Examining Rural Livelihoods Relevant to Human-lion Conflict Interventions within the Communal Conservancies of the Kunene Region, Namibia

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ABSTRACT

In the Kunene Region of northwest Namibia, desert-adapted lion (*Panthera leo*) numbers increased from the late 1990s to 2015. They have since declined by as much as two-thirds. The primary cause has been lions killed following human-lion conflict (HLC) incidents, within communal conservancy lands. HLC and conflict with other predators threatens pastoralists' already-tenuous livelihoods. Our survey quantitatively and qualitatively examined pastoralists livelihoods, perceptions of lions, and the efficacy of recently implemented HLC interventions in core lion range conservancies; it is a follow-up to a previous survey published in this journal (Heydinger et al. 2019). Results show livestock losses over the past decade likely exceed 80%. These losses are overwhelmingly attributed to the effects of drought and predators. Lions are considered the most problematic predator species, with 57% of respondents holding negative attitudes towards lions, while 84% say they do not benefit from having lions in their conservancy. Yet, problems with other predators, such as spotted hyena (*Crocuta crocuta*) and black-backed jackal (*Canis mesomelas*), are more widespread. HLC interventions, including Lion Rangers, Rapid Response Teams, an Early-Warning System, and predator-proof livestock enclosures (kraals), are achieving unequal results and show no clear improvement in respondents' attitudes towards lions. Results are discussed in the context of supporting pastoralists' livelihoods, and as part of an ongoing process for strengthening HLC interventions for the conservation of lions and other carnivores on communal lands.

KEYWORDS

Lions; Social surveys; Human-wildlife conflict; Desert-adapted lions; Lion Rangers; Drought

HIGHLIGHTS

- Livestock losses during the past decade exceed 80%.
- Conservancies are failing to support most local livelihoods.
- Lions are considered the most problematic predator in certain areas, yet problems with other predator species are more widespread.
- Attitudes towards lions are largely negative and correlated with a lack of benefits.
- Human-lion conflict interventions are having unequal effects on attitudes towards lions.

1. INTRODUCTION

African lion (*Panthera leo*) populations living outside of fenced protected areas are an important part of the continent-wide conservation of the species (Jacobson and Riggio, 2018; IUCN 2018). Though lions inhabiting fenced protected areas are closer to estimated carrying capacities than unfenced populations (Packer et al. 2013), Africa's protected areas with lions face dramatic funding shortfalls (Lindsey et al. 2018), exacerbated by the COVID-19 crisis and structural economic challenges (Lindsey et al. 2020). During the twenty-first century, lions' range has contracted to an estimated 10% of their historically

recorded range (IUCN 2018). Free-ranging[1] lion populations, particularly outside fenced protected areas, may prove more resilient if broad-based local support for their persistence can be achieved. Such populations may not be as susceptible to the negative effects of changing governmental priorities, nor to funding shortfalls.

One example of sustained lion population growth and recent range expansion comes from the desert-adapted lion population of the Kunene Region, in northwest Namibia. Covering a core range of approximately 40,000 km^2, up from approximately 7,000 km^2 in the 1990s (GRN 2017), the desert-adapted lions primarily inhabit communal conservancy lands which they share with semi-nomadic pastoralists and their livestock. Since the late 1990s, this lion population has rebounded from an estimated low of 20 individuals (Stander 2018), to an estimated 180 individuals in 2015 (GRN 2017). This period of recovery coincided with the growth of Namibia's communal conservancy system, a form of community-based natural resource management (CBNRM) where local people maintain qualified rights to manage and benefit from certain natural resources (Jones and Murphree 2001; Owen-Smith 2010). Since 2015, the population has declined to an estimated 57-60 individuals in 2022 (Heydinger and Muzuma, 2023).

The proximate driver of this decline has been lions killed in response to human-lion conflict (HLC). When lions invade conservancy farms, frequently killing and/or injuring livestock, lions are often killed in retaliation – no human deaths or serious injuries have been recorded. Even as the lion population was rebounding from 2000-2010, HLC incidents were responsible for 80% of lion (non-cub) mortalities (Stander 2018). This trend continued through the 2010s to the present. From 2021 through mid-2023, HLC has been responsible for at least 27 of 30 lions either being killed or permanently removed from conservancy lands – this represents more than 90% of lions lost during this period (Heydinger unpublished data). At the same time lions have been responsible for at least 512 livestock deaths, including cattle, sheep, goats, donkeys, horses, chickens, and dogs (Figure 1).

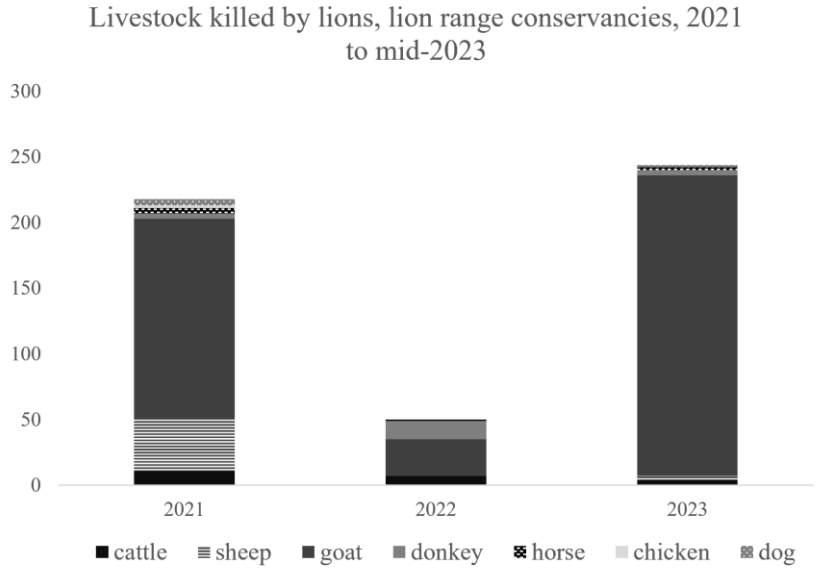
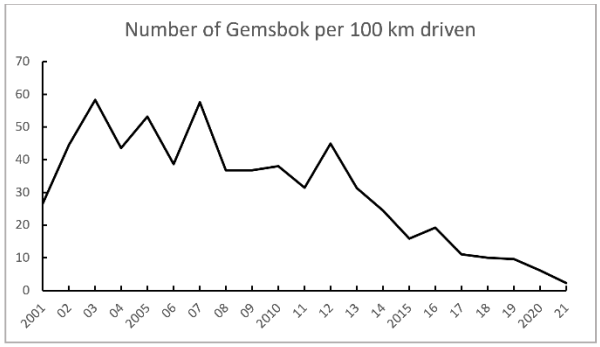


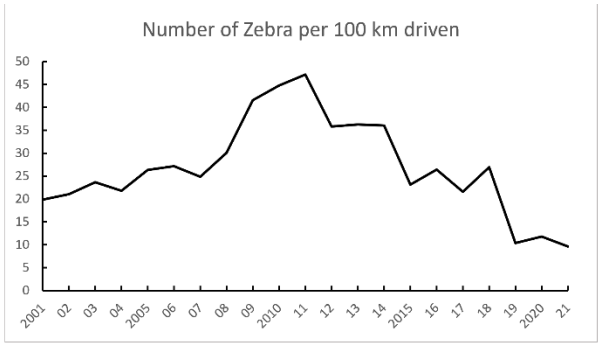
Figure 1: Livestock deaths to lions, all lion range conservancies, 2021 to mid-2023 source: Lion Rangers' field data.

The ultimate driver of HLC and subsequent lion mortality is likely to be the dramatic decline in wildlife numbers, coinciding with reduced rainfall and available vegetation for grazing and browse during the past decade. Since 2010, indicator prey species (gemsbok (*Oryx gazella*), springbok (*Antidorcas*

[1] Free-ranging defined as lions inhabiting fenced areas > 1,000 km^2 or partially or unfenced areas > 500 km^2 (IUCN 2018).

marsupialis), and mountain zebra (*Equus zebra*)) numbers have declined by as much as 69-96% (NACSO 2023) (Table 1). Lion survival appears to have been similarly affected by the declining prey base (Heydinger et al. under review), which may also have driven lions to increasingly switch to livestock as prey.





