Hindawi
International Journal of Ecology
Volume 2023, Article ID 8437073, 18 pages
https://doi.org/10.1155/2023/8437073

Research Article

Population Density of Wild Animals and Their Conflict in Konasa_Pulasa Community Conserved Forest, Omo Valley, Southern Ethiopia

Mesfin Matusal, Aberham Megaze, and Taye Dobamo

Department of Biology, Wolaita Sodo University, P.O. Box 138, Wolaita Sodo, Ethiopia

Correspondence should be addressed to Aberham Megaze; abme749@yahoo.com

Received 18 October 2022; Revised 1 December 2023; Accepted 13 December 2023; Published 22 December 2023

Academic Editor: Daniel I. Rubenstein

Human-wildlife conflict presents an increasing challenge to conservation, particularly in densely populated parts of low-income countries. An investigation on wild animal population density and its conflict was carried out from December 2019 to May 2020 in the Konasa–Pulasa Community Conserved Forest, Omo Valley, Southern Ethiopia: implications for wildlife conservation. The distance sampling method was used to estimate the population status of wild animals in an area of 187.57 km^2. Human-wild animal conflict was quantified using a questionnaire survey with 290 randomly selected household heads from five villages. In addition, focus group discussions were conducted to obtain additional information. The mean density of the Anubis baboons was 4.51 ± 0.76, that of the grivet monkeys was 3.24 ± 0.51, that of the porcupines was 0.89 ± 0.17, that of the spotted hyenas was 0.58 ± 0.15, and that of the black-backed jackals was 0.65 ± 0.12 individuals/km^2. The result shows that crop damage and livestock predation were common problems in the study area. The most damaged cereal crops were maize (26.5%). The Anubis baboon was the most common crop raiding species (34.9%). An estimated average loss of different crop types was US$15.01 per year per household. Regarding livestock, sheep (36.2%) and poultry (44.3%) were the animals most attacked. The predator responsible for livestock depredation reported most frequently was the spotted hyena (35%), followed by the black-backed jackal (24%) and the leopard (16%), and it was responsible for the loss of 271 domestic animals with an estimated economic loss of US $24,395.92 in five villages. Guarding (47.4%) was the main means of mitigation methods. Most farmers' (47.4%) attitude towards wild animal conservation was positive. The extent of the damage varied between villages and with the distance from the forest boundary. Local people close to the forest boundaries were highly vulnerable to wild animal conflict. Our results show that livestock predation and crop damage were common problems caused by Anubis baboon, verves monkeys, porcupines, spotted hyenas, and black-backed jackals. The increase in the population of wild animals and the proximity to the forest are the causes of HWC. Guarding is the dominant traditional method used to reduce HWC in the study area. Using effective methods to reduce livestock damage and loss to crops, including improved livestock husbandry, cultivating unpalatable crops near the forest and raising local community awareness could make local residents aware of conservation.

1. Introduction

Understanding the population size and habitat requirements of mammalian species is crucial to tracking the state of an animal's conservation [1] and to solving human-wildlife conflict. Therefore, wildlife biologists must have a sound understanding of the population status and dynamics of the problem species [2, 3]. Human-wildlife conflict (HWC) is not a present-day event in human settlement landscapes; it has existed for some time and is a fundamentally emerging challenge in developed and developing countries, including Africa [4–9]. Even though all countries, whether developed or developing, are affected by HWC, developing countries are more vulnerable than developed countries due to a heavily dependent economy on the subsistent use of natural resources [10]. Livestock rearing and agriculture are also important parts of the rural livelihoods of developing countries [11–14]. The nature and extent of HWC vary from country to country and locality to locality, including crop damage, livestock loss, disease transmission, human death or injury, and other intangible social costs around the conservation area [4, 15–17].

Various studies have been conducted on the impacts of wildlife predation on livelihoods in different parts of Africa. The reported wildlife species considered domestic animal predators were spotted hyena [18–21], leopard [8], jackal [22–25], and lion [26]. The frequency of predation varies throughout the season depending on the type of species and habitat [23, 27].

African elephant (*Loxodonta africana*) [16, 28], Anubis baboon (*Papio Anubis*) [11, 15, 29, 30], crested porcupine (*Hystrix cristata*) [31], bush pig (*Potamochoerus larvatus*) [29], warthog (*Phacochoerus africanus*) [32], and Swayne's hartebeest (*Alcelaphus buselaphus swaynei*) [33] were the main crop raiding wild animals in Africa.

