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Impacts of shared home range on human-wildlife conflicts

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Human-wildlife conflicts (HWCs) are becoming increasingly common in landscapes altered by human activity, often threatening both livelihoods and wildlife conservation. We investigated HWCs in two communities: Bbaale village near Nabugabo Research Site in Uganda (73 households surveyed in 2019) and Manyangalo village near the Lewa-Borana Conservancy in Kenya (50 households surveyed in 2022) using descriptive statistics. We assessed how socioeconomic factors influenced household responses to HWCs using ordinal logistic regression models and explored community perceptions of living near a research site or conservancy. Our results showed that HWCs at Bbaale were reported as more severe (62%), often involving crop damage and livestock losses, while encounters near Manyangalo occurred more frequently (86%) but caused less damage. Households in Bbaale used a range of management strategies, including banging tins (86%), using dogs (60%) and scarecrows (59%), whereas Manyangalo residents primarily relied on noisemaking (100%). Larger cultivable areas were associated with more reported conflicts, and individuals with secondary education reported less severe impacts. Despite differences in HWC experiences, most respondents (Bbaale: 88%, Manyangalo: 86%) in both villages expressed positive views of the research site or conservancy, suggesting local support for conservation initiatives. These findings emphasize the importance of tailoring HWC management strategies to local conditions and community needs.

KEYWORDS
human-wildlife conflicts, conservation, community perceptions, socioeconomic factors, mitigation strategies

1 Introduction

The rapid growth of human activities since the Anthropocene has severely affected natural habitats, threatened global biodiversity, and placed > 44,000 species at risk of extinction due to habitat loss, degradation, and fragmentation (IUCN Redlist, 2024; Yang et al., 2024). Human-wildlife conflict (HWC), an issue of high concern for conservation, refers to a negative impact of the needs, goals, or behaviours of humans on wildlife and vice-versa (IUCN, 2023). HWCs have been documented globally throughout history (Lamarque et al., 2008), and pose a significant threat to wildlife populations worldwide

(Ladan, 2014). HWCs arise from competition over resources, leading to human concerns about crop damage, livestock predation, property loss, disease, safety risks, and well-being, while also negatively impacting wildlife through mortality, poaching, behavioural disruptions, invasive species introduction, and population decline or extinction (Mukeka et al., 2019; Thirgood et al., 2009; Treves et al., 2006). Shared home ranges, which refers to the areas where human and wildlife activities overlap spatially, can lead to interactions (including conflicts) and result in an increase in frequency, magnitude, and type of human-wildlife interactions (Ma et al., 2024).

Managing HWC is complex and context-dependent (Nanni et al., 2025), requiring strategies that address both ecological dynamics and the socioeconomic and cultural realities of affected communities (Blackwell et al., 2016; Li et al., 2023). Although the incidents of HWC occur all over the world, they are not uniformly distributed (Mekonen, 2020): the spatial and temporal patterns of HWC are influenced by human attitudes towards wildlife (Dickman et al., 2013), human activities and behaviours (Penteriani et al., 2016), wildlife adaptation and exploitation of anthropogenic resources (Kumar et al., 2019), and climate-induced shifts in biotic distributions (Pecl et al., 2017). For example, people tend to report fewer instances of HWC in developed regions where there is less competition for limited resources (Engeman and Sterner, 2002; Tzilkowski et al., 2002), whereas people in developing regions rich in biodiversity, such as south and south-east Asia, tend to report more HWC (MadhuSudan and Karanth, 2002). Socio-economic factors such as age, gender, education level, and economic status influence people's values, religious beliefs, attitudes, and socialization, which in turn affect how they perceive the world, interpret information, and make decisions (Castleman et al., 2019). Additionally, an understanding of animal behaviour and awareness of the risks posed by wildlife have also been linked to human responses (Marchini and Macdonald, 2012).

The impacts of protected areas or conservancies on local economies have been extensively discussed in the literature (Adams and Hutton, 2007; Roe, 2008). While the global benefits of biodiversity and ecosystem services are widely acknowledged (Balmford et al., 2002), the costs associated with conservancies may disproportionately affect local communities (Clements et al., 2014) because of their effects on people's livelihoods, which can influence their attitudes toward conservation (Abukari and Mwalyosi, 2020; Bragagnolo et al., 2016). It is crucial to understand not only the requirements of individual wildlife species, but also the broader cultural and economic factors that significantly influence conservation (Baillie et al., 2004). There is a growing acknowledgment that the loss or preservation of biodiversity hinges on local actions, making it vital to understand the viewpoints of local communities for sustainable wildlife management programs (Pratt et al., 2004).

Human-wildlife interactions are part of complex and dynamic social and ecological systems (Marchini et al., 2024). In this framework, coexistence does not mean conflicts are absent, but rather that people and wildlife can coexist when risks and impacts are managed (Marchini et al., 2024). The framework highlights the importance of understanding what drives conflicts, who is involved, and how human and wildlife behaviors influence each other to effectively plan strategies that facilitate coexistence (Marchini et al., 2024). There is a need for approaches that are tailored to local contexts so that any actions taken reflect real-life scenarios and can be adapted as those contexts change (Fletcher and Toncheva, 2021; König et al., 2020; Marchini et al., 2024). By linking social, cultural, economic, and environmental factors, this approach helps explain how people's attitudes, behaviors, and the environments they live in work together to determine the outcomes of human-wildlife interactions.

Thus, this study investigates HWC in two ecologically and sociologically distinct sites in East Africa to: (1) compare reported cases of HWC, (2) examine relationships between socioeconomic factors and community responses to wildlife, and (3) understand community perceptions of living near a research site and a conservancy.

2 Methods

2.1 Study sites

The study was conducted in Bbaale village adjacent to the Nabugabo Research Site on the shores of Lake Nabugabo, South Central Uganda (0.21°S, 31.52°E; Chapman et al., 2016a) (Supplementary Figure 1) and Manyangalo village adjacent to Lewa-Borana Conservancy in Kenya (0.20°N, 37.42°E; Dupuis-Desormeaux et al., 2023) (Supplementary Figure 2). Lake Nabugabo is mostly surrounded by wetlands, grasslands, and patches of swamp forest, and consists of farmers' fields, degraded forests, and a few buildings on the west side of the lake (Chapman et al., 2016b). The Nabugabo Research Site hosts long-term research on monkeys, fish, and local ecology. At Manyangalo, the landscape consists of savannah grasslands with patches of Northern Acacia-Commiphora bushlands and thickets (Dupuis-Desormeaux et al., 2023) and a network of roads, villages, agricultural lands, and pastures (Davidson et al., 2019). Agricultural activities along the Lewa-Borana Conservancy border encompass a spectrum, ranging from sizable commercial farms to community farming on smaller plots involving cultivation of subsistence crops like maize, carrots, onions, and wheat (Dupuis-Desormeaux et al., 2023).