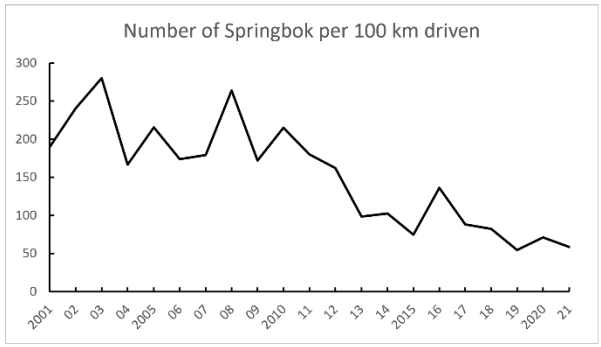


Table 1: Estimated populations of three indicator species, from 2001-2021, based upon road-based Northwest Game Count data (NACSO 2023).

Increasingly erratic rainfall patterns and rising daytime temperatures (Atlas of Namibia Team 2022) are beyond the control of local people, whereas HLC incidents can be minimized, provided lion movements are monitored and proactive steps are taken to limit contact between lions, pastoralists, and livestock. In 2017, Namibia's Ministry of Environment, Forestry and Tourism (MEFT) published the *Human Lion Conflict Management Plan for North West Namibia* (NW Lion Plan) (GRN 2017), a policy document outlining interventions for addressing the related challenges of limiting HLC and supporting pastoralists' livelihoods in the Kunene Region. Among the recommendations within this plan was activating and upscaling four HLC interventions. These include: a Lion Rangers program (lionrangers.org), five Human Wildlife Conflict Rapid Response Teams, an Early-Warning System providing stakeholders with relevant lion movement information, and construction of predator-proof kraals (details below).

Human social factors are increasingly acknowledged as an important part of fostering durable programs aimed at conserving lions and other dangerous wildlife (Dickman 2010; Hazzah et al. 2017). Though HLC may never be fully preventable, securing the future of lions on communal lands includes assessing what drives negative retaliation to HLC incidents by local pastoralists and working to transform these drivers. As part of ongoing efforts to limit HLC, we performed social surveys to ascertain local perceptions of desert-adapted lions as well as the effectiveness of interventions aimed at limiting HLC and ameliorating its negative effects. This effort is a follow-up to our study in 2017, which was previously published in this journal (Heydinger et al. 2019). The prior survey found large-scale livestock losses due to drought, the magnitude of which had been exacerbated by large carnivores. Lions were responsible for livestock losses averaging approximately US$ 2,900 (2022 value; CPI 2023) per household during preceding years. While respondents overwhelmingly (84%) stated they do not benefit from living with lions, 76% maintained it is important to continue to share communal lands with lions.

Our current survey interrogates similar questions, as well as the effectiveness of alternative HLC interventions. We also highlight information concerning local livelihoods and perceptions relevant to the efficacy of communal conservancies. The resulting picture suggests that the conservancy system is struggling to deliver on certain founding principles (Jones and Murphree 2001). We examine the effects of drought and predators on pastoralists' livelihoods as well as their attitudes towards living with lions. Our analysis is based on the perspective that societal norms and values fostering pro-environmental behaviour (Ostrom 2000; Muntifering et al. 2015) may be just as important as ecological factors.

1.1 Study area

The core range of the desert-adapted lions encompasses approximately 40,000 km^2 of unfenced communal conservancies and government-managed lands. This includes eleven communal conservancies, three tourism concessions, and a portion of Skeleton Coast National Park (Figure 2 & Table 2). Our surveys include a subset of households within each conservancy in this landscape. In comparison, Heydinger et al. (2019) surveyed only three communal conservancies (Anabeb, Puros, and Sesfontein) totalling 7,597 km^2. Our expanded scope is due to a broader focus of limiting HLC across the landscape, as well as reflective of the greater reach of research teams and the Lion Rangers program. Our expanded scope therefore provides a more comprehensive picture of livelihoods and HLC in core lion range conservancies.

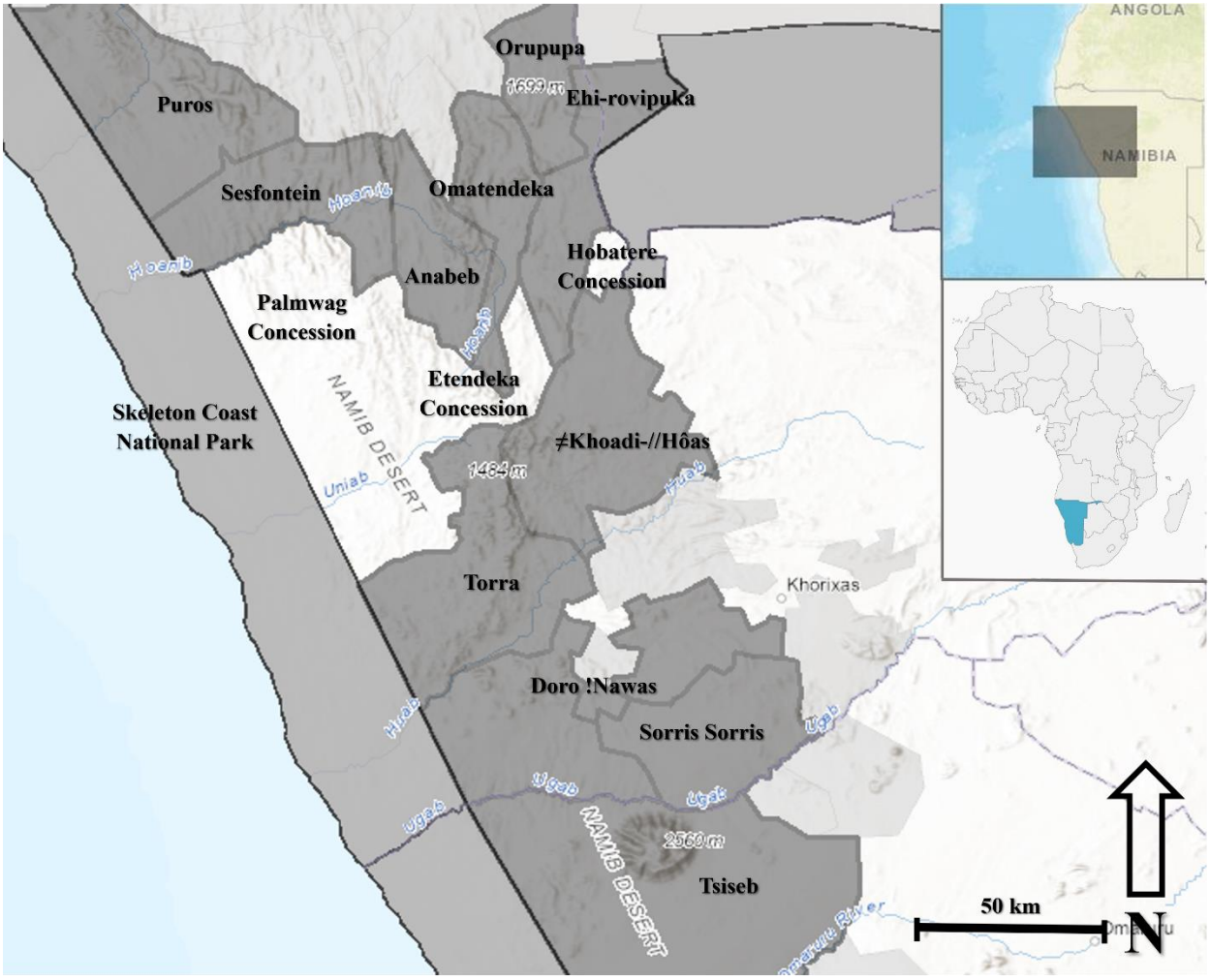


Figure 2: Core lion range with conservancy and government-manage area boundaries within the Kunene Region.