The studies show that the presence of high human-wildlife conflict in Africa, including Ethiopia, has a greater impact on livelihoods where farmers are adjacent to protected areas [34]. There are many different wildlife species in Ethiopia, each with its own distinct ecological and environmental circumstances. However, the majority of the country's wildlife habitats have been destroyed, fragmented, or degraded, and most of its species are mainly restricted to a small number of protected areas. In Ethiopia, almost all protected areas are surrounded by agricultural land, which allows direct interaction between people and wild animals [35]. Thus, HWCs increase. Yigrem et al. [21] noted that a total of 377 livestock losses were recorded in the last five years due to the depredation of spotted hyenas, and the economic loss was 47,885 USD$ in the Damota Community Conservation Forest in Southern Ethiopia. Tamrat et al. [33] reported that 1,062 livestock had been killed by wild carnivores (spotted hyena and African wolves), with livestock worth a local market value of 29,207 USD$ around Senkele Swayne's hartebeest Sanctuary, Ethiopia. Merkebu and Yazezew [17] reported that the estimated loss of wheat, barley, and potato yield due to crop raiders was about 2,743 kg. Eniang et al. [36] documented a total of 379 bags as perceived losses by primates in Nigeria's Gashaka Gumti National Park. In Tanzania, the Rungwa-Katavi Wildlife Corridor, Kwaslema et al. [14] mentioned that 417 kg of maize and 13 kg of other crop types were recorded and the estimated loss was between 125$ and 1.30 $ per year per household due to the ranked crop raiders such as elephant, warthog, and greater kudu.

Large, medium, and small-bodied wild mammalian species cause crop damage and predation on livelihoods, which negatively influence the attitudes of local people towards wildlife and increase the local community to take retaliatory killings [27, 35]. People's attitudes towards forests and wild animal conservation are likely influenced by the demographic and socio-economic characteristics of residents [30, 37]. Experienced costs and benefits, personal or cultural beliefs about wildlife, and other environmental factors also influence the local people attitudes towards wildlife [5, 28, 38]. The increases in human activities at an alarming rate decreased the conservation area of Ethiopia and the rest of all other African countries and had significant effects on the habitat of wildlife. Human population growth rates around the periphery of protected areas, habitat loss or fragmentation, cutting trees for the purpose of making firewood or charcoal, killing of wildlife, and a lack of awareness towards wildlife conservation contribute to a decline in the existence of wildlife and the competition for or sharing of limited resources with humans [25, 33, 39]. Considering the actual threat rate of humans and the increasing demand for natural resources, it is clear that the HWC will not be eradicated in the near future; however, it needs to be managed urgently [5]. A wide range of management tools have been developed in human-dominated landscapes to address the impact of HWC (Treves & Karanth, 2003) [12], but most are site- and species-specific and are not widely or easily accessible [6, 15, 25]. Most local farmers use their indigenous knowledge to mitigate the effects of HWC in their localities. This provides insight on how different landowners survive with wildlife and compete for resources [40].

Ethiopia's conservation areas have great economic and environmental importance but continue to face threats from deforestation, agriculture expansion, and grazing land [29]. The scenario is the same in Southern Ethiopia [21, 41]. In the Konasa-Pulasa Community Conserved Forest, Omo Rift Valley, wild animal habitat has been deforested mainly due to agricultural activities. The high deforestation has resulted in a scarcity of resources for wild animals to fulfill their survival and production requirements [17, 21]. In Konasa-Pulasa Community Conserved Forest, mixed farming, crop cultivation, and livestock rearing are sources of income for farmers. Predators such as spotted hyenas (*Crocuta crocuta*), black-backed jackals (*Canis mesomelas*), leopards (*Panthera pardus*), and crop raiders such as grivet monkeys (*Chlorocebus aethiops*), Anubis baboons (*Papio anubis*), and porcupines (*Hystrix cristata*) were frequently seen [21].

The overarching goal of this study was to develop a better understanding of the population density of wild animals and their conflict with local people and to promote human-wild animal coexistence in the study area. However, there is limited scientific information regarding the population density of wild animals and their conflict in the study area. Therefore, the aim of this study is to fill the gap in scientific data on the population density of wild animals, their types and extent of conflict, and farmers' attitudes towards wild animal conservation in Konasa-Pulasa Community Conserved Forest to minimize the existing problem and create a better coexistence between humans and wild animals in the study area. This study provides basic information for community-conserved forest authorities and governmental and nongovernmental groups to develop and implement appropriate conservation policies and strategies that will aid to improve human-wild animal coexistence in the area.

2. Materials and Methods

2.1. Description of the Study Area. The study was carried out in Konasa-Pulasa Community Conserved Forest, Wolaita Zone, Omo Valley, Southern Ethiopia. The study area lies in the north part of Wolaita Sodo town, over the plateau of Damota, which is the most prominent feature in the region with an average elevation of 2950 m. The area is included in the Great Rift Valley of Ethiopia, near Lake Abaya and the Omo River, at a distance of 364 km south of Addis Ababa, which is the capital city of Ethiopia. It was located at 6°.59′0″ to 7°.35′00″ North latitude and 37°48′ to 38°.44′07″ East longitude with an altitudinal range from 1500 to 2950 meters at sea level, and the study area covers 187.6 km^2 (Figure 1).

