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Assessment of human-wildlife conflict in the Central Omo River Basin, Ethiopia

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Abstract

Human-wildlife conflict is a global issue for wildlife provisional due to crop damage and livestock depredation by wild animals. Developing effective human-wildlife conflict mitigation strategies requires understanding the conflict patterns, species involved, and attitudes of local people living along protected area boundaries. The human-wildlife conflict was investigated via an emphasis on crop damage and livestock depredation in the Central Omo River from 2019 to 2020. Cross-sectional study designs were used to assess human–wildlife conflict. A total of 300 household heads were selected using systematic random sampling techniques. The data was collected by means of a questionnaire survey and focus group discussion. The responses were compared using a non-parametric Pearson Chi-square test after the data was analysed using descriptive statistics. Anubis baboon (38.75%) and porcupine (26.07%) contributed to higher crop loss cases. The most common types of crop damaged by the wild animals were sweet potatoes (38.34%) and maize (19.14%). The average estimated loss of crops and livestock cost was US $102.2 and US $185.4 per year per household, respectively. The highest livestock loss was: cattle (n = 336), followed by goats (n = 241). The most frequently reported predator responsible for livestock depredation was the spotted hyena (40.3%) and leopard (34.4%). More crop loss and livestock depredation incidents occurred in the villages close to the forest. The local people utilized various traditional methods to mitigate these problems, which includes guarding (26.0%). The findings suggest the need to address the issue of human-wildlife conflict in the context of sustainable conservation practice through a combination of indigenous and conventional rationales to demonstrate that wildlife can co-exist with people.

Keywords: Crop raiding, Economic loss, Livestock depredation, Mitigation methods

Introduction

The conversion of global landscapes from predominantly wild to anthropogenic over the last centuries has created competition between humans and wildlife for space and other resources, reaching unprecedented levels (Kate, 2012). Human-wildlife conflicts (HWCs) occur when wildlife requirements overlap with those of human populations, at the cost of both humans and wildlife. Even though all continents and countries, whether developed or not, are affected by human-wildlife conflict, developing countries are altogether more vulnerable than developed nations (Ogutu et al., 2014; Redpath et al., 2015). It is generally more intense in developing countries, particularly in Africa, which includes Ethiopia, mainly in and around protected areas where their livelihood is heavily dependent on subsistence agriculture and extractive use of natural resources (Eniang et al., 2011). According to Heberlein (2004), HWC is an inter-disciplinary or multidisciplinary area of research that deals with the dimensions of both humans and wildlife. "Human-wildlife conflict occurs when the needs and behaviours of wildlife impact negatively on the goals of humans, or when the goals of humans negatively impact the needs of wildlife" (IUCN World Parks Congress, 2005).

The wildlife dimension results in crop damage, cattle-lifting, human casualties, and household damage. The human dimension includes: social, economic, political and poaching (Heberlein, 2004). HWC results negative impact on humans or their resources and on wildlife or their natural habitat; and it carries significant threats to the survival of many wildlife species (Amaja et al., 2016). Crop and property damage, livestock depredation, human injury and casualties are common effects of HWC; resulting in substantial economic losses that makes people migrates from wildlife-conflict areas to non-conflict areas (Tola et al., 2017). The amount and type of damage caused by wildlife vary according to the species, time of the year, the availability of natural prey and crop types (Anand and Radhakrishna, 2017; Mwamidi et al., 2018).

In Ethiopia, HWC is a significant problem in most protected areas and in the community forest areas. Almost all protected areas in Ethiopia are surrounded by agricultural landscapes, whereby there is immediate contact between the wildlife species and the people (Tewoderos and Afework, 2008). This, in turn, escalates HWCs. The frequency and intensity of HWC in Ethiopia mainly arises from crop damage, livestock depredation, human injuries and casualties caused by wildlife, illegal logging, livestock grazing, fodder collection, poaching, and poor relations between local people and protection units (Aberham et al., 2017). Therefore, to enhance the

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mitigation of human-wildlife conflict, there is a need to compile case-specific studies at various localities worldwide. These studies may help describe the best scenarios and experiences to solve similar problems elsewhere in the world and lead to the development of holistic models that could sustainably mitigate HWCs globally and promote coexistence through balancing both human and wildlife needs (Gemechu et al., 2014). Most of the studies about human-wildlife conflicts were focused in and around the protected areas in Ethiopia. This is because the government and the researchers prioritize protected areas over community forest areas.

However, people around the Omo river basin are also facing the problems of HWCs. From this perspective, it is imperative to assess the human–wildlife conflict that occurs within local communities living adjacent to the Omo river basin. Identifying the potential ways to reduce conflicts for the better wellbeing of both people and wildlife is the main objective of conducting research on human–wildlife conflict. Hence, this study was focused on the human-wild mammal conflicts around the Omo River basin area, a representative landscape of the Rift valleys. Such information provides the guidelines for the conservation and management of the forest outside the protected areas and helps to minimize the conflict issues in and around the Omo River basin area.