Conservancy	human population	area (km²)
Anabeb	1402	1570
Doro !Nawas	1242	3978
Ehi-rovipuka	1846	1980
≠Khoadi-//Hôas	4308	3364
Omatendeka	1985	1619
Orupupa	2024	1234
Puros	641	3562
Sesfontein	1941	2465
Sorris-Sorris	950	2290
Torra	1064	3493
Tsiseb	2415	7913
Government Area	**human population**	**area (km²)**
Etendeka Concession	0	633
Hobatere Concession	0	258
Palmwag Concession	0	5891
Skeleton Coast National Park*	0	8000

Table 2: Surveyed communal conservancy and government-managed areas. *Skeleton Coast National Park encompasses 16,845 km^2; core lion range within the park, from the Hoaruseb to the Huab rivers, encompasses approximately 8,000 km^2.

Core desert-adapted lion range is dominated by the Namib Desert, running along the Atlantic coast, merging into Nama karoo along the western African escarpment, transitioning into highland savanna further east. It is bisected by ephemeral riverbeds running east to west. The soil is typically basaltic, shallow, rocky, and unproductive (Atlas of Namibia Team 2022). Rainfall is patchy and generally occurs during the wet season (January-May), increasing from west to east. The entire area falls within the ≤ 200 mm isohyet with annual rainfall variability ≥ 60%. Prey species, including gemsbok, springbok, mountain zebra, giraffe (*Giraffa camelopardalis*), and kudu (*Tragelaphus strepsiceros*), maintain seasonal movements, responding to localized rainfall and subsequent available grasses and browse. During the dry season (June-December) prey and livestock often congregate in ephemeral riverbeds.

Core lion range is home to approximately 19,800 rural residents, primarily Otjiherero- and Damara-speaking peoples whose primary source of income is derived from livestock farming of cattle (*Bos taurus*), sheep (*Ovis aries*), goats (*Capra aegagrus hircus*), and donkeys (*Equus asinus*). Households within the region typically suffer from the "triple whammy" facing poor communities: incomes are low, uncertain, and financial opportunities are extremely limited (Mendelsohn et al. 2002; Collins et al. 2009). By Namibian standards, 38% of residents in Kunene are considered impoverished, while 24% are considered severely impoverished (NNPC 2015); 63% of residents are unemployed (NNPC 2018). Livelihoods have been further hampered by a downturn in tourism-based income stemming from the COVID-19 pandemic (Lendelvo et al. 2020). Social prospects are also limited: Kunene has Namibia's highest primary school drop-out rates, with only 55% of residents completing primary school by age seventeen (UNICEF 2013).

Kunene is one of Namibia's most heavily degraded and drought-prone regions (NNPC 2015). Over-utilization of rangelands is caused by high concentrations of livestock in specific areas. Due to an intensive government borehole-drilling program during the 1970s, much of the region is considered grazing-, not

water-limited (Bollig 2020). From 2000 to 2010, the region experienced a relatively wet period, resulting in wildlife and livestock increases. From 2011 to 2017, extensive drought caused the decline of livestock numbers by as much as 67% (Heydinger et al. 2019), as well as indicator prey species (above). These challenges are likely to be exacerbated in coming years, as Kunene is projected to experience a 2-3°C temperature increase by 2060 (Atlas of Namibia Team 2022).

1.2 Background – Communal Conservancies and HLC Interventions

The desert-adapted lions primarily inhabit communal conservancy lands, which they share with semi-nomadic pastoralists and their livestock. Following independence in 1990, Namibia's Nature Conservation Amendment Act (No. 5/1996) empowered communal area residents to form conservancies: officially registered, legally-recognized institutions to manage natural resources within a defined, community-agreed-upon jurisdiction, without recourse to further government authorization. In addition to subsistence hunting and harvesting, conservancies engage in trophy hunting of non-protected and protected species, such as lions, and can trade and sell most natural products with government approval. To become registered, each conservancy must pass a constitution for governing environmental affairs and outlining how benefits will flow to members (NACSO 2020). Based upon the tenets of CBNRM, communal conservancies stand upon four conceptual pillars: sustainable use as a conservation paradigm, market-based valuing of resources (economic instrumentalism), locals empowered with decision-making rights (devolutionism), and local, collective proprietorship of natural resources (Jones and Murphree 2001). Though the intent of conservancy legislation was to provide residents with ownership rights to wildlife, certain restrictions, including limitations on hunting protected species, have created "considerable gaps" (Jones 2010: 117) between the tenets of CBNRM and the implementation of the conservancy system. There remains a dearth of research examining the effectiveness of conservancies in Kunene for reconciling rural livelihoods with wildlife conservation.

Among the challenges facing core lion range conservancies has been persistent HLC. As many Kunene conservancies secured tenure to their wildlife, numbers increased; so too did the number of lions and the negative effects of lions and other potentially dangerous species. Since 2009, the Namibian government has provided limited financial offsets to communal residents in the form of cash payments through a "Human Wildlife Conflict Self Reliance Scheme" (HWC SRS) (GRN 2018). Implemented by the national government, the HWC SRS devolves responsibility to conservancies to report human-wildlife conflict and disperse payments to affected residents. However, the funds made available through this program only partially offset the cost of livestock losses and 92% of surveyed lion range conservancy members are dissatisfied with the program (Heydinger et al. in press; Heydinger unpublished data).

Recognizing that HLC was negatively affecting local livelihoods and leading to unsustainable numbers of lion deaths, MEFT's 2017 NW Lion Plan provided a series of interventions in addition to the existing HWC SRS. First was re-activating the local Lion Rangers program (lionrangers.org). A CBNRM initiative whereby community-appointed conservationists are employed, trained, and equipped to monitor lions and limit HLC within their conservancies (Heydinger 2023; Heydinger et al. in press), the Lion Rangers' program goal is to support a sustainable lion population within Kunene conservancies. There are currently 47 Lion Rangers across all eleven core lion range conservancies. Based-upon other successful CBNRM programs in Kunene (Hearn 2003; Jacobsohn and Owen-Smith 2003; Muntifering et al. 2015), as well as the Lion Guardians in Kenya and Tanzania (Hazzah et al. 2014; Dolrenry et al. 2016), Lion Rangers serve as liaisons between their communities and lions inhabiting communal areas.

Second was activating and capacitating five Human-Wildlife Conflict Rapid Response Teams. Employed by local NGOs, each Rapid Response Team receives Lion Ranger training, and is further capacitated with full-time use of a 4x4 vehicle. Each of these is outfitted with a mobile 'rover' unit. These rovers are linked to the iridium satellite network, enabling Rapid Response Teams to query the location of collared lions, communicate between rover units in near real-time, and communicate with program leadership, even in areas without cellular coverage. The primary responsibility of Rapid Response Teams is to transport Lion Rangers across the landscape, respond to HLC in far-flung areas, and safely chase lions away from farms when other conflict prevention and mitigation measures fail.

Third was up-scaling an existing Early-Warning System. With the increasing availability of GPS/satellite and VHF collars at relatively affordable prices, research teams and MEFT have collared more than 45 of the regions' estimated 57-60 adult lions. These collars provide location fixes relayed via the iridium satellite network to a secure online interface. Geofence polygons have been created, whereby Lion Rangers, Rapid Response Teams, permitted researchers, and key government staff, receive automated SMS notifications when lions enter designated farming areas. On the ground, collar locations are also communicated to Early-Warning Towers, which have been deployed in key HLC-hotspot farms. Standing 4-5 meters tall, these towers constantly scan for radio-frequency identification (RFID) tags affixed to lion collars. When the tags are detected nearby, the Early-Warning Towers alert farmers via bright lights and sirens. Towers work round-the-clock, serving as a back-up when geofence alerts and Rapid Response Teams are insufficient. There are currently 14 Early-Warning Towers across the landscape.