The area is characterized by rugged topography and diversified agro-ecology. The district has a total population of 151,079 (74,227 males and 76,852 females) [42]. The main occupations of the inhabitants are mixed agriculture, mainly crop and livestock production. The mixed crop-livestock farming system is the main economic activity in the study area. In this system, crops and livestock play interdependent roles, with livestock providing meat, dairy products, and manure for crop production, while crop residues provide feed for the livestock. The Damota communities herd cattle, sheep, donkeys, goats, mules, and horses at a small scale [43]. Cattle, sheep, and horses were released to nearby forests during the daytime and returned to their sheds near human houses late in the evening. Heifers, goats, sheep, and poultry were stall-fed and primarily kept in sheds near the settlement.

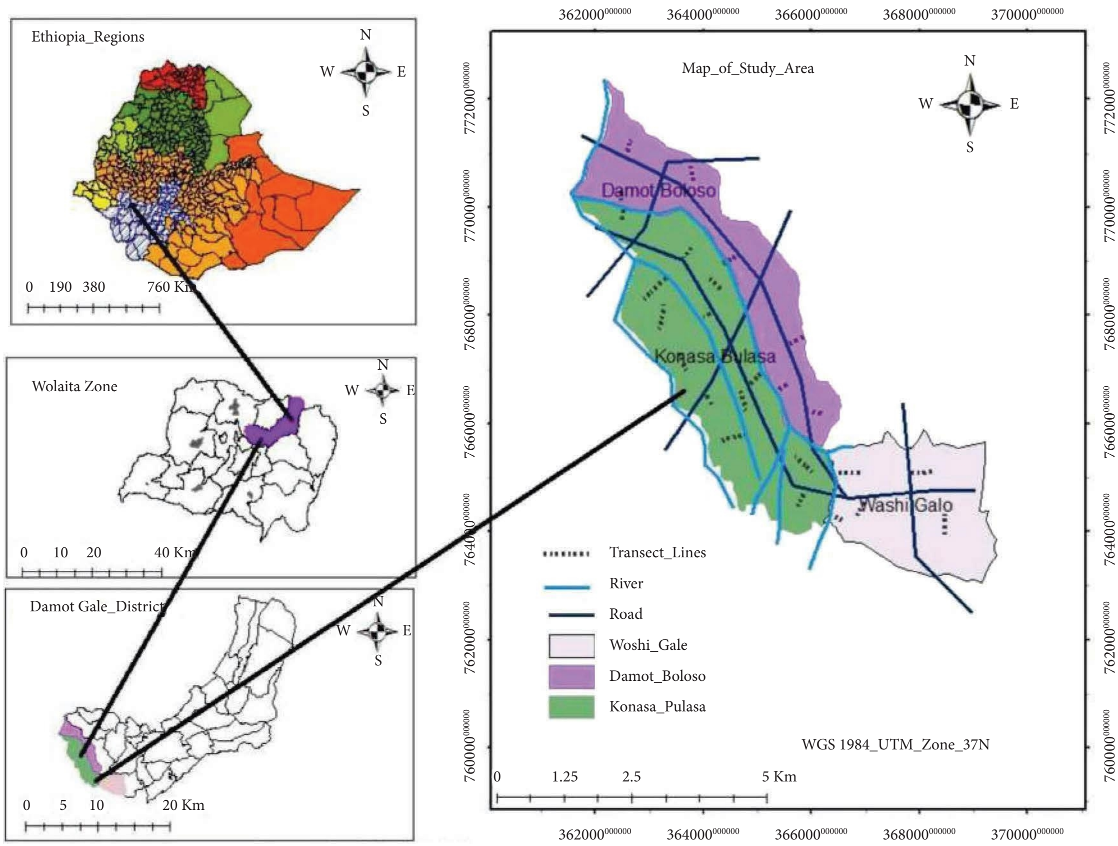
Mainly, agricultural expansion and grazing pressure posed by livestock are the causes of human-wild conflict in the forest. Livestock usually intensively compete with wild animals for the same habitat resources, including forage and water sources. The residents also used forest resources for different purposes. Trees were cut to construct houses, firewood, and livestock fences and collect spice/medicinal plants from the forest.