Materials and methods

The study area

The study area is located between 6°53'30" and 7°4'30" N latitude and 37°20'00" and 37°31'30" E longitude with an altitudinal range from 800 to 1200 m a.s.l. It covers an area of 137.4 km^2 and found within the Central Omo River Basin. It is located in the Wolaita and Dawro Zones of Southern Ethiopia, 480 km from Addis Ababa, the country's capital city (Fig.1). The socio-economic condition of the people is mainly agro-pastoralism. The rainfall pattern around Kindo Koysha, Boloso Bombe, and Loma administrative districts is bimodal. There is a short rainy season from March to April, while the primary rainy season is from June to September. The total annual rainfall in the area varies between 800 and 1600 mm, with a mean annual rainfall of 1210 mm. The annual minimum temperature in the area is 15.3°C, and the annual maximum is 35.5°C (National Meteorological Agency, 2019). The Omo River and its tributaries drain the area. The area is rich in floristic and faunal biodiversity. There are hippopotamuses (*Hippopotamus amphibius*), Nile crocodiles (*Crocodylus niloticus*), leopards (*Panthera pardus*), spotted hyenas

(*Crocuta crocuta*), warthogs (*Phacochoerus africanus*), bush pigs (*Potamocherus larvatus*), jackals (*Canis aureus*), and serval cats (In addition, the area is believed to possess ample diversity of birds, fish, reptiles, and also amphibians. Regarding plant species, savannah with scattered trees, woodlands, montane forest, and riverine forest are the primary vegetation types in the study area. The dominant tree species includes: *Acacia* sp ecies, *Uvaria leptocladon, Combretum aculeatum*, *Combretum collinum*, *Combretum molle* in association with *Terminalia brownii, Terminalia schimperiana, and Terminalia laxiflora, Grewia tembensis, and Maytenus senegalensis.* The floristic composition of the forest is commonly rich in climbers and saprophytes. The most frequent large trees along the riverside are: *Cordia Sinensis, Acacia mellifera, Ziziphus mauritiana, Ficus sycomorus*, *Ficus glucose, Ficus ingens, Ficus sur, Ficus thonningii,* and *Ficus vasta* (Car, 1998). The main ethnic groups in the study area are: Wolaita and Dawuro. Mixed agricultural practices are the sole livelihood of most of the inhabitants around the study area. They practice a traditional agricultural farming method that combines perennial and annual cultivation with livestock rearing. Permanent crops harvested in the area includes: cereals, fruits and vegetables.

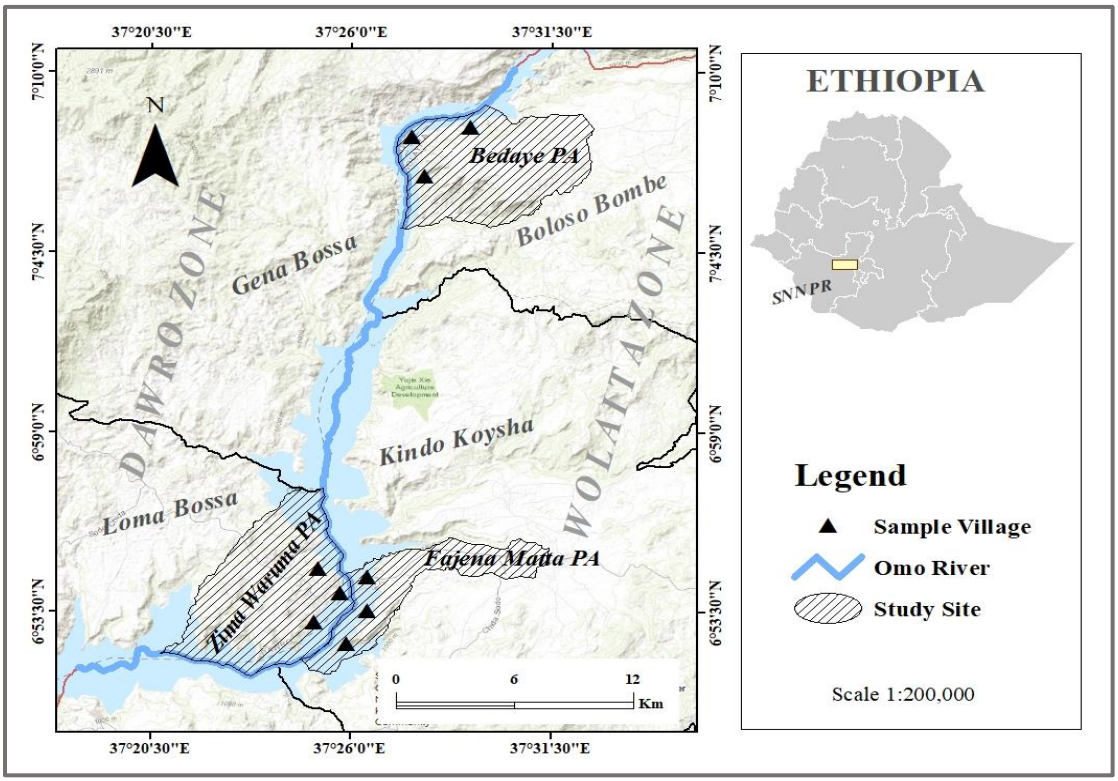

Figure 1. Map of the study area

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Study design

A preliminary survey was conducted in September 2019, before the actual data collection period. Based on the preliminary survey, the study areas were purposively selected. The respondents and villages in these areas were selected using stratified random sampling methods and were used to assess human-wildlife conflict in the area.