2.2 Survey methods

A semi-structured survey (Connelly et al., 2012) was used to interview the households in Bbaale, Uganda (September–November 2019) and in Manyangalo, Kenya (July–September 2022). These sites were selected for their contrasting ecological and sociocultural contexts: Bbaale is a small-scale agricultural landscape within which the Nabugabo Research Site is located (i.e., non-protected area), whereas Manyangalo is a village adjacent to Lewa-Borana Conservancy, which is a fenced (i.e., protected) savannah area supporting wildlife-based livelihoods and conservation programs (lewa.org).

Households were selected opportunistically. A total of 123 respondents participated (Bbaale: 73 of approximately 200 households; Manyangalo: 50 of approximately 500 households), representing ~36.5% and 10% of the households in each community. The sample size was chosen based on feasibility, with the aim of capturing a broad range of experiences and perspectives across different households, while also accounting for COVID-related delays, funding and time constraints, participation interest, and other logistic challenges.

The survey was adapted from previously used surveys in communities near Kibale National Park, Uganda (Naughton-Treves et al., 2011; MacKenzie et al., 2017), and communities bordering a fenced wildlife conservancy in Kenya (Dupuis-Desormeaux et al., 2023). Survey questions covered three main categories:

1. Household demographics: age, gender, education, size of cultivable land, distance between households and cultivable land, sources of income.
2. Experiences with wildlife: observed species, frequency and severity of HWC, and strategies used to prevent or mitigate conflict.
3. Perceptions: perceived risks and benefits associated with living near the Nabugabo Research Site or Lewa-Borana Conservancy.

Research assistants and community liaison staff explained the purpose of the study, obtained participants' consent, and carried out interviews in the language each participant preferred (English, Luganda, or Kiswahili). Participants were given a small honorarium for their involvement.

2.3 Data analyses

We analysed respondents' answers to HWC questions at Bbaale and Manyangalo using Chi-square tests to compare percentages for types, severity, frequency, perceived causes, mitigation methods, and local perceptions of the research site or conservancy. We categorized the negative effects and their ranks (Rank 1 being the most important, and Rank 2 being the second most important) reported by the respondents as negative effects from the researchers, negative effects from the animals, and no negative effects.

We used ordinal logistic regression to test for the influence of socioeconomic factors (i.e., respondents' age, gender, education level, acres of cultivable land, distance between households and cultivable land, number of sources of income, and site) on types, severity, and frequency of reported HWCs (Supplementary Table S1). For each model, we used the 'dredge' function in the MuMIN package (Barton, 2023) to identify the "top" model(s) within Δ7 AICc (Burnham et al., 2011). When multiple top models were identified, we conducted model averaging and calculated 95% confidence intervals for each predictor variable (Buckland et al., 1997; Burnham et al., 2011). Because there were few data points "moderately severe" and "less severe" HWC, we combined them into the single category "low severity". We first developed separate models for each outcome variable for each study site. However, the limited number of data points made them ineffective. As a result, we used a single combined model for each outcome variable for both study sites. Models were checked for multicollinearity among predictor variables (VIF < 5) (James et al., 2017). All analyses were conducted in R statistical software RStudio, version 4.0.3 (R Core Team, 2021).

3 Results

3.1 Characteristics of respondents

A total of 123 participants were surveyed across the two study sites: Bbaale (N = 73) and Manyangalo (N = 50). Of these, 115 respondents [Bbaale: N = 68; Manyangalo: N = 47] were included in the analyses after excluding cases with incomplete socioeconomic data. The socioeconomic and demographic characteristics of respondents are summarized in Supplementary Table S1. Overall, respondents from Bbaale (mean: 42.74; range = 19-84) were generally younger than those from Manyangalo (mean: 48.68; range = 22-76). A higher proportion of respondents at Bbaale were women (60.27%) compared to Manyangalo (48%). More respondents at Bbaale (50.68%) cultivated 100–500 acres of land, whereas more respondents at Manyangalo (52%) cultivated over 1000 acres. Furthermore, multiple sources of income were common at Manyangalo (88%), while most respondents at Bbaale (54.79%) relied on a single source.

3.2 HWC between Bbaale and Manyangalo

There were significant differences in the percentage of respondents reporting on the severity (χ^2 = 19.98, $p < 0.05$) and frequency (χ^2= 37.29, $p < 0.05$) of HWC, with people at Manyangalo reporting lower severity but higher frequency of HWC than at Bbaale. Specifically, 89% of respondents at Bbaale reported the conflicts as very severe, compared to 62% at Manyangalo. Conversely, 86% of respondents at Manyangalo reported conflicts occurring more than once per day, compared to 48% at Bbaale.

There were also significant differences in the reports of HWC at Bbaale and Manyangalo in terms of crop foraging (χ^2 = 211.33, $p < 0.05$), destruction of food stores (χ^2 = 12.54, $p < 0.05$), scaring livestock (χ^2 = 95.42, $p < 0.05$), and threatening of people (χ^2 = 48.89, $p < 0.05$). At Bbaale, the main crop-foraging species were reported as vervet monkeys (92%), rats (70%), and small birds (62%). At Manyangalo, vervet monkeys (98%), baboons (98%), and small birds (84%) were most frequently reported foraging crops. For food store damage, only rats at Manyangalo (76%) exceeded 50% reporting. Birds of prey were the primary species reported to scare livestock at both sites (60% at Bbaale; 58% at Manyangalo), along with hyenas (60%) at Manyangalo. Lastly, only four species were reported to be involved in threatening or killing people with 19%

reporting snakes at Bbaale, whereas nine species were reported at Manyangalo with 60% reporting snakes.

At Bbaale, most of the respondents reported vervet monkeys (91%), rats (68%), and birds of prey (47%) as the most severe sources of HWC, while HWC with redtail monkeys (99%), small antelope (98%), colobus monkeys (95%), dogs (85%), snakes (77%), and small birds (38%) were reported as not severe (Figure 1). Very few respondents reported HWC with wildlife as moderately severe or least severe (Figure 1). At Manyangalo, most respondents reported HWC with vervet monkeys (92%) and baboons (84%) as the most severe, whereas HWC with birds of prey (56%), snakes (50%), and rats (44%) were reported as moderately severe. Additionally, HWC with small birds (78%) and small antelope (52%) were reported as the least severe, while HWC with dogs (56%), lions (54%), elephants (52%), and hyenas (36%) were reported as not severe (Figure 1).