The rainfall pattern in the study area was bimodal. There is a short rainy season from March to April, while the main rainy season is from June to September. The average annual rainfall in the area was 1365 mm. In the study area, the hot months are reported from November to February and the cold months from June to September. The average annual minimum and maximum temperatures in the study area were 15°C and 18°C (National Meteorological Agency, 2019). The soil type of Konasa-Pulasa and the surroundings is mainly clay and loam in texture, which occupy other parts of our county's Ethiopian highlands [43]. Yechiya, Ethana, Kaleta, Bortuwa, Chareke, and Walacha rivers and their tributaries drain the area. These rivers then flow to Omo River (Yechiya and Ethan) and Abaya Lake (Kaleta, Chareke, Bortuwa and Walacha). There are different natural, historical, and cultural heritage sites in the study area, such as king "Amado," "Arujia," and "Gugisa" caves. The area is rich in floristic and faunal biodiversity. The vegetation of the area was diverse and dominated by various floral species that provide great importance as traditional medicine for local people living around the study area [43], such as *Juniperious procera*, *Acacia bervispica*, *Croton macrostachyus*, *Euphorbia tirucelli*, *Oliniarochetiana*, *Syzygium guineense*, *Buddleja polystachya*, *Eriobotrya japonica*, *Croton macrostachyus*, *Bersama abyssinica*, *Albizia schimperiana*, *Maytenus gracilipes*, *Rytigyni aneglecta*, *Allophylus abyssinicas*, *Rhamnu sprinoides*, *Erica arborea*, *Maesalance olata*, *Ole aeuropaea sp. Acacia hockii*, *Celtis africana*, *Agarista salicifolia*, *Fagaropsis angolensis*, *Buddle japolystachya*, *Flacourtia indica*, *Calpurnia aurea*, *Cupressus lusitanica*, and *Carissa edulis*.

Konasa-Pulasa Community Conserved Forest (hereafter referred to as "KPCCF") hosts a variety of faunas such as olive baboons (*Papio anubis*), grivet monkeys (*Chlorocebus aethiops*), bushbucks (*Traglapus scriptus*), common duikers (*Sylvicapra grimmia*), guenther's dikdiks (*Madoqua guentheri*), porcupines (*Hysteric cristata*), and predators including black-backed jackals (*Canis mesomelas*), white-tailed mongoose (*Galerell aflavescens*), aardvarks (*Orycteropus afe*), leopards (*Panthera pardus*), leopards (*Leopards wiedii*), serval cats (*Leptailurus serval*), African civets (*Civetticis civetta*), and spotted hyenas (*Crocuta crocuta*). In addition, the area is believed to possess ample diversity of birds, reptiles, and amphibian species [44]. The socio-economic condition of the people in the study area is mainly agro-pastoralists. The main crops are cereals such as maize (*Zea mays*), sorghum (*Sorghum bicolor*), teff (*Eragrostis tef*), pea (*Pisum sativum*), beans (*Faba vulgaris*), and cash crops such as coffee (*Coffea Arabica*), root crops such as potato (*Solanum tuberosum*), Enset (*Ensete ventricosum*), and sweet potato (*Ipomoea batatas*), and fruits such as banana (*Musa paradisca*) mango (*Mangifera indica*) and avocado (*Persea americana*), while livestock predominantly include cattle, sheep, goat, chicken, horse, mule, and donkey [44].

2.2. Data Collection Method. Data were collected from December 2019 to May 2020. A mixed-methods approach was used to collect data. The distance sampling method to estimate the population status of wild animals, a questionnaire survey to quantify human-wildlife conflict, and focus group discussions to support the questionnaire data were used in the present study area.

2.2.1. Population Estimate. The study area was stratified into two main blocks based on the main vegetation types. In each block, permanent parallel transect lines were established, as Sutherland (1996) adopted. A total of 25 transects were sampled. The number of transects in each block varied depending on visibility. We used distance sampling procedures to estimate the density of wild animals in the study area [45, 46]; Karanth and Sunquist, 1992; [47]. Line transects were randomly established to estimate the population size of wild animals. The transect lines were delineated by global positioning system (GPS) coordinates, poles, and natural signs. In order to eliminate the edge effect, it was discovered that the end points of each transect were spaced sufficiently distant from the margin of each habitat. The transect length varied from 1.5 to 3.0 km depending on the topography of the area and habitat type. Consecutive transects were established at a distance of 500 m to 1 km to avoid double counting. Transects were surveyed at the same time systematically with the help of trained and experienced local people during the wet and dry seasons at a constant speed to maximize the probability of seeing all individuals on both sides (Norton-Griffiths, 1978). Each transect was surveyed two times within a day, early in the



Source: ArcGIS 10.4.1; Ethio_GIS_Shape_File ,2021 By Mesfin M.

Figure 1: Map of the study area.

morning (06:00 to 10:00 h) and late afternoon (16:00–19:00 h), when they were active and when visibility was good. The counting was carried out using normal vision, GPS, 7×35 magnifying binoculars, and while on foot during the counting period. The average speed for walking transects was 2.5 km/h. A silent detection method was followed to minimize disturbances. For each detection, sighting distance, wild animal observation, sighting angle, and time were recorded. The distance and angle between the observer and animals were measured by a laser meter from the center of the transect line, following Buckland et al. [45]; whenever wild animals (individual or group) were observed, group size, sighting distance (ri) as the distance from each line transect to the geometric center of the groups or individuals, and sighting angle (θ) between the transect line and individual or group were recorded on the data sheet. Then, the perpendicular distance from the transect line to the animal is calculated as $x = \text{ri} \sin(\theta)$.