Finally, predator-proof livestock enclosures (kraals) have been deployed at approximately 120 farms in core lion range conservancies. These kraals are constructed with chain-link fencing and aluminium poles, wrapped in semi-transparent shade-netting, topped with barbed wire at three meters height, all cemented one-half meter into the ground. Predator-proof kraals are a proven method of deterring lions from attacking livestock when livestock are inside, with only one recorded incident of lions penetrating a poorly sited predator-proof kraal since the program's inception. These kraals serve as a last line of defence, when monitoring and early-warnings fail to alert farmers to lions' presence.

Following the guidelines of the NW Lion Plan, the four interventions began in 2018. From 2016-2021, HLC incidents declined by 33% (MEFT unpublished data). However, early data from 2023 show a 38% *increase* in livestock losses compared to the 2021-2022 average (Figure 1 above). Our surveys are part of an ongoing effort to assess the effectiveness of HLC interventions and the extent to which they have succeeded in fostering community tolerance of living alongside lions.

2. Materials and Methods

Semi-structured surveys eliciting both quantitative and qualitative information were performed *in situ* at 323 farms, across 11 communal conservancies in the Kunene Region. Surveys were primarily performed with the heads of livestock-owning households at their homesteads, in the preferred language of the respondent, including English, Afrikaans, Otjiherero, and Nama-Damara. Sampling was limited to one respondent per household, though other family and community members were frequently present and provided input and all were encouraged to participate. Surveys typically took 35-45 minutes. Topics included (i) demographic information; (ii) coarse-grain employment and income-source information; (iii) experiences regarding conservancy membership; (iv) household livestock data focusing on quantitative trends; (v) experiences and perspectives of predator species, emphasizing lions; (vi) experiences and perspectives of HLC interventions. Responses were quantitative or categorized according to response – e.g. when asked "what type of important benefits are you receiving from your conservancy" – responses were grouped where possible, such as "meat," "money," or "seeds for gardens." For livestock numbers, respondents were encouraged to provide precise quantitative values. However, if respondents were unsure about numbers they were asked to estimate. When a list of possible responses was available – e.g. "how common are lions in your conservancy": a) very common; b) common; c) rare; or, d) absent – respondents were given the chance to answer freely. Where responses were categorized – e.g. "how would you describe the problems you have with lions: none, low, moderate, or serious?" – levels were not predefined. Attitudes towards lions and HLC interventions were surveyed using a series of Likert-scale responses adapted from Heydinger et al. (2019) and were categorized based upon surveyors' discretion. Our approach facilitated open dialogue: whenever possible, comments were used to clarify responses and respondents were encouraged to elaborate. We believe respondents felt empowered to answer each question honestly. All responses were recorded on standardized survey forms and input to Microsoft Excel. Data were analysed and visualised using Microsoft Excel. Analysis was performed at the landscape and at a conservancy-by-conservancy level.

3. RESULTS

3.1 Demographics

323 respondents from 110 different farming areas were surveyed. Table 3 presents basic demographic and livelihood information. All respondents self-identified cultural group. Greater than 50% of respondents were age 50 or older: this is reflective of targeting the head of the household or person who would have the most information about livestock.

Conservancy	**n**	**%**
Anabeb	30	9.3
Doro !Nawas	18	5.6
Ehi-rovipuka	31	9.6
ǂKhoadi-//Hôas	49	15.2
Omatendeka	32	9.9
Orupupa	22	6.8
Puros	31	9.6
Sesfontein	27	8.4
Sorris-Sorris	15	4.6
Torra	46	14.2
Tsiseb	22	6.8
total	323	100
Sex	**n**	**%**
male	210	65.6
female	110	34.4
total	320	100
Cultural identification	**n**	**%**
Herero	112	34.7
Himba	68	21.1
Damara	111	34.4
Riemvasmaker	14	4.3
Nama	5	1.5
other	9	2.8
no response	4	1.2
total	323	100
Family size (median)	**n**	
avg # children	5	
avg # grandchildren	2	
Age range	**n**	**%**
20-29	20	6.2
30-39	61	18.9
40-49	56	17.3
50-59	72	22.3
pensioner*	104	32.2
not recorded	10	3.1
total	323	100
Do you have income?	**n**	**%**
yes	179	55.8
occasional	127	39.6
no	15	4.7
total	321	100
Sources of livelihood‡	**n**	**%**
pension	110	34.1
selling livestock	167	51.7
subsidies for children	27	8.4
conservancy employee	21	6.5
government salary	7	2.2
tourism employee	12	3.7
other (e.g. selling crafts)	33	10.2
total	377	

Table 3: Summary of demographic and livelihood information for respondents. *Respondents either stating they were over 60 years of age, or stating they did not know their age but estimated to be over 60, were recorded as pensioners. ‡Numerous respondents indicted multiple livelihood sources.

Of the 171 people reporting consistent income, only 55 (17% of all respondents) are receiving consistent income that is not primarily derived from social welfare sources (i.e. pension or government subsidies for children). When only non-salaried or inconsistent incomes were reported, these were classified as occasional income. 95% of respondents (n = 306) reported at least one source of income, 25% (n = 82) reported at least two sources, and 3% (n = 10) reported three or more sources of income. Selling livestock was the most consistently reported source of income (52%; n = 167), and an additional 11% (n = 37) reported selling livestock without listing it as an income source.

3.2 Livestock

91% (n = 294) of respondents reported currently keeping livestock. Summary statistics of livestock ownership are given in Table 4. The rightward skew of all livestock species indicates livestock ownership is concentrated among certain households. To assess recent changes in livestock numbers, respondents were asked to compare the number of each species they owned, with the number owned three years ago. For cattle, zero reported an increase, 83% (n = 264) reported a decrease, and 16% (n = 51) reported no change. For sheep, 2% (n = 5) reported an increase, 82% (n = 259) reported a decrease, and 16% (n = 52) reported no change. For goats, 3% (n = 11) reported an increase, 93% (n = 297) reported a decrease, and 4% (n = 12) reported no change. For donkeys, 1% (n = 3) reported an increase, 82% (n = 260) reported a decrease, and 16% (n = 52) reported no change. When asked about the greatest threats to their livestock, overwhelmingly the most frequently identified were drought (95%; n = 300) and predators (93%; n = 296).

	cattle	sheep	goats	donkeys
mean	4.5	8.2	38.3	0.9
median	0	0	25	0
skew	3.98	3.15	3.14	2.41
min	0	0	0	0
max	94	110	361	11
total	1,460	2,646	12,329	276
count	322	322	322	322

Table 4: Summary statistics of livestock ownership for all respondents. Mean and median number of livestock owned; skew, Pearson's second skewness coefficient, positive values indicate rightward skew among responses; min, minimum number of specific type of livestock owned; max, maximum number of specific type of livestock owned; total, total number of specific type of livestock owned by all respondents; n responses, number of respondents for each specific type of livestock.