Method of data collection

The present study was carried out using a questionnaire survey to collect primary data among the households in three peasant associations (Bedaye, Fajena Matta, and Zima Waruma). The three peasant associations (the smallest administrative unit) were purposefully selected for the survey due to their location and problems related to crop damage and livestock loss. The questionnaire had both open-and closed-ended questions to obtain information about human-wildlife conflict in the study area. A preliminary survey was conducted in September 2019, before the actual data collection period. During this period, essential information such as: accessibility, the number of villages/sites around the Omo River basin, vegetation type, fauna and topography were gathered. The questionnaire was pre-tested on 49 randomly selected individuals from all nine villages of varying age, sex, and background among the local communities, which was not included in the main sample group. This helped to modify the questionnaire accordingly. The pretested questionnaires were used in examining the practicability, reliability and suitability of the method. The respondents' comments helped to improve the sequence and layout of the questionnaire. Three villages from each of the Peasant Associations were selected purposely based on the information gathered using the preliminary survey, proximity to the forest, problems related to crop damage and livestock loss, and also local people's dependence on the forest. From the total population of 1,197 households in the three peasant associations, 300 households were selected randomly for the questionnaire survey based on Yamane's (1967) formula.

$n= N/1+N(e)^2$

Where: n= sample size

N= is the population size

e= is the level of precision (%)

$n=1197/ 1+1197 (0.05)^2 =400$

These households were randomly selected by following a pattern of skipping one household, and the second household was interviewed. The questionnaire was administered to all households during the wet and dry seasons of 2019 to 2020. The interviews were translated and conducted in the Wolaita and Dawuro local languages to reduce misunderstandings during the interviews due to cultural and language differences (through back-translation of the interview script) (Müller, 2007). The questionnaire survey was translated into local languages spoken in the study area. A lack of proper due diligence can cause delays, confusion, and field errors during the translation process, potentially leading to inaccurate data collection. Accurate translation requires significant time and skill. Therefore, a professional translator with sector-specific knowledge and experience in translating was selected. All technical terminology was cross-checked with local counterparts who are well-versed in the subject area. Twenty-seven local people, consisting of three residents in each of the nine study villages were recruited and trained to administer the questionnaires. The same translators were used to ensure accuracy, and the same interview questions were administered during two separate seasons. Each interview lasted an average of 43 min (range: 35–50 min). Based on the proximity to the forest, the villages were stratified in each peasant association as near (0-1km), medium (1-2km), and far (2-4km). Hence, nine villages were systematically selected and subjected to the study. The villages covered were: Dershiya (n = 32), Dusha (n = 32), Loma (n = 35) from Zima Waruma Peasant association, Koyisha (n = 34), Shamana (n = 33), Kirko (n = 35) from Bedaye Peasant association and Solko (n = 34), Idaho (n = 32) and Fajita matta (n = 33) from Fajina Matta Peasant association. The sample size was proportionally distributed to each of the three peasant associations. The questionnaire consisted of a series of structured questions focusing on three main areas of interest, namely: (1) demographic data, (2) human-wildlife related issues, and (3) wildlife damage control methods. The economic value of crop and livestock losses was estimated based on market value. It is difficult to develop accurate cost estimates associated with wildlife damage to crops. However, approximations of these costs can be useful to illustrate the magnitude of the problems faced by farmers. The cattle, sheep, goat, donkey and chicken in the study area were the local indigenous breeds; as a result they were comparatively low priced.

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Focus group discussion

This method was used to gather information on how local communities perceived human-wildlife conflict, respondents' level of human-wildlife conflict, benefits derived from the wildlife, and suggestions on checking further conflicts. In addition, the method was used to reinforce the data collected through the questionnaire. Two focus group discussion sessions were conducted in each study village, and the group size in each discussion site varied from 8 to 12. Participants of the FGD were village leaders, local elders, religious leaders, a primary school teacher in the village, and other government employers of both sexes to discuss their experience of human-wildlife conflict and gather information on wildlife in the area. Information collected from group discussions was collated and summarized using the text analysis method and presented narratively. Thus, the information acquired was triangulated through questionnaires and focus group discussions. A guide checklist was prepared for the focus group discussion.

The data was analysed using SPSS 20 (SPSS, Chicago, IL, USA). Appropriate statistical methods such as the descriptive statistic and chi-square test were used to analyse the data. The descriptive statistics were used in the form of percentages and frequencies to analyse the socioeconomic profiles of the respondents. Chi-square tests were used to determine the significant differences between villages in ways of protecting crops and livestock from depredation and trends in problem causing animals. The study was focused on medium and large-sized animals, and therefore, we excluded small-sized animals such as rodents from the analysis. All statistical tests were two-tailed, and the significance level was set at $P < 0.05$.