2.2.2. Sample Size Determination and Sampling Technique. The study used a questionnaire survey method among the households to assess livestock depredation and crop damage by wild animals. Three peasant associations (Konasa, Woshi Gale, and Damot Boloso) were purposefully selected among seven peasant associations around KPCCF. Five villages were selected purposefully from the three peasant associations, such as Wonchiro, Mehal, Damota, Sutancho, and Sorto villages, depending on their proximity to the forest and the highest incidences of human-wild animal conflict within the area. Then, based on their proximity to the forest, the villages were divided into three groups based on their distance from the KPCCF edge: near (0.5–1 km), medium (1–3 km), and far (4-5 km).

The questionnaire was pretested on 45 randomly selected individuals from all five villages of varying age, sex, and background among the local communities, not included in the main sample group. This helped modify the questionnaire accordingly. The pretested questionnaires were used to examine the practicability, reliability, and suitability of the method. The sample size of the study population was selected from 1043 households from five villages. Systematic random sampling techniques were used to select the households based on the simplified formula developed by [48].

$$n = \frac{N}{1 + N(e)^2}, \tag{1}$$

where n is the sample size, N is the total population size, and e is the level of precision.

$$\begin{aligned} n &= \frac{1043}{1 + 1043(0.05)^2}. \\ &= 290 \end{aligned} \tag{2}$$

The sample sizes in each study village were determined based on their proportion to the total households of the five study villages.

The questionnaires consisted of pretested closed and open-ended questions. The questions were prepared in English and translated into the Wolaitagna language for accessible communication during data collection to reduce misunderstandings, and the answers of the respondents were translated back to English. Data collection was carried out from 2019 to 2020. Each respondent of the study village was randomly selected following a pattern of skipping two households, and the third household was interviewed [13]. A total of 290 respondents were selected from five sample villages (Wonchuro 19.7%, $n = 57$, Mehal 39.7%, $n = 115$, Damota 19.7%, $n = 57$, Sutancho 8.9%, $n = 26$, and Sorto 12.1%, $n = 35$). Among them, 243 males and 47 females of various ages were selected. Due to the dominance of male household heads' role in most activities of livestock husbandry and their small exposure to human-wildlife conflict, the number of females included in the questionnaires was very small. Fifteen local people, consisting of three residents from each of the five study villages, were recruited and trained to administer the questionnaires. Each interview lasted an average of 43 minutes (range: 35–50 minutes) [49, 50]. The age category of the participants ranged from 18 to 61 years old and above. The questionnaires were administered to members of the households randomly on a first-come, first-served basis. The questionnaires focused on three main areas of interest: These include (i) demographic and socio-economic information of respondents, (ii) the identification of problematic wild animals responsible for crop damage and domestic animal depredation, (iii) mitigation measures, and farmer attitudes towards wild animal conservation by following the procedures of Naughton-Treves and Treves [38] and Gebo et al. [37]. The attitude of the respondents towards the wild animal was categorized as a major problem (negative perception), a minor problem (negative perception), no problem (positive perception), and no response (neutral). Each attitude statement is stated according to their strength of agreement by a five-point Likert scale [51].

Field observation of crop damage and livestock depredation was mainly used to verify the response of the respondent and collect reliable information since farmers amplify the problems [17]. The extent of crop and livestock damage by wild animals was estimated using their tooth marks left on damaged plant parts, livestock, and fecal drops [19, 29]. For each type of crop sample from $1000\,m^2$ farm land, 12 plots with $2\,m^2 \times 2\,m^2$ lengths were prepared. The observation was carried out from 2019 to 2020, on sample farmlands in the five villages. During the germination (seedling) stage, daily observation was performed. However, more emphasis was made on the timing of flowering and maturation. In each of these stages, observations were made two times per week. The entire damaged crop was recorded and counted on each farmland on the same day during the visit. At the end of each stage of development, damaged plants were added and estimated. Finally, the mean damage to crops was calculated in kilograms, and by comparing the current market price and total yield loss of each village, the totals were added up and summarized [39]. Similarly, the financial loss for each respondent from livestock killed by predators was calculated based on market prices (Ethiopian birr) from the nearest town, which was then converted to US dollars for the different types of livestock [14].