Surveys in Anabeb, Puros, and Sesfontein conservancies in 2017 (Heydinger et al. 2019) serve as a basis of comparison for changes in livestock ownership. Within these conservancies, ownership of cattle, sheep, and donkeys is skewed, becing more concentrated within a few wealthy households (Table 5 & Figure 3). Livestock losses over the past decade have exacerbated this concentration. Since the early 2010s, mean cattle numbers have decreased by 97% (87% since 2017), sheep by 89% (72% since 2017), goats by 79% (56% since 2017), and donkeys by 84% (47% since 2017).

cattle	early 2010s	2017	2021/2
mean	48.2	10.3	1.3
median	25	4	0
skew	3.622	4.041	3.925
min	0	0	0
max	500	140	20
total	4003	854	117
n responses	83	83	88
median US$	$13,727	$2,996	$0

sheep	early 2010s	2017	2021/2
mean	28.7	11	3.1
median	20	5	0
skew	2.430	4.718	1.675
min	0	0	0
max	200	150	20
total	2381	911	270
n responses	83	83	88
median US$	$2,026	$506	$0

goats	early 2010s	2017	2021/2
mean	143	71	30.7
median	100	50	25
skew	1.253	1.503	0.897
min	0	0	0
max	600	300	110
total	11867	5894	2698
n responses	83	83	88
median US$	$12,799	$6,400	$3,200

donkeys	early 2010s	2017	2021/2
mean	5.1	1.6	0.8
median	4	1	0
skew	1.731	2.058	1.955
min	0	0	0
max	25	11	7
total	415	129	72
n responses	82	82	88
median US$	$332	$83	$0

Table 5: Table summarizing changes in livestock ownership for Anabeb, Puros, and Sesfontein conservancies. Mean and median number of livestock owned; skew, Pearson's second skewness coefficient, positive values indicate rightward skew among responses; min, minimum number of specific type of livestock owned; max, maximum number of specific type of livestock owned; total, total number of specific type of livestock owned by all respondents; n responses, number of respondents for each specific type of livestock; median US$, the value of the median size herd for that species (cattle = US$ 549.09/head, sheep US$ 101.29/head, goats U$ 127.99/head, donkeys = US$ 82.89/head; 2022 values, CPI 2023).

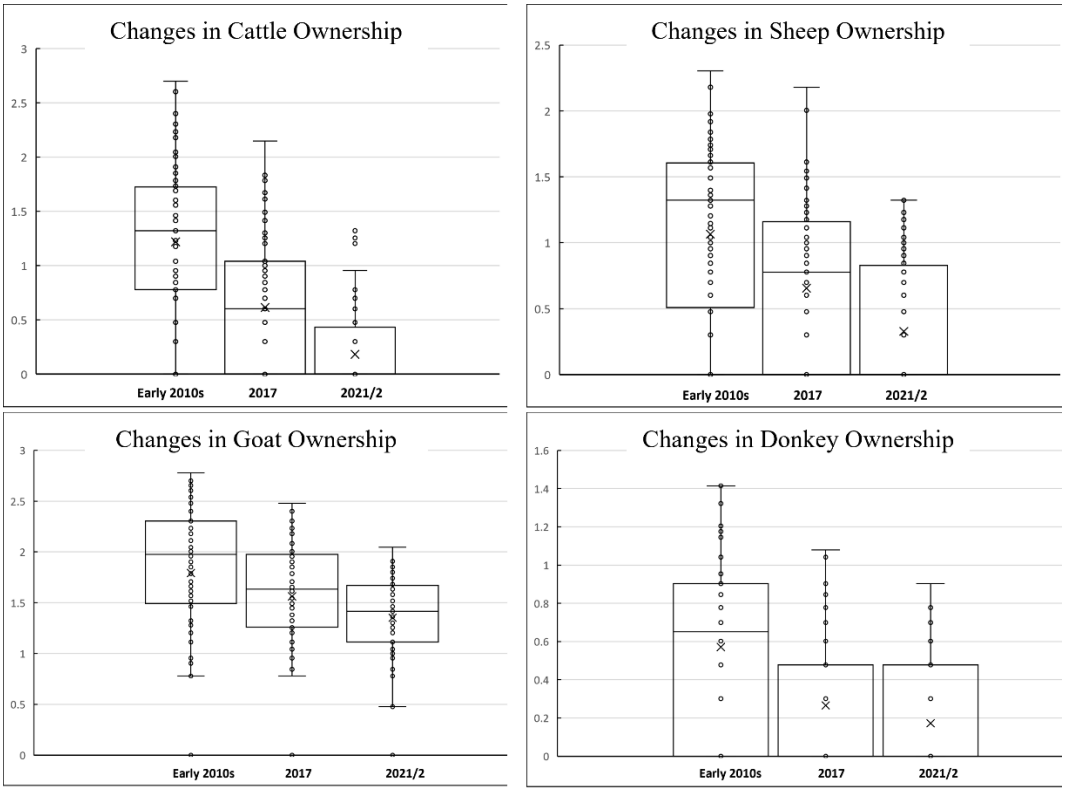


Figure 3: Boxplots visualize household ownership for each species for Anabeb, Puros, and Sesfontein, comparing 2021/2 ownership with previous survey results (Heydinger et al. 2019). Data have been log10+1 transformed. Boxes indicate interquartile range. Solid horizontal lines within the box visualize mean response. 'X' within the box visualizes median response.

Heydinger et al. (2019) asked respondents to estimate the monetary value (in Namibian dollars) of an average-sized adult female for each livestock species. Based upon these estimates, in the early 2010, the value of a median livestock herd (all species combined) was US$ 28,884 (2022 values; CPI 2023). In 2017, the value of a median livestock herd was US$ 9,185 (68% decrease), and by 2021/2 the value of a median livestock herd was US$ 3,200 (89% decrease since the early 2010s; 65% decrease since 2017). The total value of livestock lost across all households since 2010 is US$ 3,549,589 (US$ 883,392 since 2017). Again, these values only represent three of eleven surveyed conservancies.

3.3 Conservancy Challenges

When asked whether they have received important benefits from their conservancy, 41% (n = 132) replied affirmatively, while 59% (n = 191) say they have not. Positive responses ranged from a low of 18% in ≠Khoadi-//Hôas (n = 9) and Orupupa (n = 4) to a high of 77% (n = 24) in Puros. Conservancy-by-conservancy responses differed from the expected distribution, (X^2 (df 10, 1; n 323) = 50.9, $p < 0.001$), indicating a respondent's conservancy was correlated with whether they reported receiving important benefits. When asked to specify benefits, the most frequent response was meat (67%; n = 89) from own-use hunting, followed by food parcels (31%; n = 41), employment (17%; n = 22), and access to water (16%; n = 21). When asked to identify the biggest challenges facing conservancy residents, the most frequent response was drought (51%; n = 165), followed by human-wildlife conflict (32%; n = 104), and predators (29%; n = 93). Though human-wildlife conflict encompasses a wider range of challenges than predators, there may have been overlaps in what respondents sought to convey in these responses.

3.4 Predator Problems

When asked, "how often are you losing livestock to predators" 84% (n = 262) report at least a few times per year, while 66% (n = 207) report a near-monthly basis. 99% (n = 310) report having lost livestock to predators at some point. When asked whether they have ever received financial offsets for lost livestock through the HWC SRS, 37% (n = 112) of respondents stated that they have, while 59% (n = 179) have not or were unaware of the offset program.

When respondents were asked, "what predators do you have the most problems with, starting with the worst" lions were the species most frequently identified as the most problematic (38%; n = 123), spotted hyena (*Crocuta crocuta*), were the second most problematic (26%; n = 82), and black-backed jackal (*Canis mesomelas*) were the third (15%; n = 48). For this question, respondents could identify up to three species. When up to three responses were included, spotted hyena were the most frequently identified (64%; n = 207), followed by black-backed jackal (61%; n = 196), and lion (58%; n = 186). Table 6 summarizes conservancy-by-conservancy response frequency, when up to three responses were included. Answers differed between conservancies (X^2 (df 10, 6; n 323) = 130.97, $p < 0.001$), indicating a significant relationship between a respondent's conservancy and which predators they considered among the most problematic. Assessed on a species-by-species basis, there was an association between a respondent's conservancy and whether they considered lions (X^2 (df 10; n 323) = 38.44, $P < 0.001$), leopard (*Panthera pardus*) (X^2 (df 10; n 323) = 21.09, $p = 0.02$), and cheetah (*Acinonyx jubatus*) (X^2 (df 10; n 323) = 26.87, $p < 0.01$) among the most problematic. For other species, the association between conservancy and species did not differ significantly from the expected distribution.