Results

Utilization of resources

The data was gathered from 300 respondents of nine villages based on the information gathered using the preliminary survey, the distance from the forest, problems related to crop damage and livestock loss by wildlife. The majority of the respondents acknowledged getting benefits from the forest. Among the benefits: access for livestock grazing, firewood gathering, fodder collection, wild meat and farming are the main ones. Among the respondents, 48.8% used farm land along the forest boundaries and 27.8% used forest area for livestock grazing (Fig. 2). There

was no significant difference ($\chi 2$ = 72.26, df = 8, P > 0.05) among respondents of different villages in using the various forest resources.

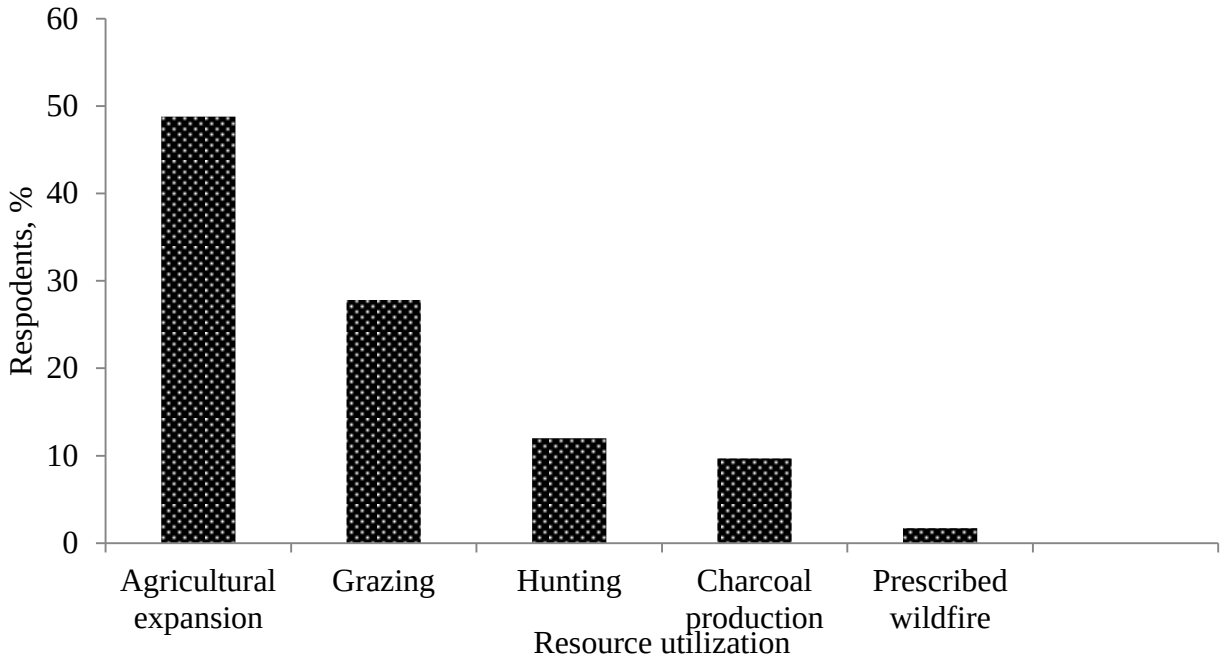

Figure 2: Percentage of resource utilization by the respondents among different villages around Omo River basin

Population trends of problem animals

The majority of respondents believed that the population status of vermin animals has increased in the area over recent years (Fig. 3). When asked about population trends, 60.9% of the respondents felt that most animal populations have increased over recent years. However, 27.7% of the respondents stated that they have decreased, 6.4% of the respondents remarked that the wildlife populations have remained without much change. Only a few of the respondents (5.0%) were unsure of the status of the wildlife population. The respondents' views on the trend of the wildlife population in their locality were significantly different ($\chi 2$ = 82.64, df = 3, P < 0.05).

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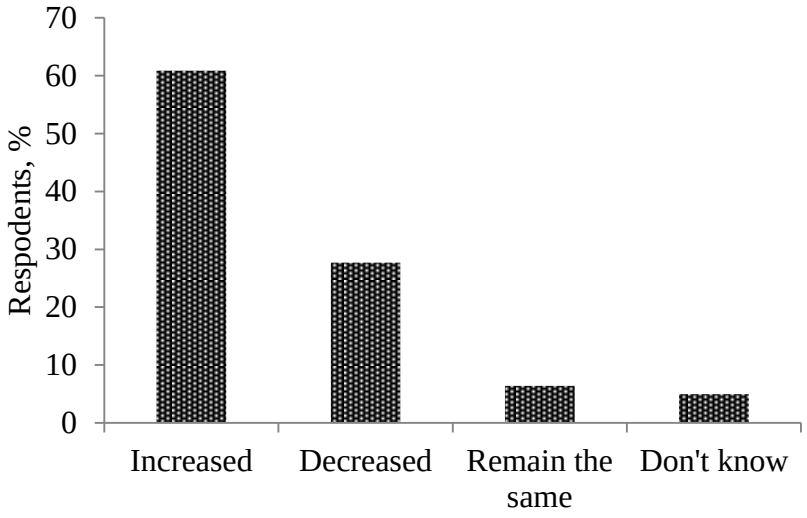