Two focus group discussion sessions were conducted in each study village after the questionnaire to support the questionnaire data. The group size in each discussion village varied from 7 to 13 people. A checklist of questions was developed to guide focus group discussions to obtain first-hand information from participants [52]. The FGDs were held under the guidance of ten well-trained mediators who are familiar with the local languages. District agricultural offices, village leaders, local elders, model farmers, peasant female associations, teachers, and students participated to discuss their experiences concerning the causes of HWC and their mitigation, the management style of the species, and the attitudes of informants towards the community-conserved forest [53]. The information collected from the group discussions was collated and summarized using the text analysis method and presented narratively. Therefore, the acquired information was triangulated through questionnaires and focus group discussions. It is difficult to develop accurate cost estimates associated with wildlife damage to crops and livestock. However, approximations of these costs can be useful in illustrating the magnitude of the problems facing farmers.

2.3. Data Analysis

2.3.1. Density Estimation of Wild Animals. DISTANCE (Version 6.0, Release 2) Software was used for density estimation of problem-causing wild animal populations. The key to distance sampling analyses is to fit a detection function to the observed distances and use the fitted function to estimate the proportion of objects missed by the survey. All observations recorded from transects laid in a specific habitat were grouped together for analysis. Following Buckland et al. [54], a variety of key functions and adjustment term combinations were considered to model the detection function, the key function, negative exponential growth by adjustment functions: cosines and half-normal by adjustment function: cosines were chosen over the others on the basis of best fit (i.e., minimum AIC value).

2.3.2. Sociological Data Analysis. Data analysis consisted of descriptive and inferential statistics. ANOVA was used to test the statistical difference in the means of the variables of the total number of types of livestock lost to predators in villages and the economic costs associated with livestock losses. In addition, nonparametric χ^2 tests were used to test the observed frequency of predation on different types of livestock between villages, the attitudes of the respondents about problem animals, and the seasonality of depredation. A correlation was also performed to determine the relationship among livestock depredation, crop damage, and distance of villages from the forest. The effects of socioeconomic variables on participants' attitudes were investigated as continuous variables such as gender, age, education status, family size, farm land size, and farming practice which were converted into categorical variables following Mkonyi et al. [55] to compare the effect within a group. Perceived depredation was used as dependent variables, while socioeconomic variables were used as an independent variable. Descriptive statistics in the form of percentages and frequencies were used to analyze the demographic and socioeconomic profiles of the respondents. The predation control methods practiced by the local people were analyzed using descriptive statistics. Information was collected from the focus group discussion, summarized by text analysis, presented narratively, and used to supplement the perceptions of the household respondents. Mean values, ranges, percentages, and frequencies are also calculated using descriptive statistics. All analyses were conducted using the Statistical Package for Social Science (SPSS) version 23.0 for Windows. All statistical tests were two-tailed, with a significance level of $p \leq 0.05$.

3. Results

3.1. Population Estimation of Wild Animals. In the present study area, the mean population estimates for Anubis baboons were 852.5 ± 140.47, for grivet monkeys were 533.5 ± 80.25, for porcupines were 89 ± 17.20, for spotted hyenas were 58 ± 14.00, and for black backed jackals were 93.5 ± 17.23 individuals, respectively. The density of wild animals was estimated based on the minimal AIC values in a number of significant essential functions. The mean estimated densities of Anubis baboons were 4.51 ± 0.76; for grivet monkeys, they were 3.24 ± 0.51, for porcupines, they were 0.89 ± 0.17, for spotted hyenas, they were 0.58 ± 0.15, and for black-backed jackals, they were 0.65 ± 0.12 individuals/km^2, respectively. The detection probabilities for wild animals (grivet monkey, Anubis baboon, porcupine, spotted hyena, and black backed jackal) in 2019 and 2020 were (0.27; 0.26), (0.25; 0.35), (0.41; 0.38), (0.37; 0.55), and (0.47; 0.43), respectively (Table 1). A minimum AIC value was computed for each species using the half-normal, uniform, negative exponential, and hazard rate key functions (Figures 2–6).

3.2. Demographic Profiles of the Respondents. Among the sociodemographic variables, age and education are affecting respondents' attitudes toward wild animal conservation in the study area. The age of the respondents ranged from 18 to 61 years and above. Among these sample respondents, 18% ($n = 51$) were of young age (18–30 years old), 36% ($n = 106$) of them were between the ages of 31–45 years old, 25% ($n = 73$) of them were between the ages of 46–60 years old, and 21% ($n = 60$) of respondents were above the age of 61 years old. The respondents between the ages of 18–45 years old showed more positive attitudes toward wild animals than older groups. Thirty-three percent ($n = 95$) of the respondents were illiterate, 39% ($n = 113$) completed primary education (1–8), 20% ($n = 59$) completed secondary education (9–12), and 8% ($n = 23$) were above grade 12 (graduated from college and university). The respondents with increasing education levels had more positive attitudes toward wild animal conservation. The better educated groups had a more positive attitude than the uneducated respondents. According to the present findings, 47.4% of the respondents had a positive feeling towards wild animal species conservation, while 40.0% respondents had a negative feeling towards wild animal species conservation, and 12.5% of the respondents were neutral about the presence of wild animals in the study area (Table 2). Therefore, there was a significant difference in the attitudes of the respondents toward wild animal species in the study area ($\chi^2 = 128$, df $= 2$, $p < 0.05$).