The frequency of HWCs reported at Bbaale and Manyangalo differed significantly between sites by time of the day ($\chi^2 = 45.24$, $p < 0.05$) and month ($\chi^2 = 94.01$, $p < 0.05$). While most of the respondents at Bbaale and Manyangalo reported HWC in the morning (78% at Bbaale; 96% at Manyangalo), afternoon (88% at Bbaale; 76% at Manyangalo), and evening (89% at Bbaale; 84% at Manyangalo), only respondents at Manyangalo (46%) reported HWC at night. At Bbaale, there was a bimodal distribution in the seasonal timing of the reported HWC frequency, peaking in March-April and again in August-October, while at Manyangalo, HWC were reported to be most frequent from July to November (Figure 2).

There was a significant difference in response to when local HWC started ($\chi^2 = 58.69$, $p < 0.05$) and the causes of HWC ($\chi^2 = 57.63$, $p < 0.05$). Most of the people at Manyangalo stated HWCs started about 6–10 years ago, while most people at Bbaale reported uncertainty about the beginning of the HWC (Supplementary Table S2). At both Bbaale and Manyangalo, respondents commonly attributed HWC to factors like insufficient food in animal habitats (100% at Bbaale; 92% at Manyangalo), growing animal populations (95% at Bbaale; 96% at Manyangalo), and expanding human settlements (96% at Bbaale; 60% at Manyangalo), with additional respondents from Bbaale indicating the presence of researchers in the area (64% at Bbaale; 4% at Manyangalo), and other causes (such as the proximity of forests to their gardens) (Figure 3).

While there was a significant difference in the mitigation strategies used to guard against wildlife between Bbaale and Manyangalo ($\chi^2 = 84.34$, $p < 0.05$), shouting was the most commonly reported method for deterring wildlife from crop foraging at both Bbaale (89%) and Manyangalo (100%). At Bbaale, respondents frequently mentioned strategies like banging tins (86%), using dogs (60%) and scarecrows (59%), and less commonly reported strategies including fencing (40%), poisoning (14%), trapping and killing (7%), trapping and releasing (4%), and lighting bonfires (4%); these latter methods were not used or used less frequently at Manyangalo (Figure 4).

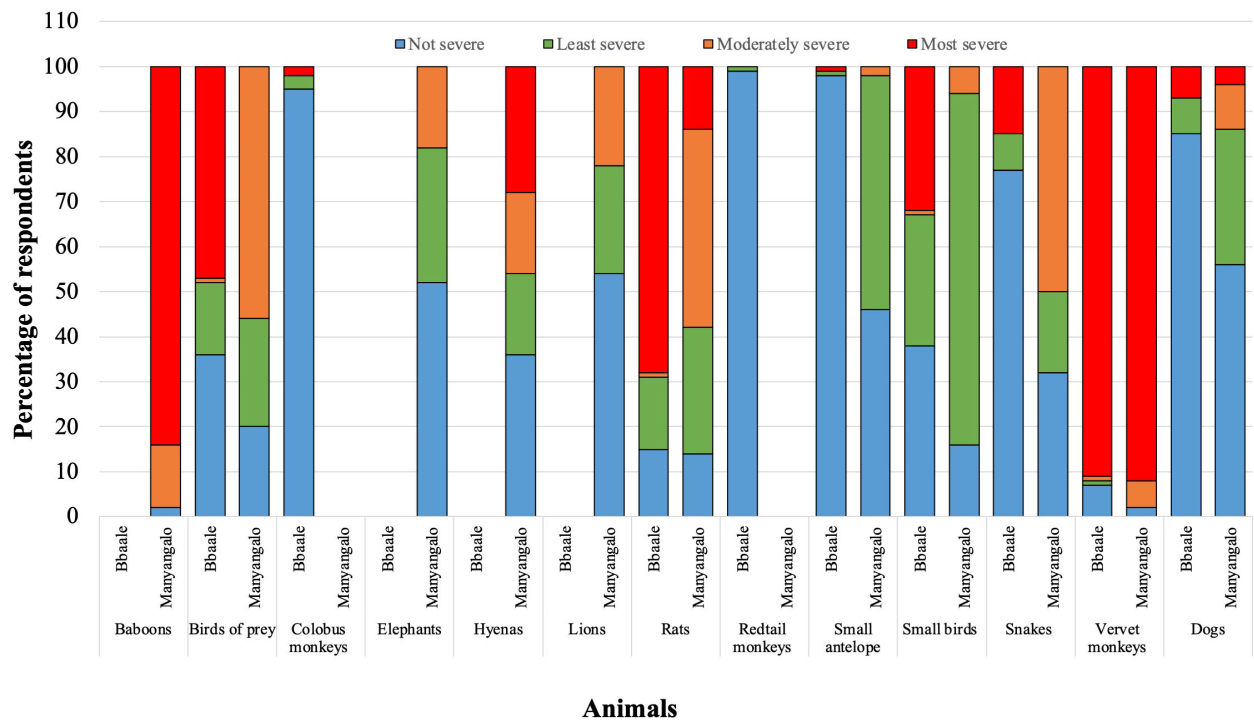

FIGURE 1
Percentage of respondents who reported severity of conflicts in relation to wildlife seen in the area at Bbaale (N = 73) and Manyangalo (N = 50).