Figure 3: Respondents' opinions on the status of the population problem of the wild animals in the study area from 2015 to 2019

Crop damage and an estimated economic loss assessment

Most respondents had experienced crop damage due to the wild animals. The type of crop damaged by the wild animals includes: maize (19.14%), sorghum (4.94%), haricot bean (16.06%), sweet potato (38.34%), taro (0.29%), potato (2.68%), enset (15.44%) and mango (3.08%) (Table 2). An estimated average loss of 3724 kg of crop loss, equivalent to US $30674.6, was reported from nine villages per year. The annual estimated loss of different crop types was 1241.33 kg, which is equivalent to US $1021.5. An average estimated loss of different crop types was US $102.2 per household. The results show that distance to the forest is the major determinant of the intensity of the economic loss due to crop damage by problematic wild mammals. The economic loss was found to be higher near the forest area than in the area far from the forest. Among the villages, Kirko consists of a 13.7% crop loss, Fajina Mata 13.37%, Dershiya 12.64%, Solko 12.48%, Idaho 11.36%, Dusha 10.66%, Loma 9.74%, Koiysha 9.07%, and Shamana 6.98%. There was a significant difference in crop loss among the villages (χ^2 = 63.65, df = 8, $P < 0.05$). Based on the respondents, most crop damage was caused by Anubis baboon (38.75%), followed by a porcupine (26.07%), bush pig (15.87%), vervet monkey (11.73%), bushbuck (3.81%), duiker (2.01%), and warthog (1.61%).

Table 1: The estimated crop loss caused by wild animals in the nine villages based on the responses of 300 people

Crop type	Estimated loss of crop (in kg) by wild animals in the nine villages										
	Villages and distance to the forest by km										
	Dershiya (0-1km)	Dusha (1-2km)	Loma (2-4km)	Koyisha (1-2km)	Shamana (2-4km)	Kirko (0-1km)	Solko (1-2km)	Idicho (2-4km)	Fajina matta (0-1km)	Total loss in kg	Total loss in US$
Maize (*Zea mays)*	86	81	74	69	47	95	91	73	97	713	7639.3
Sorgum (*Sorghum bicolor*)	28	18	13	11	12	29	24	19	30	184	2171.5
Haricot beans (*Phaseolus vulgaris*)	72	67	56	52	48	81	75	73	74	598	6407.1
Sweet potato (*Ipomoea batatas*)	175	145	143	144	119	183	176	165	178	1428	8432.1
Taro (*Colocasia esculenta*)	2	1	0	0	0	3	1	0	4	11	78.6
Potato (*Solanum tuberosum*)	15	12	9	8	0	16	11	10	19	100	1071.4
Enset (*Ensete ventricosum*)	75	64	61	50	32	79	74	67	73	575	3285.8
Mango (*Mangifera indica*)	18	9	7	4	2	25	13	14	23	115	1588.8
Total loss in kg	471	397	363	338	260	511	465	421	498	3724	30674.6

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Livestock depredation

A total of 750 livestock were recorded to have been killed by predators in nine villages within three years. The livestock most frequently killed were cattle (n = 336), followed by goats (n = 241), sheep (n = 98), chickens (n = 71) and donkeys (n = 4). Most depredations were reported in Dershiya (15.33%), followed by Fajina mata (14.2%), Kirko (13.2%), Dusha (12.4%), Solko (11.2%), Loma (9.47%), Shamana (8.4%), Koyish (8.13%) and Idicho (7.87%) villages. There was a significant difference in livestock loss among nine villages ($\chi^2 = 38.38$, df = 8, $P < 0.05$) (Table 4). Total economic losses caused by livestock depredation in the study area are valued at roughly US $55,630.00, representing an average of US $185.43 per household. The highest livestock losses were cattle (US $38,400.00), followed by goats (US $13,769.00), sheep (US $2,800.00), donkeys (US $457.00) and chickens (US $204.00). The economic loss was higher near the forest area than in the area far from the forest. The spotted hyena (40.3%), n = 302) was the most frequently reported predator responsible for livestock depredation, followed by leopard (34.4%, n = 255), Anubis baboon (16.4%), n = 123, Common jackal (4.8%), n = 36), and Serval cat (4.5%, n = 34) (Table 3). Throughout the study period, in the local markets, cattle were sold at an average price of US $57.14/animal, goats and sheep were sold at an average price of US $57.14/animal, chicken was sold at an average price of US $2.85/animal, and donkeys were sold at an average price of US $114.28/animal.