3.3. Human-Wildlife Conflict. In the study area, crop damage, livestock depredation, human injury and/or death, and disease transmissions are the common types of wild animal conflict. Most of the respondents (41.0%, $n = 119$) reported that crop damage and livestock predation were the common causes of human-wildlife conflict, followed by crop raiding only (27.2%, $n = 79$), 23.1%, ($n = 67$) livestock predation only, 5.9% ($n = 17$) were reported to be human attacks, and 2.8% ($n = 8$) who faced disease transmission were reported as the main challenges of the surrounding community. The difference was statistically significant among all study villages ($\chi^2 = 125$, df $= 4$, $p < 0.05$) (Table 3).

3.3.1. Types of Wild Animal Species Involved in Crop Damage. In the study area, five crop-raiding wild animals were identified based on the respondent report. The Anubis baboon (*Papio anubis*) (35.9%, $n = 104$) was the most frequently reported crop raider responsible for crop damage in all villages, followed by the grivet monkey (*Chlorocebus aethiops*) (28.3%, $n = 82$), the porcupine (*Hystrix cristata*) (23.8%, $n = 69$), the bushbuck (*Tragelaphus scriptus*) (7.9%, $n = 23$), and the common duiker (*Sylvicapra grimmia*) (4.1%, $n = 12$) (Figure 7). Out of the identified crop raiders, grivet monkey, Anubis baboon, and common duiker are reported as diurnal crop raiders, while bushbuck and porcupine are reported as predominantly nocturnal crop raiders in the study area. There was a significant difference in crop damage among five villages ($\chi^2 = 68.9$, df $= 4$, $p < 0.05$). The grivet monkey and Anubis baboon caused damage to crops in all stages, from the time of germination to the time of harvest, whereas bushbuck and duiker affected crops early in the seedling stage. Root and tuber crops, such as enset and potatoes, were particularly vulnerable to porcupine attack.

According to the respondents, the crops that are most raided by these wild animals are maize, enset, haricot beans, potato, wheat, pea, barely, and teff. The most preferable and vulnerable crop type to be raided by wild animals in the area was maize (*Zea mays*) (26.5%, $n = 77$), followed by enset (*Ensete ventricosum*) (19.7%, $n = 57$), haricot beans (*Phaseolus vulgaris*) (14.8%, $n = 43$), and potato (*Solanum tuberosum*) (12.8%, $n = 3$) (Table 4).

3.3.2. Estimated Economic Loss of Crops by Wild Animals. Most of the respondents had experienced crop damage due to wild crop raiding animals. An estimated average loss of

Table 1: Density estimates for wild animals in Konasa-Pulasa community conserved forest (2019 and 2020).

Animal	Year	Parameter	Estimate	Standard error	% CV	95% CI	AIC	Model
Grivet monkey	2019	P	0.27	0.34	12.58	0.21–0.35	655.54	Ne/Cos
		ESW	23.06	2.9013	12.58	17.97–29.59		
		D	3.57	0.67839	18.99	2.44–5.23		
		N	481.00	91.333	18.99	328.00–703.00		
	2020	P	0.26	0.19	7.46	0.22–0.29	574.71	Hn/Cos
		ESW	25.85	1.9291	7.46	22.28–29.99		
		D	2.91	0.34297	11.80	2.28–3.69		
		N	586.00	69.164	11.80	461.00–745.00		
Anubis baboon	2019	P	0.25	0.3031	12.06	0.19–0.32	673.32	Ne/Cos
		ESW	25.14	3.0312	12.06	19.79–31.93		
		D	3.66	0.65529	17.88	2.58–5.20		
		N	249.00	44.530	17.88	175.00–354.00		
	2020	P	0.35	0.23	5.39	0.22–0. 47	897.43	Hn/Cos
		ESW	24.49	1.32	5.39	22.02–27.25		
		D	5.35	0.87	16.24	3.84–7.48		
		N	1456.00	236.40	16.24	1043.0–2033.0		
Porcupine	2019	p	0.37	0.3772	10.28	0.29–0.45	1060.92	Hr/Cos
		ESW	21.43	2.2038	10.28	17.49–26.25		
		D	1.08	0.22109	20.43	0.72–1.61		
		N	108.00	22.070	20.43	72.00–162.00		
	2020	p	0.55	0.23443	4.29	0.50–0.59	1112.41	Uf/Cos
		ESW	31.94	1.3695	4.29	29.35–34.76		
		D	0.69	0.12260	17.60	0.49–0.98		
		N	70.00	12.321	17.60	49.00–99.00		
Spotted hyena	2019	p	0.41	0.79	19.68	0.28–0.59	1616.97	Hr/SPs
		ESW	19.549	3.84	19.68	13.30–28.72		
		D	0.61	0.14	22.59	0.39–0.95		
		N	61.000	13.78	22.59	40.00–95.00		
	2020	p	0.38	0.91	23.76	0.24–0.61	1303.28	Hr/Cos
		ESW	18.427	4.38	23.76	11.61–29.24		
		D	0.55	0.15	25.89	0.34–0.92		
		N	55.00	14.238	25.89	34.00–92.00		
Black backed jackal	2019	p	0.47	0.35333	7.48	0.41–0.55	744.57	Hn/Cos
		ESW	23.06	1.7253	7.48	19.88–26.74		
		D	0.58	0.10202	17.46	0.40–0.85		
		N	84.00	14.670	17.46	58.00–122.00		
	2020	p	0.43	0.65934	15.32	0.32–0.58	719.01	Hr/Sps
		ESW	21.02	3.2196	15.32	15.54–28.44		
		D	0.72	0.13746	19.22	0.49–1.05		
		N	103.00	19.799	19.22	70.00–151.00		