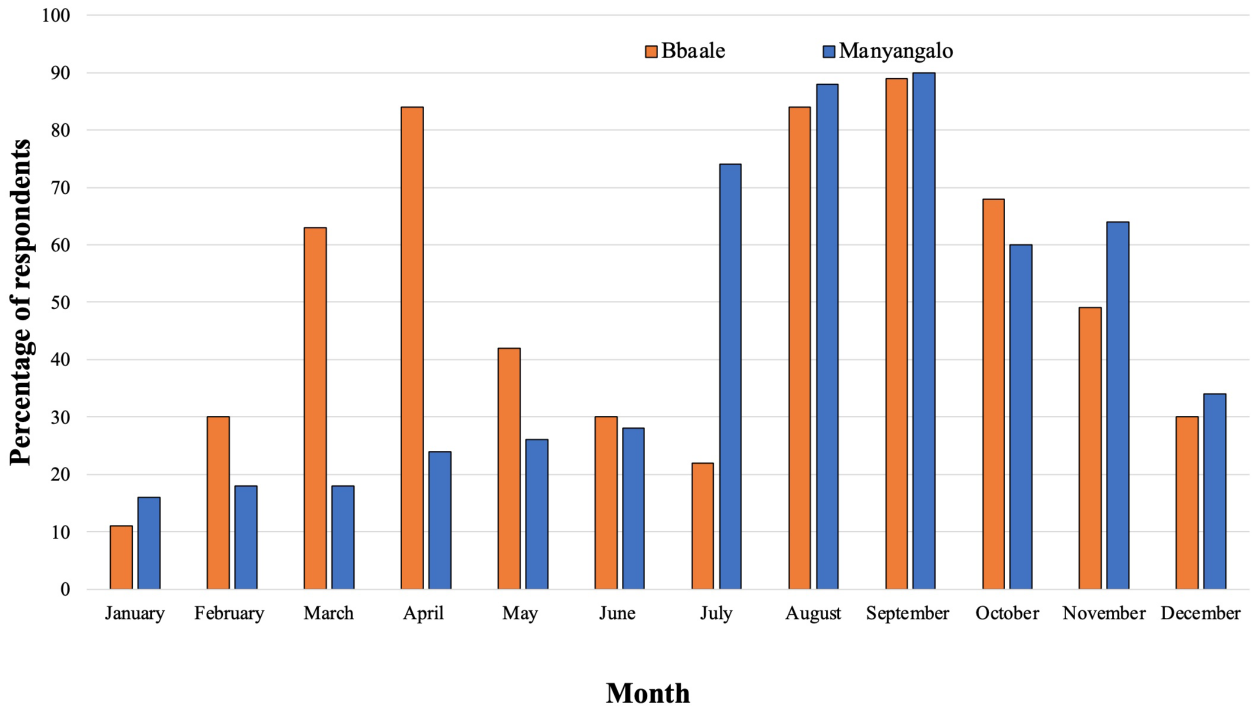

FIGURE 2
Percentage of respondents who reported frequency of conflict with wild animals during different months within the last one year in Bbaale village, Uganda (N = 73) and in Manyangalo village near Lewa Borana Conservancy, Kenya (N = 50).

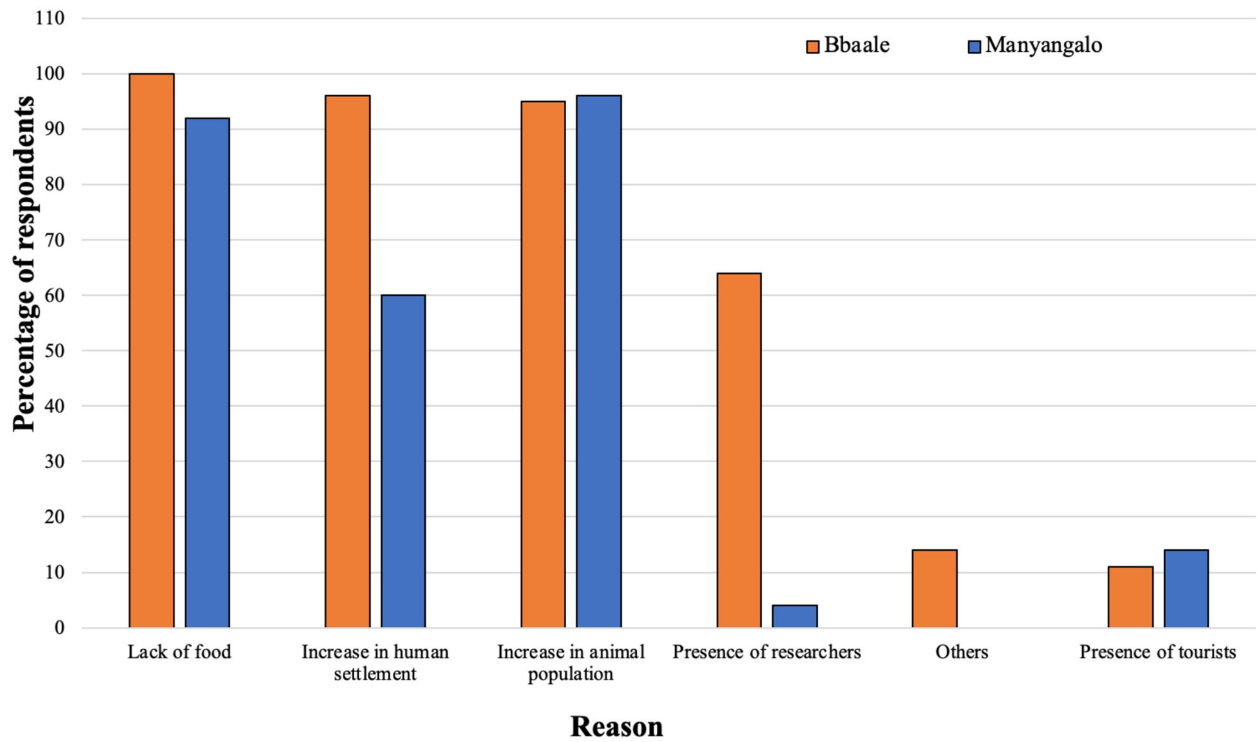

FIGURE 3
Percentage of respondents who reported different reasons for the wildlife conflicts in Bbaale village, Lake Nabugabo, Uganda (N = 73) and Manyangalo village, near Lewa-Borana Conservancy, Kenya (N = 50).

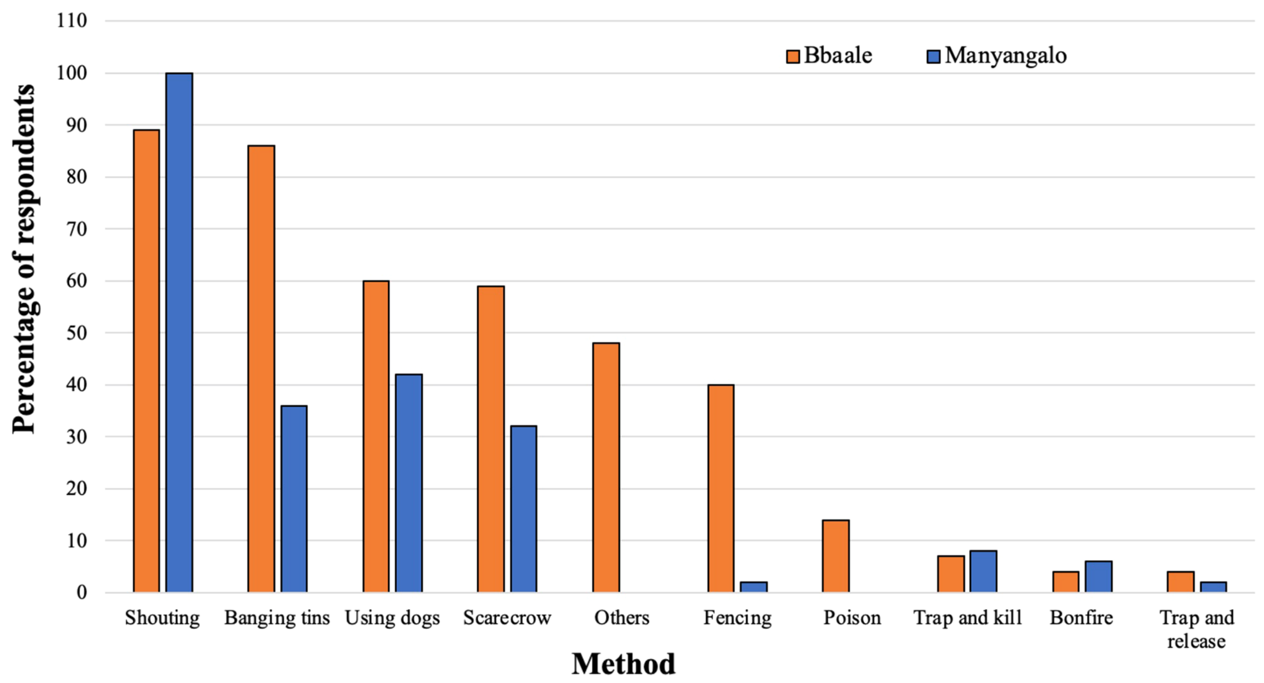

FIGURE 4
Percentage of respondents who reported different types of methods used to guard against the wildlife in Bbaale village, Lake Nabugabo, Uganda (N = 73), and in Manyangalo village in Lewa-Borana Conservancy, Kenya (N = 50).