Table 2: The number of livestock killed by wild predators in the Omo River basin over the last three years (2017–2019)

Type of Livestock	No. of attacks by the predator					Total
	Leopard	Spotted hyena	Common Jackal	Anubis baboon	Serval cat	
Goat	109	23	7	92	10	241
Sheep	29	54	3	8	4	98
Cattle	117	219	0	0	0	336
Donkey	0	4	0	0	0	4
Chicken	0	2	26	23	20	71
Total	255	302	36	123	34	750
Percentage (%)	34	40.3	4.8	16.4	4.5	100

Table 3: Economic loss due to livestock depredation in the last 3 years (2017–2019) around Omo River basin

	Economic loss (US$) due to livestock depredation and distance of villages (km)									
Type of livestock	Dershiya (0-1km)	Dusha (1-2km)	Loma (2-4km)	Koyisha (1-2km)	Shamana (2-4km)	Kirko (0-1km)	Solko (1-2km)	Idicho (2-4km)	Fajina Matta (0-1km)	Price of livestock in US$
Goat	40(2285)	30(1714)	22(1257)	24(1371)	23(1314)	32(1828)	23(1314)	11(629)	36(2057)	13769$
Sheep	8(229)	11(314)	12(343)	10(286)	13(371)	8(229)	11(314)	13(371)	12(343)	2800$
Cattle	51(5829)	43(4914)	32(3657)	24(2743)	25(2857)	42(4800)	40(4571)	30(3429)	49(5600)	38400$
Donkey	1(114)	0(0)	0(0)	0(0)	0(0)	2(229)	0(0)	0(0)	1 (114)	457$
Chicken	15(43)	9(26)	5(14)	3(9)	2(6)	15(43)	10(29)	5(14)	7(20)	204$
Total in US$	115(8500 $)	93(6968$)	71(5271$)	61(4409$)	63(4548 $)	99(7129$)	84(6228$)	59(4443$)	105(8134$)	750(55630$)

Note: The number out of the bracket indicates the total number of livestock and the number in parenthesis indicates the price in US dollars (1 US dollar is worth 35 Ethiopian dollars during the time of the study) during the study period.

Focus group discussion

Focus group discussants also noted human injury as an impact of human-wildlife conflict in the area. They reported that 3 humans were attacked by leopards from 2015 to 2019 in an attempt to guard their livestock from attack. The participants also agreed that the local communities benefited from the forest resources. Most of them described the shortage of private grazing land and decreased farmland holdings due to the forest around them. This could have increased pressure on the forest area resources for livestock grazing and agricultural expansion. Some of the discussants noted that, previously, they used to hunt different wild animals and minimize their threat. However, at present, the negative effects of the animals are on the increase.

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Mitigation methods

Villagers adopted different approaches to minimize the wildlife-induced damage in the study area. The local people adopted locally available techniques to deter crop-raiding and depredating livestock animals. The primary techniques deployed were physical barriers (fences, walls), guarding (watching, watchtower, dogs), and fear-provoking stimuli (visual: erection of scarecrows, lighting fires, auditory: exploders, beat drums, and distress calls) around the forest. Most respondents reported guarding as an effective method in all villages (26.0%), followed by physical barriers (20.0%) and snares (17.0%) (Fig. 4). Views of the respondents of villages did not significantly differ ($\chi 2 = 105.2$, df = 8, $P < 0.05$) in using the different techniques to protect crops and livestock. No one used only one method alone, but combined and integrated all the local methods to prevent crop-raiding and livestock predation.

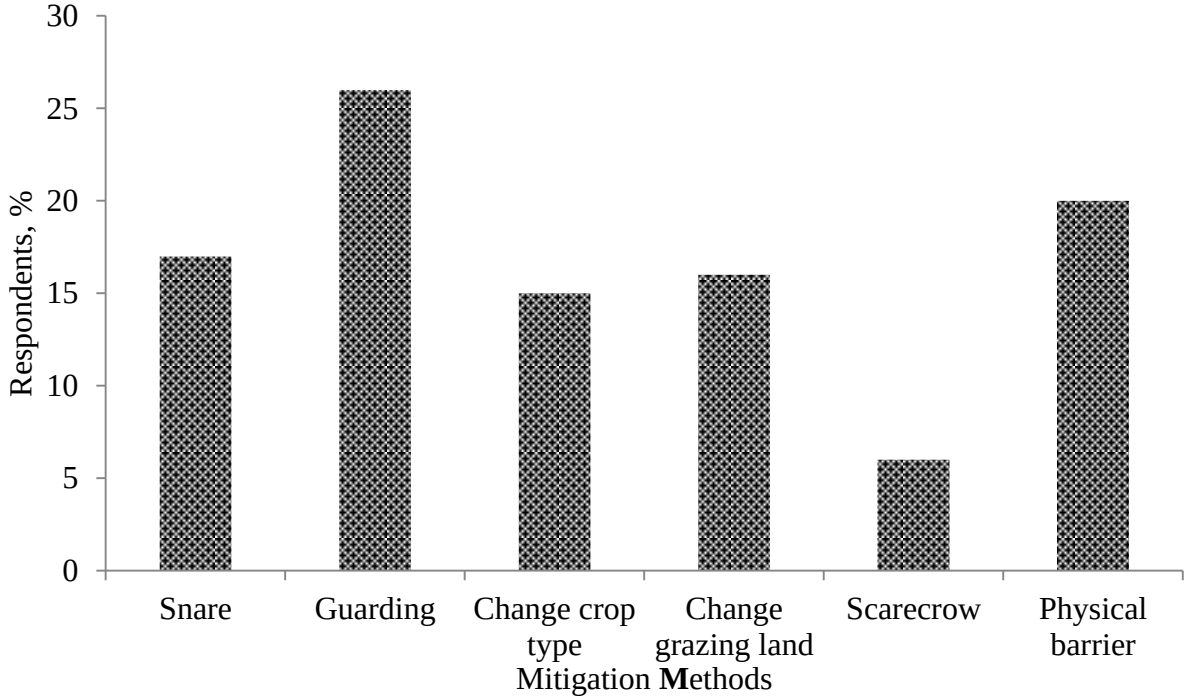

Figure 4: Techniques used by villagers to protect crop loss and livestock depredation around the Omo River