Conservancy	lion % (n)	leopard % (n)	sp. hyena % (n)	b-b jackal % (n)	cheetah % (n)	n respondents
Anabeb	57% (17)	53% (16)	67% (20)	73% (22)	40% (12)	30
Doro !Nawas	28% (5)	67% (12)	67% (12)	61% (11)	33% (6)	18
Ehi-rovipuka	94% (29)	42% (13)	68% (21)	71% (22)	6% (2)	31
≠Khoadi-//Hôas	82% (40)	22% (11)	51% (25)	51% (25)	24% (12)	49
Omatendeka	50% (16)	53% (17)	72% (23)	53% (17)	56% (18)	32
Orupupa	23% (5)	45% (10)	91% (20)	64% (14)	23% (5)	22
Puros	68% (21)	42% (13)	81% (25)	65% (20)	6% (2)	31
Sesfontein	48% (13)	7% (2)	78% (21)	59% (16)	26% (7)	27
Sorris-Sorris	20% (3)	40% (6)	53% (8)	87% (13)	13% (2)	15
Torra	78% (36)	61% (28)	41% (19)	50% (23)	17% (8)	46
Tsiseb	5% (1)	59% (13)	59% (13)	59% (13)	36% (8)	22
n total	186	141	207	196	82	323

Table 6: Table summarizing frequency of responses to survey question "what predators do you have the most problems with, starting with the worst" by conservancy. Up to three responses were recorded per respondent. Column headings: species % (n), percentage (and total number) of respondents within the indicated conservancy identifying that species among top three most problematic predator species; n respondents, number of respondents. Percentages are relevant to proportion of responses within a conservancy. Shading increases from light (low) to dark (high), indicating which predator species are considered most problematic within each conservancy.

3.5 Perceptions of Lions

Respondents differ as to how common they believe lions are within their conservancy (Table 7). Conservancy-by-conservancy, responses differed from the expected distribution (X^2 (df 10, 3; n 318) = 250.6, $p < 0.001$). Though respondents were not asked to define what was meant by "very common," "common," etc., previous research indicates current lion prevalence is considered relative to past lion prevalence (Heydinger et al. 2019, Heydinger et al. in press).

Conservancy	vcommon	common	rare	absent	n responses
Anabeb	63%	27%	10%	0%	30
Doro !Nawas	0%	17%	61%	22%	18
Ehi-rovipuka	58%	19%	23%	0%	31
≠Khoadi-//Hôas	31%	52%	17%	0%	48
Omatendeka	22%	31%	41%	6%	32
Orupupa	0%	0%	32%	68%	22
Puros	45%	26%	29%	0%	31
Sesfontein	73%	27%	0%	0%	26
Sorris-Sorris	0%	21%	57%	21%	14
Torra	20%	47%	33%	0%	45
Tsiseb	5%	5%	24%	67%	21
n responses	102	92	86	38	318

Table 7: Summary of responses to survey question, "how common are lions in conservancy" Column headings: vcommon, percentage of respondents stating lions are very common in their conservancy; common, percentage of respondents stating lions are common in their conservancy; rare, percentage of respondents stating lions are rare in their conservancy; absent, percentage of respondents stating there are no lions in their conservancy; n responses, number of respondents.

When asked, "do you benefit from having lions in your conservancy" 84% (n = 271) responded "no" or were unsure. When asked, "how would you describe your attitude towards lions" 17% (n = 58) responded positively, while 57% (n = 190) described their attitude as negative. From conservancy to conservancy, responses differed significantly from the expected distribution (X^2 (df 10, 3; n 321) = 104.11, $p < 0.001$). There was a moderate positive correlation between a respondent's attitude towards lions, and whether or not they report benefitting from lions (r(n 312) = 0.44, p <0.001). When asked, "how serious a problem are lions in your conservancy" 54% (n = 175) considered lions to be a serious problem, 14% (n = 44) consider lions a moderate problem, while 30% (n = 98) considered lion problems to be low, or stated there were no lions in their conservancy. From conservancy to conservancy, responses differed significantly from the expected distribution (X^2 (df 10, 3; n 317) = 223.8, $p < 0.001$).

When asked, "is it important for there to continue to be lions in your conservancy" 60% (n = 187) of respondents stated "no," 28% responded "yes," and 12% described their feelings as neutral or were unsure. There was a moderate correlation between whether a respondent benefits from having lions in their conservancy and whether they feel it is important for lions to persist in their conservancy (r(n 302) = 0.41, p <0.001).

3.6 HLC Interventions

Responses varied by conservancy as to respondents' level of engagement by, and attitudes towards, HLC interventions (Table 8). Whether the Lion Rangers (X^2 (df 10, 2; n 323) = 58.45, $p < 0.001$) or Rapid Response Teams (X^2 (df 10, 2; n 320) = 70.05, $p < 0.001$) had visited a respondent's farm, or whether a respondent had the Early-Warning System (X^2 (df 10, 2; n 321) = 28.89, $p < 0.01$) or a predator-proof kraal (X^2 (df 10, 2; n 321) = 46.24, $p < 0.001$) at their farm, differed significantly from the expected distribution, signalling an association between a respondent's conservancy and the presence of that intervention (Figure 4). There was a strong positive correlation between positive attitudes towards the Lion Rangers and whether Lion Rangers had visited a respondent's farm (r(n 320) = 0.59, p <0.001). There was a moderate positive correlation between positive attitudes towards the Rapid Response Teams and whether Rapid Response Teams had visited a respondent's farm (r(n 317) = 0.39, p <0.001). By comparison there was a weak positive correlation between attitudes towards the Early-Warning System and whether respondents had the system

at their farm (r(n 306) = 0.19, p <0.001) and a non-significant correlation between attitudes towards predator-proof kraals and whether a respondent had a predator-proof kraal at their farm.

	Have you heard of the Lion Rangers?			Have the Lion Rangers ever visited your farm?			What is your attitude towards the Lion Rangers?			Have you heard of the HWC Rapid Response Teams?			Have the HWC Rapid Response Teams ever visited your farm?			What is your attitude towards the HWC Rapid Response Teams?		
	yes	no	unsure	yes	no	unsure	positive	negative	neutral/ unsure	yes	no	unsure	yes	no	unsure	positive	negative	neutral/ unsure
Anabeb	93%	3%	3%	73%	27%	0%	69%	3%	28%	97%	3%	0%	97%	3%	0%	77%	10%	13%
Doro !Nawas	78%	22%	0%	61%	39%	0%	61%	0%	39%	61%	39%	0%	33%	67%	0%	17%	17%	67%
Ehi-rovipuka	90%	6%	3%	71%	23%	6%	55%	6%	39%	52%	42%	6%	39%	52%	10%	29%	6%	65%
ǂKhoadi-//Hôas	65%	35%	0%	27%	73%	0%	29%	4%	67%	82%	16%	2%	49%	49%	2%	35%	31%	35%
Omatendeka	88%	9%	3%	50%	41%	9%	50%	6%	44%	56%	34%	9%	38%	53%	9%	38%	6%	56%
Orupupa	32%	59%	9%	9%	82%	9%	9%	0%	91%	5%	90%	5%	0%	95%	5%	5%	0%	95%
Puros	100%	0%	0%	48%	52%	0%	71%	10%	19%	87%	13%	0%	43%	57%	0%	65%	6%	29%
Sesfontein	96%	4%	0%	63%	37%	0%	56%	7%	37%	59%	37%	4%	42%	54%	4%	41%	15%	44%
Sorris-Sorris	60%	40%	0%	40%	60%	0%	47%	0%	53%	60%	40%	0%	40%	60%	0%	47%	0%	53%
Torra	85%	15%	0%	52%	46%	2%	54%	13%	33%	78%	22%	0%	46%	50%	4%	42%	7%	51%
Tsiseb	59%	41%	0%	45%	55%	0%	55%	0%	45%	18%	82%	0%	18%	82%	0%	23%	0%	77%
total	79%	20%	2%	49%	49%	2%	50%	6%	44%	64%	33%	2%	43%	53%	3%	40%	11%	50%
median	85%	15%	0%	50%	46%	0%	55%	4%	39%	60%	37%	0%	40%	54%	2%	38%	6%	53%
st. dev.	0.198	0.187	0.027	0.181	0.175	0.037	0.169	0.042	0.189	0.265	0.257	0.031	0.223	0.218	0.035	0.195	0.087	0.219
n responses	255	63	5	158	157	8	161	18	143	206	107	8	138	171	11	127	34	160
n total			323			323			322			321			320			321