3.3 Socio-economic factors influencing responses to HWC

Of the 115 survey respondents at Bbaale and Manyangalo for whom we had socioeconomic data, 26% reported only one type of HWC, 18% reported two types of HWC, 21% reported three types of HWC, and 35% reported four types of HWC. The model selection procedure identified 44 models within ΔAICc < 7 (Supplementary Table S3). Model averaging indicated that only the amount of cultivable land was a significant predictor of the number of types of HWC reported (Table 1), with the odds ratio indicating the respondents who cultivated > 1000 acres reporting significantly higher number of HWC than those who cultivated < 100 acres (Table 1).

In terms of HWC severity, 80% reported high severity, 14.8% reported low severity, and 5.2% said they were unsure. The model selection procedure identified 12 models within ΔAICc < 7 (Supplementary Table S3). Model averaging showed that education and site were the only significant predictors of reported HWC severity (Table 1), with the odds ratio of the respondents reporting high severity being lower for those who attended or completed secondary level than the respondents who did not attend any schooling (Table 1). Furthermore, the odds ratio of the Bbaale respondents reporting high severity was greater than for the Manyangalo respondents (Table 1).

With regard to HWC frequency, 65.2% reported that HWC occurred more than once per day, 13% reported once per day, 6.1% reported two-three times per week, 12.2% reported once per week, and 3.5% (N = 4) reported once per month. The model selection procedure identified 36 models within ΔAICc < 7 (Supplementary Table S3). Model averaging indicated that site was the only significant predictor of the frequency of HWC reported by the respondents (Table 1), with the odds ratio of the Bbaale respondents reporting high frequency of HWC being less than that of the Manyangalo respondents (Table 1).

3.4 Perception of people towards the Nabugabo research site and Lewa-Borana conservancy

At Bbaale, 8% respondents reported dislike towards the Nabugabo Research Site. Among the 24 respondents at Bbaale who reported Rank 1 negative effects, more respondents attributed these effects to the researchers (71%) than to the monkeys (29%), while this was split evenly among the four respondents who reported Rank 2 negative effects. On the other hand, 88% of respondents reported liking the Nabugabo Research Site. When asked to rank the benefits from the Nabugabo Research Site, among the 71 respondents who reported Rank 1 benefits, the majority (83%) reported job opportunities, while only a small number mentioned financial aid to villagers, school activities, infrastructure development, and similar aspects (Figure 5A). Among the 51 respondents who reported Rank 2 benefits, some reported help for villagers (31%) and knowledge about research (24%) while a few highlighted job opportunities, infrastructure improvements, organized activities, and enhanced tourist attractions (Figure 5A). In terms of ideas to improve the relationship between community and researchers at Nabugabo

TABLE 1 Model averaged parameter estimates for the top models for the outcomes: number of types of conflicts, severity of conflicts and frequency of conflicts.

Outcomes	Predictors/levels	∑	b	SE	OR	95% CI for b
Number of types of conflicts	Age	0.27	0.01	0.01	1.01	-0.02 to 0.03
	Gender_Male	0.25	-0.20	0.22	0.82	-0.98 to 0.58
	Education_Primary	0.10	-0.33	0.23	0.72	-1.67 to 1.01
	Education_Secondary		-0.65	0.31	0.52	-2.20 to 0.91
	Cultivable land_100–500 acres	**1.00**	-0.19	0.58	0.83	-1.34 to 0.96
	Cultivable land_500–1000 acres		0.00	0.63	1.00	-1.24 to 1.24
	Cultivable land_More than 1000 acres		**3.48**	**1.02**	**32.45**	**1.46 to 5.49**
	Distance_100–500 m	0.35	-0.75	0.47	0.47	-1.78 to 0.28
	Distance_More than 500 m		-0.73	0.45	0.48	-1.70 to 0.24
	Sources of income_Single	0.29	0.31	0.26	1.37	-0.49 to 1.12
	Site_Bbaale	0.41	-0.62	0.44	0.54	-1.61 to 0.37
Severity of conflicts	Age	0.23	0.00	0.01	1.00	-0.05 to 0.05
	Gender_Male	0.22	0.03	0.29	1.03	-1.19 to 1.25
	Education_Primary	**1.00**	-1.02	1.33	0.36	-3.65 to 1.61
	Education_Secondary		**-3.35**	**1.42**	**0.04**	**-6.17 to -0.52**
	Cultivable land_100–500 acres	1.00	-0.76	1.19	0.47	-3.13 to 1.60
	Cultivable land_500–1000 acres		0.66	1.42	1.93	-2.15 to 3.46
	Cultivable land_More than 1000 acres		2.47	1.49	11.83	-0.48 to 5.42
	Distance_100–500 m	0.08	0.18	0.27	1.20	-1.66 to 2.02
	Distance_More than 500 m		-0.59	0.34	0.55	-2.64 to 1.45
	Sources of income_Single	0.70	1.65	1.05	5.22	-0.08 to 3.39
	Site_ Bbaale	**1.00**	**4.02**	**0.85**	**55.62**	**2.34 to 5.70**
Frequency of conflicts	Age	0.23	0.00	0.01	1.00	-0.03 to 0.03
	Gender_Male	0.24	-0.17	0.22	0.84	0.67 to 0.84
	Education_Primary	0.25	-0.06	0.38	0.94	-1.58 to 1.45
	Education_Secondary		-0.85	0.56	0.43	-2.51 to 0.81
	Cultivable land_100–500 acres	0.20	-0.39	0.31	0.67	-1.57 to 0.78
	Cultivable land_500–1000 acres		-0.42	0.33	0.66	1.71 to 0.86
	Cultivable land_More than 1000 acres		1.57	0.84	4.79	-0.96 to 4.10
	Distance_100–500 m	0.15	0.68	0.33	1.97	-0.43 to 1.79
	Distance_More than 500 m		0.46	0.27	1.58	-0.63 to 1.54
	Sources of income_Single	0.25	0.26	0.25	1.29	-0.61 to 1.12
	Site_Bbaale	**0.99**	**-1.66**	**0.57**	**0.19**	**-2.73 to -0.58**

The table contains relative importance (∑), regression coefficient (b), unconditional standard error (SE), odds ratio (OR), and 95% confidence interval (CI) for b. Statistically significant predictors are in bold. The reference for gender is “Female”, for education is “None”, for the cultivable land is “Less than 100 acres”, for distance is “Adjacent”, and for sources of income is “Multiple” and for site is “Manyangalo”.