Discussion

Utilization of resources

Most of the local people around the Omo basin areas depend on subsistence agriculture and livestock rearing. Mainly agricultural expansion and grazing pressure posed by livestock are the causes of conflict in the study area. Among these, agricultural expansion contributes to the largest share of the problem. Grazing was the predominant activity in the area. Livestock usually intensively competes with wild animals for the same habitat resources, including forage and water sources, which might substantially impact wildlife, their habitat and the overall ecosystem function and structure. Most of the respondents consider the river basin as their communal pasture area, and they rely on the area for grazing and watering their cattle, especially during the dry seasons. According to the respondents, most local people used forest resources. Trees were cut to construct houses, firewood and livestock fences. The main causes of the presence of human-wildlife conflict in the study area are crop damage and livestock depredation. Collections of spice/medicinal plants were threats to wildlife in the Omo River basin, as Giliba et al. (2011) noted in the Meru catchment forest reserve in Tanzania. Illegal hunting is a serious threat to the conservation status of many species in Africa (Nielsen and Meilby, 2013). Like many of Africa's protected areas, the Omo River basin has also been under increasing pressure from hunting. Poverty might also have been a reason for hunting wild animals in the area.

As indicated by the respondents, wild meat was the cheapest source of protein, and it represented a source of meat for the poorest households around the Omo basin. A study by Lindsey et al. (2011) in south-eastern Zimbabwe also reported that critical drivers of the wild meat trade were poverty and food shortages. Increasing human pressure due to continuously increasing demand for farming, grazing land and illegal hunting might reduce the availability and quality of habitats for wild animals in the present study area. Similar results were also reported earlier by Tadesse and Kotler (2013) and Ryan et al. (2015). According to Aberham et al. (2017) and Yigrem et al. (2016), habitat loss and agricultural expansion are significant causes of conflict between humans and wildlife. The study indicated the local people were exploiting grass and firewood from the forest area for household activities and as a source of income for their livelihood. This can affect the forest habitat and the existing wildlife resources in the area. According to Wilfred (2010), biodiversity loss is more pronounced in developing countries, which are more dependent on natural resources as it is their primary source of income.

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Crop damage

Most of the local people in the area were victims of wild animals, as problem animals had destroyed their crops. More crop damage occurred in the villages close to the forest around the Omo River. This is because villages close to the wildlife-protected areas face the most contact with wildlife species. The highest crop damage incidence in nearby households was probably attributed to the absence of a buffer zone between the forest and farmlands. Similar studies elsewhere in the world have revealed that local communities residing nearby are more susceptible to crop damage than those living far from protected areas (Alemayehu et al., 2021; Ango et al., 2017; Mwakatobe et al., 2014; Hariohay and Rskaft, 2015; Alelign and Yonas, 2017). An annual loss of 1,241.33 kg of various crops was reported by respondents, which affects a significant amount of household income in the villages. An average estimated loss of crop types of US $102.2 per household was reported from the villages of the study area. Hariohay and Rskaf (2015) reported a loss of close to US $154 per household that suffered crop damage in the Kwakuchinja Wildlife Corridor in Northern Tanzania. Emerton and Mfunda (1999) also reported a loss of approximately $155 per household due to crop damage in the western Serengeti. In the present study area, crops such as maize, sweet potatoes, and beans were highly preferred by most wild animals. The following vertebrate pests, such as: Anubis baboon, Vervet monkey and porcupine were the most induced to cause crop damage. A similar finding by Leta Gobosho et al. (2015) reported that olive baboon, bush pig, warthogs, grivet monkey and porcupine were the most identified damage-causing wild animals on crops in the Gera district, Jimma zone, southwestern Ethiopia. Hill (2002) also supported that porcupines and duikers are the primary pests on sweet potatoes.

Livestock depredation

Depredation incidents were influenced by the distances between households and forest boundaries, as livestock owners who lived in the closest villages experienced more incidents than those who lived in distant villages. The difference in livestock depredation among villages could be due to the difference in village proximity to the national forest (Miller et al., 2016). The influence of distance on livestock depredation in villages close to the protected area has also been reported for the western Serengeti wildlife corridor (Mwakatobe et al., 2014). Livestock depredation by predators could also be attributed to livestock husbandry practices and the

depletion of natural prey (Lindsey et al., 2017; Mbise et al., 2018). Various studies have demonstrated that livestock depredation is more common in areas with low prey abundance (Polisar et al., 2003; Yigrem et al., 2022). Local environmental conditions such as livestock husbandry practices and characteristics of attacked villages and livestock enclosures have influenced livestock depredation (Miller et al., 2016).