	Have you heard of the Early-Warning System?			Do you have the Early-Warning System at your farm?			What is your attitude towards the Early-Warning System?			Have you heard of predator-proof kraals?			Do you have a predator-proof kraal at your farm?			What is your attitude towards predator-proof kraals?		
	yes	no	unsure	yes	no	unsure	positive	negative	neutral/ unsure	yes	no	unsure	yes	no	unsure	positive	negative	neutral/ unsure
Anabeb	83%	13%	3%	20%	77%	3%	76%	0%	24%	100%	0%	0%	30%	70%	0%	90%	7%	3%
Doro !Nawas	61%	39%	0%	0%	100%	0%	56%	0%	44%	83%	17%	0%	11%	89%	0%	61%	6%	33%
Ehi-rovipuka	58%	42%	0%	19%	77%	3%	62%	0%	38%	97%	3%	0%	55%	45%	0%	83%	3%	14%
ǂKhoadi-//Hôas	36%	62%	2%	6%	91%	2%	28%	2%	70%	88%	13%	0%	31%	67%	2%	53%	19%	28%
Omatendeka	53%	44%	3%	0%	97%	3%	58%	0%	42%	100%	0%	0%	28%	72%	0%	97%	3%	0%
Orupupa	10%	90%	0%	0%	100%	0%	21%	0%	79%	32%	68%	0%	0%	100%	0%	64%	0%	36%
Puros	84%	16%	0%	29%	71%	0%	68%	6%	26%	100%	0%	0%	19%	81%	0%	94%	0%	6%
Sesfontein	56%	44%	0%	7%	93%	0%	52%	0%	48%	96%	4%	0%	19%	81%	0%	85%	7%	7%
Sorris-Sorris	40%	60%	0%	13%	87%	0%	40%	0%	60%	87%	13%	0%	14%	86%	0%	73%	0%	27%
Torra	52%	48%	0%	15%	83%	2%	26%	7%	67%	96%	4%	0%	53%	47%	0%	73%	12%	15%
Tsiseb	41%	59%	0%	18%	77%	5%	59%	0%	41%	64%	36%	0%	18%	82%	0%	73%	0%	27%
total	53%	46%	1%	12%	86%	2%	48%	2%	50%	88%	12%	0%	29%	71%	0%	77%	7%	17%
median	53%	44%	0%	13%	87%	2%	56%	0%	44%	96%	4%	0%	19%	81%	0%	73%	3%	15%
st. dev.	0.201	0.205	0.013	0.093	0.098	0.017	0.174	0.026	0.17	0.199	0.199	0	0.160	0.161	0.006	0.134	0.058	0.122
n responses	170	147	3	39	276	6	149	6	153	283	38	0	93	226	1	238	21	52
n total			320			321			308			321			320			311

Table 8: Table summarizing extension and effectiveness of HLC interventions by conservancy.

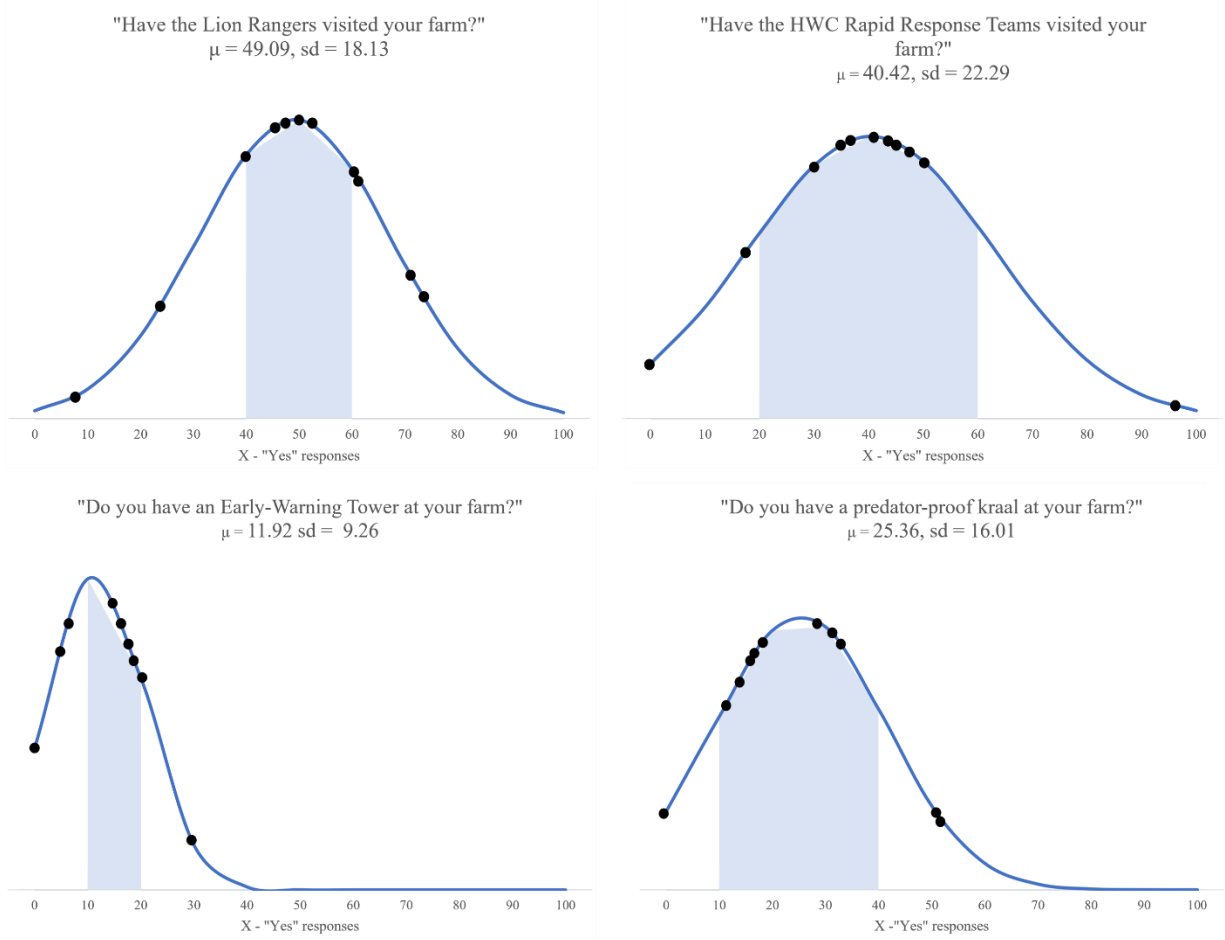


Figure 4: Graphs indicating landscape spread of HLC interventions. Points represent percentage of "yes" responses by conservancy; line shows normalized distribution of responses; shaded area indicates one standard deviation from the mean.

For all HLC interventions, there was a weak positive or non-significant correlation between a respondent's attitude towards lions and whether an intervention had been or was present at their farm. There was a weak positive correlation between whether a respondent stated they were benefiting from having lions in the conservancy and whether they have an Early-Warning Tower (r(n 312) = 0.23, p <0.001), or predator-proof kraal at their farm (r(n 311) = 0.14, p <0.05).

4. DISCUSSION

Estimated livestock losses across core lion range conservancies have been nothing short of catastrophic. Respondents point to the effects of drought and predators as the drivers of such losses. For each of the four livestock species, more than 80% of respondents report a decrease in numbers. While historic comparisons were only available for three conservancies (Anabeb, Puros, and Sesfontein), trends in these conservancies indicate a 79-97% decrease in livestock numbers by species, representing an estimated 89% decrease in median household herd value since the early 2010s. Such losses coincide with diminished rainfall since 2011 (Figure 5). Though these three conservancies fall within the western half of the area surveyed, which is more arid than further east, our field work indicates similar livestock losses across Kunene's communal lands. These losses mirror region-wide declines in prey species during the same period. Because selling livestock is the most common source of income, livestock deaths compromise human wellbeing.

