also be true in the study area, considering rainfall has been decreasing over the years. In the past, rainfall was generally high in the study area leading to adequate grazing

for livestock and potentially camouflaging the effects of overstocking. This may explain why the participants did not notice the effects of overgrazing albeit high numbers of cattle per homestead. Generally, however, land challenges in communal areas are mostly attributed to low rainfall and not necessarily to livestock management aspects.[3] Nonetheless, considering that land degradation involves complex interactions between human and natural factors (e.g., climate),[53] more in-depth and closely integrated interdisciplinary research is needed to disentangle the contribution of various factors to rangeland degradation in this part of Namibia.

Recommendations: How can livestock farmers be supported to adapt to future changes and challenges?

Based on our survey results, we elaborate on key recommendations that could help pastoral farmers adapt to and overcome the perceived future changes and challenges in livestock farming.

- Our study has established that some farmers are already engaging in alternative sources of livelihood as mechanisms to cope with current and future livestock challenges. However, given that farmers in the area do not have a long history engaging in other livelihoods apart from livestock farming, they may require training and support to effectively engage in these activities. The training may encompass effective horticultural practices, poultry farming, and marketing strategies to sell their produce.
- The communities need effective mechanisms for halting bush encroachment and removing bushes on grazing land. Currently, some communities are not allowed by the State to de-bush. Therefore, there is an urgent need for the State to provide permission for bush removal in the communal areas. The permission must be accompanied by training on sustainable bush removal techniques and utilization (e.g., bush feed and charcoal production).
- The current water infrastructures in the study area need modernization to support effective horticultural practices. For example, diesel pumps should be replaced with solar-powered (i.e., photovoltaic) pumps that require less financial input for daily operation and maintenance to reduce financial burden on the farmers. Adapting the infrastructure for horticultural purposes, including water harvesting technologies and water saving irrigation technologies (i.e., drip systems) could help people to intensify and expand gardening activities in a socially-ecologically sustainable manner.
- Lastly, we recommend programs aimed at addressing current and future challenges of land degradation in livestock farming areas should incorporate the views and perceptions of local farmers toward sustainable land management.

Conclusions

Our work highlights the perceptions of livestock farmers on the future of cattle farming in the semiarid region of the Okakarara Constituency through semistructured interviews and focus group discussions. Our study demonstrates that farmers expect various socio-ecological changes and challenges will affect livestock farming, and their livelihoods. The changes and challenges include human population growth, increasing land degradation processes (e.g., bush encroachment, reduction of grass vegetation), and drought coupled with climate change. Our study showed that livestock farmers have plans to overcome and adapt to socio-ecological changes and challenges and are willing to forgo their generational traditional ways of living, which is livestock dependent.

Our findings are vital, as they explicitly indicate farmers observe and understand their land use dynamics. This is also a clear indication of how essential it is to include the views and perceptions of livestock farmers when designing programs aimed at assisting them with land degradation challenges. Lastly, our findings may assist in developing further policy interventions needed to enhance local subsistence farming, eventually promoting food security and income generation within communal areas.

Declaration of competing interest

All authors declare they have no conflicts of interest on the subject matter discussed in the manuscript.

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Appendix 1

Okakarara Communal Farmers Interview Questioning Line by H.Heita and J.Karaerua

Aspect Categories	Questions	Possible Follow-up questions
1. **Soil**	How do you foresee future soil productivity in your area e.g., 5-20 years from now?	Will it be different from the past? What could be the major changes? What will cause such changes? If soil become unproductive, what measure will you take? Will the soil gene bank remain?
2. **Water**	How do you foresee water availability in your area?	Do you think there will be enough ground water? Will it be comparable to the past?
3. **Vegetation (species extinct)**	How do you see vegetation in your area?	Will you experience plant extinction? Will perennial grasses be available? Will it be comparable to the past? Do you foresee some of your valuable plant species disappearing/Extinct?
4. **Rangeland**	How do you foresee your future grazing land?	Will it be enough? Will it sustain your livestock? What are possible major changes likely to happen?
5. **Drought**	Do you foresee more drought condition in future?	Do you think this will be more severe compared to what you have experienced? How will this affect your livestock, plant, and lifestyle? What precautionary measures will you take to prepare for such uncertainties?
6. **Bush encroachment**	Sketch the possible future of bush encroachment in your area	Do you think bush encroachments will be a threat to your livestock farming? If yes, how will you overcome it?
7. **Population**	Will population growth a threat to your rangeland?	how will this affect your farming practices?
8. **Invasive species**	Do you foresee invasive plant species invading your area?	How will this affect your land, livestock, and soil?
9. **Precipitation**	Do you see fluctuation in rainfall patterns?	Millimetres of rainfall you likely to receive per year?
10. **Live stocking**	Will the number of livestock increase or decreases in future	How will this affect your rangeland and livelihoods?
11. **Land management**	Mention land management mechanisms you practice in your area. Is this likely to happen in future?	What are future land management practices will you and your communities' practice to sustainably manage your land? Why?
12. **Climate changes**	What other future climatic conditions do you foresee?	How will this affect your everyday farming activities?
13. **Land degradation threating desertification tipping point**	Has your land reached a tipping point yet? Are you foreseeing it?	Why?

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