Research Site, the majority of the respondents (49%) suggested more job opportunities, followed by researchers taking initiatives to stop monkeys from crop foraging or looking after *“their”* monkeys (33%), improving communication with the villagers (30%), providing more healthcare to the community members (25%), providing financial help to the villagers (11%), providing financial compensation for damage caused by the monkeys (8%), and < 5% suggesting other solutions.

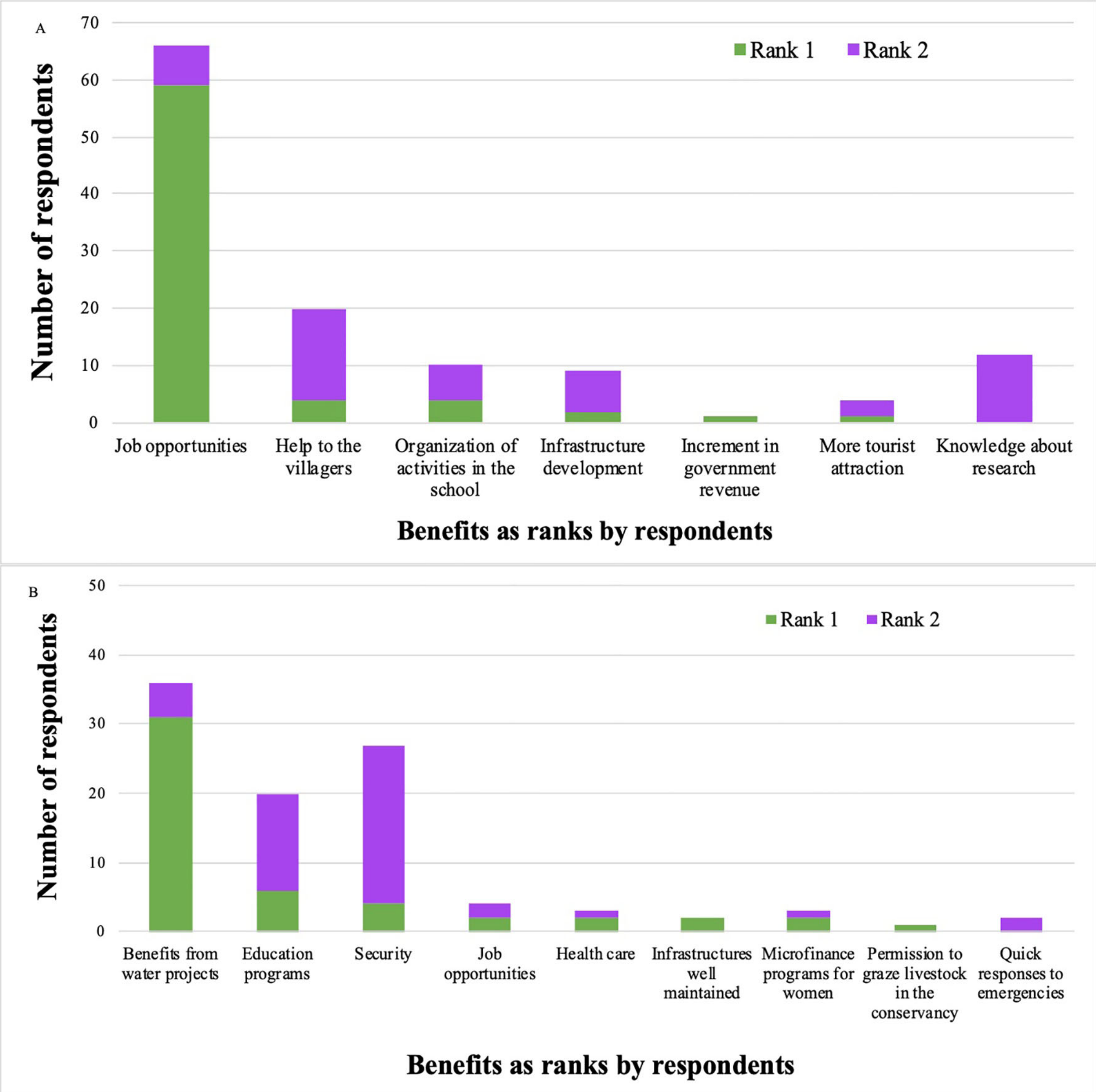

FIGURE 5
Number of respondents who ranked the benefits from the **(A)** Nabugabo Fish & Research Project on the shores of Lake Nabugabo, Uganda and **(B)** the Lewa-Borana Conservancy in and around Lewa-Borana Conservancy, Kenya. Rank 1 indicates the most important benefit and Rank 2 indicates the second most important benefit.

At Manyangalo, 8% respondents reported disliking towards the conservancy. Among the 50 respondents who reported Rank 1 negative effects, most (84%) attributed these effects to wildlife, while a smaller number (16%) pointed to the conservancy and researchers as the causes of HWC. Among the 22 respondents who reported Rank 2 negative effects, 59% attributed them to the researchers, while 41% pointed to the monkeys. On the other hand, 86% of respondents reported liking the conservancy. When asked to rank the benefits from the Lewa-Borana Conservancy, the majority of the respondents (62%) reported benefits from the water projects as Rank 1, while very few respondents reported education programs, security, job opportunities etc. (Figure 5B). Among the 48 respondents who reported Rank 2 benefits, some mentioned security (48%) and education programs (28%), while a few highlighted other benefits such as water projects, job opportunities, emergency responses, and healthcare (Figure 5B). In terms of ideas to improve the relationship between the community and conservancy, 30% of respondents suggested preventing wildlife from entering community farms and destroying crops (e.g., better fencing), 26% suggested that researchers should fulfil their promises and help the community, and 20% of respondents suggested food donation should be provided during droughts. Additionally, 14% suggested financial compensation for any damage caused by the wildlife, 14% suggested finding markets for the local produce, 10% suggested that the results of the survey should be made available to the community, only 6% suggested that more job opportunities should be made available, made other suggestions, or did not respond.