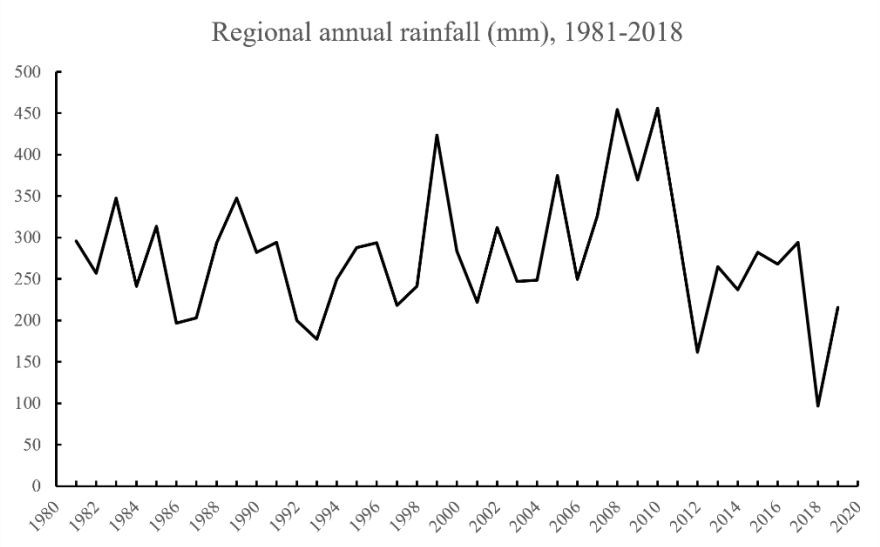


Figure 5: Regional rainfall data, adapted from Bollig 2023.

Livelihood challenges are exacerbated by lack of conservancy benefits. 59% of respondents report receiving no benefits from their conservancy, though this differs from conservancy to conservancy. Those receiving benefits most frequently sighted meat or food distribution, though many stated such benefits have declined since the drought and COVID-19 pandemic. Game hunting by conservancies, whether for own-use, shoot-and-sell, or for trophy-hunting quotas, has also been greatly curtailed in recent years due to declining wildlife numbers. Even so, the extent to which benefits (e.g. from hunting) had previously reached conservancy residents was already limited.

Livestock losses to predators have affected 99% of households, including two-thirds on a near-monthly basis. Yet, financial offset payments from the HWC SRS are not reaching most pastoralists. Comments from respondents indicate that offsets are rarely delivered, and that even when payments are made, they are too little and too late in coming, sometimes years late. Among those respondents critical of the offset payment system, many deemed the process by which claims are recorded, submitted, assessed, and potentially paid out as riven by local politics and favouritism. Livestock losses, diminished prey numbers, inconsistent benefit distribution, and inadequate financial offsets following human-wildlife conflict each undermine the economic instrumentalism pillar of the conservancy system.

Challenges presented by predators reveal subtle differences across the survey landscape. Lions are considered the most problematic predator by the greatest number of respondents (38%). This may be due to an ingrained fear pastoralists have of lions (Heydinger et al. in press). It may also be due to lions killing multiple livestock per HLC incident. In recent years such 'mass-casualty' events have occurred, each time receiving nation-wide news coverage (Hartmann 2017, 2018). However, when respondents were asked to name up to three problematic predators, more respondents identified spotted hyena (64%) and black-backed jackal (61%) than lions (58%). The association between a respondent's conservancy and whether they considered lions among the most problematic predators indicates that lion problems are spatially heterogeneous. No such association exists for hyena and jackals. The conservancies in which lions are considered most problematic are also those conservancies in which they are considered the most common. Though hyena and jackal conflict receive less attention, more households may be positively affected by expanding interventions to limiting human-hyena and human-jackal conflict.

Perceptions of lions' occurrence coincide with lion monitoring data. Results from a lion population survey (Heydinger and Muzuma 2023) completed nearly one year after these social surveys, found lions were absent from Doro !Nawas, Orupupa, Sorris-Sorris, and Tsiseb conservancies. These are the only conservancies in which > 50% of respondents considered lions to be rare or absent – suggesting local pastoralists maintain some understanding of lion movements and prevalence. Though population surveys

of other predators have not been attempted, local perceptions of, e.g., leopard, hyena, or cheetah movement and prevalence may be a useful point of departure for estimating populations of these species.

HLC interventions appear to be having an uneven affect. While respondents generally viewed HLC interventions – the Lion Rangers, Rapid Response Teams, Early-Warning System, and predator-proof kraals – favourably, many respondents were unaware of their existence. For the Lion Rangers (44%), Rapid Response Teams (50%), and Early-Warning System (50%), approximately half of respondents stated a neutral or unsure attitude towards them – overwhelmingly because the respondent felt uninformed about their existence. While much of this can be attributed to interventions being spatially concentrated within HLC 'hotspots,' increasing deployment of these interventions, and better communication regarding their purposes, is needed. The existence of a strong positive correlation between attitudes towards the Lion Rangers and whether Lion Rangers had visited a respondent's farm suggests that greater landscape coverage by the Lion Rangers will improve not only awareness, but attitudes towards them. Yet, with no correlation between the presence of interventions and attitudes towards lions, simple proximity may not be enough to foster tolerance of lions.

Attitudes towards lions are most significantly correlated to whether respondents reported benefiting from them. Though this correlation was moderate, it suggests the foundation for more proactive interventions focusing on increasing benefits, rather than only limiting conflict. A recently implemented Wildlife Credits program, whereby conservancies receive monetary benefits for living alongside lions based upon lion movement data (Heydinger et al. 2022; Conservation Namibia 2023), may increase the number of respondents receiving benefits from lions. Communication will be key if such benefits are to influence attitudes towards lions.

To-date approximately 120 predator-proof kraals have been erected at conservancy farms, free of charge to the livestock owners. These kraals have been provided specifically as a remedy to HLC. Yet, few pastoralists make the connection between predator-proof kraals and the presence of lions within the landscape. Lion Rangers and other conservation personnel can facilitate greater understanding of what benefits are due to lions' presence by engaging with pastoralists. Because predator-proof kraals are so positively received, perhaps their provision can help foster improved attitudes towards living with lions.

However, increasing benefits is no assurance of improved attitudes. While the previous survey found 76% of respondents felt it was important for lions to continue to exist in their conservancy, 60% of respondents to our current survey felt it was *not* important for lions to continue to exist in their conservancy. The number of respondents stating they do not benefit from lions mirrors the previous survey (84%). We cannot attribute the difference in these results to changed geographic scope of our survey versus the previous one. Instead, the decline may have resulted from the added harms from livestock predation on top of the continued impacts of prolonged drought. Follow-up surveys will be needed to further interrogate drivers of attitudes towards lions.

The overall picture is one in which pastoralists' livelihoods in core lion range conservancies are in trouble. This mirrors other, recent finding for the region (NNPC 2015; Namibia Statistics Agency 2021; IFRC 2022). While livelihoods have unquestionably been hampered by the recent drought, conservancies are also not providing meaningful benefits to residents. By eroding the economic instrumentalist pillar of the conservancy system, a lack of monetary benefits is already forcing many residents to question each conservancy's purpose. These challenges are exacerbated by HLC and conflict with other predators. The current challenge is how to increase benefits without further sacrificing already degraded environments (NNPC 2015; Inman 2020a, 2020b) and diminished wildlife numbers, all under the shadow of environmental transformations stemming from climate change (Atlas of Namibia 2022). HLC interventions may provide limited mitigation, but these approaches require further refining. More work and greater creativity will be needed to simultaneously support local livelihoods while fostering attitudes towards lions which limit the negative outcomes of HLC.

5. DEDICATION & ACKNOWLDGEMENTS

This paper is dedicated to the memory of Henry Jacobus Mapanka of Torra Conservancy, who believed strongly in the importance of incorporating farmers' perspectives into lion monitoring and conservation efforts.

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