Depredated livestock included cattle, goats, sheep, donkeys and chickens. Cattle were the most heavily depredated livestock, representing more than 44.8% of cases. The spotted hyena caused most depredation incidents, being responsible for more than 40.3% of cases. For the western Serengeti, Mwakatobe et al. (2014) and Nyahongo (2009) reported similar trends, where spotted hyena was the large carnivore most responsible for livestock depredation, possibly because spotted hyena can hide in small areas of community land and attack livestock at night. Most of the goats were attacked by Anubis baboons, spotted hyenas and leopards, as reported by (Hariohay and Rskaft, 2015; Tedilahun and Aberham, 2022). The chicken was mainly depredated by jackals, baboons and serval cats. However, leopards and hyenas may attack livestock at any time of the day, either in the field or at homes, as indicated by Woodroffe et al. (2007).

Loss of livestock to predators was highest in Dershiya, Fajita matta and Kirko villages. These villages are the closest to the Omo River forest. Therefore, this village experienced a probability of coming into contact with many predators, such as spotted hyenas, leopards, common jackals, baboons and serval cats. The participants of the focus group discussion also reported that local people located near the forest edge were more likely to be affected economically by crop raiding and livestock depredation. Livestock depredations were estimated to have an average of US $185.4 per household in the present study area. Holmern et al. (2007) reported an average loss of US $107.7 due to livestock depredation in the western Serengeti. Respondents residing close to forest boundaries were the most affected by wild animals. Therefore, losses incurred due to livestock depredation had significant economic impacts on the local community's livelihood.

Mitigation measures

The local people of the present study area reported applying traditional methods using simple and affordable technologies to protect their crops and livestock from pest animals. They used repellents in the form of fire, noise, and the construction of different physical barriers, guarding

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against fear-provoking stimuli such as: scarecrows, beating drums and chemical repellents for deterring crop-raiding wildlife. Respondents indicated varying views regarding the effectiveness of wildlife damage control methods. They perceived that guarding with other methods was effective and had a low capital investment; but it was often tedious and time-consuming. In addition, the behaviour and preferences of each pest are quite different (Gehring et al., 2010; Gathuku, 2015). Therefore, none of these methods provides complete protection. However, guarding was the sole method for larger animals to control crop losses and livestock depredation in the study area. Manual guarding as the most widely used crop protection measure was also reported by Tweheyoa et al. (2012) and Lyamuya et al. (2016). Some farmers were using alternative crops in the present study area, such as ginger and chilli. Besides the visible impacts, the human-wildlife conflict has indirect impacts as well. Losses might generate other costs to the household members, including an increased need to guard fields; disruption of schooling because children are needed to help guard family fields; and also an increased risk of injury from the wildlife.

Conclusions

Understanding the conflict and its cause is crucial to developing effective conservation programs in the Omo River basin. The result of the study revealed that most of the local people depend on the natural resources of the forest for their livelihoods. The effects of these human activities in and around the Omo River cause habitat alteration, displacement and local migration of wildlife species. In addition, hunting pressure and competition of cattle with wild animals for food, water and space affected the distribution of wild animals in the basin. Therefore, like most protected areas in Ethiopia, the Omo River basin also faces significant challenges in meeting human and wildlife needs. Human-wildlife conflict coupled with low-level of education and awareness has led to an increased negative human attitude towards the wildlife, with potentially harmful effects on conservation. Crop damage caused by wild animals and livestock depredation caused by carnivorous animals were the most common sources of conflict in the Omo basin. Local people close to the forest boundary were highly vulnerable to pest animals. The measures adopted by the local farmers to prevent crop damage and livestock predation were traditional methods and were not effective against wildlife threats. Therefore, it was essential to monitor conflict situations over time. It would help pinpoint where the worst conflict occurs and to make direct deterrent

efforts where they are most needed. There was a need to develop schemes where local people perceived tangible economic benefits of tolerating wildlife in their surroundings. Conservation awareness aimed at changing the attitudes of local people, provision of essential infrastructure facilities and living conditions should have been given focus by the governments. The Omo River basin harbours many mammal species, birds and other wild animals. Therefore, it can serve as an important centre for conserving the country's wildlife and tourist attraction areas in the future. Besides its wild animal potential, the basin has an impressive landscape and an artificial lake. The findings point to the need for long-term monitoring to look at changes in human-wildlife conflicts and human effects on the Omo river basin.

Recommendations

Based on the results of this study, the following recommendations were made: encouraging farmers to manage domestic animals in the proper place when they do not harm wild animal species in the study area. The concerned bodies must work with stakeholders and farmers that live close to the forest, to leave a sufficient buffer zone; between the cropland and forest, making it easy to guard against wild animals. Training and experience sharing programs should be given to the local farmers on ways to protect and conserve the natural habitat, and the responsible organization should report the side effects of wild animals in the area. Community-based conservation and management were highly recommended to solve the human-wildlife conflict in the study area.

Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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