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4 Discussion

4.1 HWC in East African villages located near research and conservancy sites

We found that more animal species were observed in the village near the Lewa-Borana Conservancy in Kenya than in the village adjacent to the Nabugabo Research Site, Uganda; thus, it is not surprising that a higher number of species were reported foraging on crops at Manyangalo. However, respondents at both sites frequently cited non-human primates (herein primates) as involved in crop foraging and food store destruction. In addition to primates, other wild animals were also reported to be involved in crop foraging and destruction of food store at both Bbaale and Manyangalo. HWC at both sites may have been prompted by cultivations such as cassava (*Manihot* spp.), beans, sweet potatoes (*Ibomoea* spp.), maize (*Zea mays*), bananas (*Musa* spp.) at Bbaale and onions (*Allium* spp.), maize, beans, and potatoes (*Solanum* spp.) at Manyangalo (data not shown). This is consistent with research in Rwanda, where wild animals raided crops such as maize and potatoes (Mc Guinness and Taylor, 2014), in the Filinga Range of Gashaka Gumti National Park, Nigeria where monkeys, baboons, birds, and rodents were reported raiding crops such as maize, cassava, rice, and banana (Eniang et al., 2011) and in Ethiopia's Bale Mountains, where species like baboons and warthogs fed on wheat, barley, and legumes (Mekonen, 2020). Together these findings show that across different parts of Africa, crop-foraging tends to focus on the same staple foods that are both nutritious and easy for wildlife to access. Thus, our findings at two locations in East Africa are consistent with broader trends within sub-Saharan Africa, where wild animals frequently target common food crops, resulting in HWCs. While it has been hypothesized that crop foraging may occur because of nutritional benefits, one study at Nabugabo, Uganda found no difference in proteins, lipid, or fiber content between wild and crop foods, indicating that crop foraging may simply confer an accessibility benefit (Cancelliere et al., 2018).

More animal species reportedly scared livestock and threatened people at Manyangalo than at Bbaale, likely due to the higher number of terrestrial predators like lions, hyenas, and dogs at Manyangalo, compared to Bbaale, where only dogs were reported as threats. Major predators like leopards and hyenas have been reported to affect livestock in and around several protected areas (Demeke and Afework, 2013; Mekonen, 2020; Messmer, 2009), including near the Lewa-Borana Conservancy where leopards, hyenas, jackals, and elephants were reported to be most commonly involved in encroachments (Dupuis-Desormeaux et al., 2023). In addition to the greater variety of wildlife, the type of wildlife present at each site may be important, as large herbivores and carnivores need extensive home ranges and substantial food resources (Owen-Smith, 1988; Sukumar, 1990), which may lead them to venture into human-occupied areas, especially during food shortages.

People at Manyangalo reported experiencing HWC during the day and night, whereas HWC were reported only during the day at Bbaale. The animal species (e.g., primates, birds of prey, small birds, small antelopes, dogs) involved in HWC, except for rats, are primarily diurnal. This may explain why respondents at both sites reported HWC during daytime hours. That said, a meta-analysis revealed that large mammals often become more active at night due to human disruption (Gaynor et al., 2018) increasing nighttime activity by as much as 68% when humans are present. Therefore, the reports of nighttime crop foraging at Manyangalo but not at Bbaale is likely due to the presence of large mammals and predators at Manyangalo, but not Bbaale.

The finding that HWC is bimodal at Bbaale and unimodal at Manyangalo suggests that seasonality significantly affects the timing and frequency of these conflicts (Long et al., 2020). Our results may be linked to rainfall patterns influencing planting (Bedane et al., 2022), growing, and harvesting, with rainfall also potentially influencing wild animals' crop foraging behaviour, since rain may be affected by the seasonal food availability (Seiler and Robbins, 2016). For example, Naha et al. (2019) found that human-elephant conflicts in North Bengal were more frequent during the rainy season, coinciding with key crop harvests. That said, increased HWC during dry seasons at Manyangalo may result from food scarcity in the natural habitat (Hockings et al., 2009; McLennan and Hill, 2010). This is supported by Ibrahim et al. (2023) who reported higher crop foraging by hamadryas baboons during the dry season in Borena-Sayint National Park, Ethiopia. Interestingly, even though we observed bi-modal reporting of seasonality of crop foraging at Bbaale, the availability of wild foods does not influence crop foraging behaviour of vervet monkeys at this site (Cancelliere et al., 2018; Schwegel et al., 2023), though this has not been examined for other crop foraging species.

More than half of respondents at Bbaale and Manyangalo cited insufficient food, rising animal populations, and increasing human settlement as primary causes of HWC, which indicates that community members are able to identity multiple factors contributing to HWC. In fact, natural food availability, dynamic animal populations and expanding human settlements have been identified worldwide as factors influencing HWC (Amaja et al., 2016; Mekonen, 2020). Similar factors, including human settlement and agricultural expansion, have been noted across several African countries (Ladan, 2014; Makindi et al., 2014; Mekonen, 2020). For example, when the availability of natural food sources for wild animals decreases, these animals may seek alternative food sources to survive (Muruthi, 2005). This can lead them to venture into human settlements or agricultural areas or food stores in search of food, which can result in conflicts with humans (Okello et al., 2014). At both sites, crop farming was the main income source (data not shown). While few at Bbaale raise livestock, many at Manyangalo do, suggesting that agricultural expansion into wildlife habitats may heighten HWC.

The use of diverse strategies to manage HWC, such as shouting, using dogs and scarecrows, reflects the reported severity of HWC at Bbaale. In contrast, Manyangalo's reliance primarily on shouting indicates a less varied approach, which may reflect the frequent but less severe HWC being perceived as a nuisance more than a serious problem. The practices at Bbaale and Manyangalo are consistent with broader regional strategies for mitigating HWC, aligning with methods observed in other East African countries (Mekonen, 2020; Musyoki, 2014). Some studies have evaluated the effectiveness of these methods. For example, a study showed that using scarecrows, noise making, and employing guard dogs are considered effective mitigation measures by many respondents, though effectiveness varies by species and setting (Hussain et al., 2022). The efficacy of these methods is determined by the amount of time, labor, and resources dedicated to them, as well as how often they are employed and the extent of their impact (Hussain et al., 2022).

4.2 Socio-economic factors influencing responses to HWC

Crop foraging is a major source of HWC globally, as many people rely on subsistence agriculture (Hill, 2002). Of the numerous socioeconomic variables examined in this study (i.e., respondents' age, gender, education level, acres of cultivable land, distance between households and cultivable land, number of sources of income, and site), only size of cultivable land and education level explained variation of the types, severity, and frequency of reported HWCs. In our study, individuals with larger cultivated areas were more likely to report higher HWC, though our findings contrast with others who found no link between landholding size and reported losses due to HWCs (Bhushal et al., 2024). Larger land areas may offer more opportunities for wildlife to access unguarded crops and could support a wider variety of crops that attract wildlife. Our findings also indicated that respondents with secondary education reported experiencing less severe HWC than those with no formal schooling. Our findings are consistent with prior research that found higher education levels were correlated with reduced risk perception and more positive attitudes (Hanisch-Kirkbride et al., 2013; Kimmig et al., 2020). Additionally, less educated individuals may be more likely to see wildlife for its tangible benefits, while those with higher education tend to have a broader appreciation of wildlife (Manfredo et al., 2003). Respondents at Bbaale reported higher severity of HWC compared to those at Manyangalo, but experienced HWC less frequently. This difference may be due to Manyangalo's proximity to a conservancy, which are protected areas that typically have organized HWCs mitigation and management strategies (Baral and Heinen, 2007; Sharma et al., 2019). For example, Manyangalo has electric fencing that limits the movement of elephants into villages, where crops are typically located.

4.3 Perception of people towards the Nabugabo research site and Lewa-Borana conservancy

At both Bbaale and Manyangalo, most respondents expressed positive feelings toward the research site and conservancy, with few showing dislike or neutrality. This aligns with studies from various regions that found local communities generally hold positive attitudes toward protected areas (Myanmar: Allendorf et al., 2006; Nepal: Allendorf, 2007; Cameroon: Bauer, 2003; Kibale, Uganda: MacKenzie et al., 2017; Ethiopia: (Munaw, 2023). These positive attitudes may stem from recognizing conservation benefits and effective management (Allendorf et al., 2006). Since people's perceptions can vary depending on their socioeconomic status, we examined whether socioeconomic factors influenced perceptions of people towards the Nabugabo Research Site and Lewa-Borana Conservancy. Our analysis found that none of the socioeconomic predictors significantly affected these perceptions.

When negative views were expressed by respondents, they disliked the Nabugabo research site due to the perceived negative effects from researchers and monkeys. They felt the researchers should manage the monkeys, which they believed were becoming bolder and damaging crops. Additionally, many blamed the on-going research for the increasing monkey population, which respondents reported as a factor contributing to crop destruction. These findings align with previous research showing that crop-foraging by wildlife is a major driver of negative attitudes among rural communities. For instance, crop damage by monkeys, as shown by studies in Southwest Ethiopia (Asaye et al., 2024) and Nigeria (Modu et al., 2024) shows a strong correlation between negative community attitudes towards wildlife and associated research or conservation projects. At both Bbaale and Manyangalo, some expressed dissatisfaction with researchers' treatment and unfulfilled promises. Furthermore, most people cited poor communication from researchers and insufficient job opportunities at Manyangalo as major drawbacks, along with wildlife-related issues like crop damage and threats to livestock. This aligns with the findings from Southern Ethiopia (Bussa, 2023) which shows poor communication and benefit sharing affect attitudes towards the conservation projects. Mitigation interventions and improved researcher/community engagement have been shown to mitigate negative attitudes (Kolinski and Milich, 2021). Our findings emphasize the need for clear communication with community members and caution against overpromising.

Perhaps not surprisingly, when asked how to improve relations between the community and researchers, many respondents at both sites suggested increasing job opportunities, better communication with researchers, and the sharing of research findings. These suggestions echo findings from other HWC and community-based conservation studies that highlight economic incentives, transparency, and benefit-sharing as keys to fostering positive community engagement (Barua et al., 2013; Dickman, 2010; Kegamba et al., 2023; Redpath et al., 2013). At both sites, respondents also raised concerns about crop damage caused by wildlife, which they often viewed as the responsibility of researchers or conservation staff. As a result, financial compensation for wildlife-related losses was frequently proposed, consistent with other studies where communities living near protected areas have called for reparative or preventive measures to reduce livelihood risks (Anand et al., 2018; Bayani et al., 2016; Galley and Anthony, 2024; Karanth et al., 2012). At Bbaale, respondents additionally highlighted the need for better healthcare services and emphasized that fulling commitments to the community is critical to maintain trust. At Manyangalo, respondents suggest that community-researcher relationship and conservation efforts could be improved by finding ways to prevent wildlife from entering farms and financial compensation for wildlife-related damages. Although Manyangalo already had extensive fencing to exclude elephants from human-occupied areas, smaller animals continue to enter crop fields, a challenge frequently highlighted in studies showing that physical barriers often mitigate but rarely eliminate conflict (Hayward and Kerley, 2009; Montgomery et al., 2022). Even though researchers do not "own" the studied wildlife and providing compensation might be beneficial to community relationships, compensation clearly has logistical challenges, as it is unlikely that such compensation would fit within the purview of research grants. Additional suggestions included fulfilling promises to the community, providing food donations during droughts, and recommended sharing survey results with community members to keep them informed.

5 Conclusions

This study contributes to the limited literature comparing HWC in a non-protected area (Bbaale) and a protected area (Manyangalo). It reveals that Manyangalo has low severity but high frequency of HWC, while Bbaale shows the opposite pattern, suggesting the need for tailored management strategies. For example, at Bbaale where conflicts occur less often but tend to be more severe, management efforts could focus on more intensive measures such as rapid-response teams to address incidents quickly and compensation programs to offset financial losses. In contrast, at Manyangalo where conflicts are frequent but less severe, emphasis could be placed on preventive measures like improving fences and wildlife barriers or adopting more effective deterrents to reduce day-to-day encounters and prevent escalation. Socioeconomic factors, namely size of cultivable land and education, also appear to influence perceptions of HWC. Effective management should address these elements to meet the unique needs of each community. For Bbaale, respondents emphasized the need for greater research awareness, suggesting activities like tourism initiatives and school programs. This points to the value of community engagement through education and awareness efforts that both support conservation and create economic benefits. In contrast, respondents at Manyangalo called for more practical improvements, such as better security and healthcare, reflecting concerns tied to living near wildlife areas and the direct impacts of conservation on their daily lives. Additionally, the overall positive attitudes toward the research site and conservancy may indicate community support for conservation efforts through both tangible (e.g., job creation) and intangible benefits (e.g., appreciation of wildlife), creating a favourable environment for initiatives that promote human-wildlife coexistence.

Data availability statement

Data are available at Figshare: https://figshare.com/s/43b68ced24f1e585dd3d.

Ethics statement

The studies involving humans were approved by York University's Office of Research Ethics (Certificate e2019-191) in Canada, Uganda's National Council for Science and Technology (reference COD/96/05) and Makerere University School of Social Science Research Ethics Committee (Permit MAKSS REC 03.19.273), and Kenya's NACOSTI (License No P/21/3425) and Kijabe Hospital Institutional Ethics and Research Review Committee (Permit KH IERC-02718/0057/2019). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

PU: Formal analysis, Writing – original draft, Writing – review & editing. SM: Conceptualization, Funding acquisition, Writing – review & editing. VS: Conceptualization, Funding acquisition, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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