D: density; N: population; ESW: effective strip width; P: detection probability; Hr/SPs: hazard rate/simple polynomials; Hr/Cos: hazard rate/cosines; Uf/Cos: uniform/cosines; Hn/Cos: half normal/cosines; Ne/Cos: negative polynomials/cosines.

8,201 kg of crop loss, equivalent to US $8,707.78, was reported in five villages in two years. The estimated annual loss of different types of crops was 4,100.5 kg, which is equivalent to US $4,353.89. The average economic loss from wild animals was US$15.01 loss per year per household. The results show that the distance from the forest is the major determinant of the intensity of the economic loss caused by problematic wild mammals. The economic loss was found to be higher near the forest area than in the area far from the forest. The degree of conflict was reported to be more intense within the 0.5 to 3 km range from the forest than within the distance villages ($r = 0.79$, $p < 0.05$). Among villages, Wonchiro consists of 24.17% crop loss, Mehal 20.85%, Damota 19.46%, Sutancho 18.36%, and Sorto consists of 17.16% of crop loss. There was a significant difference in crop loss among the villages ($\chi^2 = 82.3$, $df = 4$, $p < 0.05$). According to the respondents, most crop damage was caused by Anubis baboons, followed by grivet monkeys and porcupines (Table 5).

3.3.3. Livestock Losses by Wild Animal Depredation. A total of 2,825 livestock (cattle, $n = 910$, 32.2%; poultry, $n = 870$, 30.8%; sheep, $n = 600$, 21.2%; goats, $n = 220$, 7.9%; horses, $n = 75$, 2.6%; donkeys, $n = 97$, 3.4%; mules, $n = 53$, 1.9%) were owned by the surveyed households during the data collection. A total of 271 (9.6%) livestock predation incidences were reported by the respondents within 2 years (2019-2020) in five villages. Thus, poultry (44.3%, $n = 120$) were predominantly preyed upon, followed by sheep (36.2%, $n = 98$) and cattle (7.3%, $n = 20$), whereas the least number of

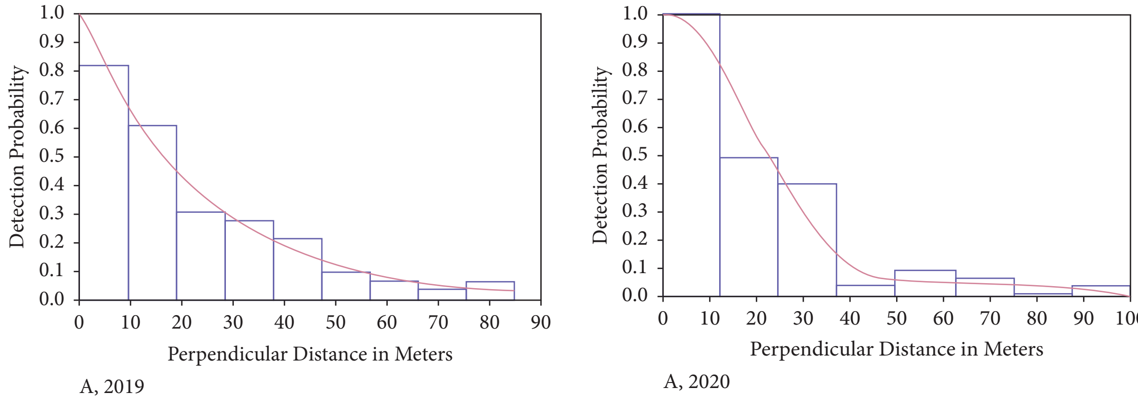


Figure 2: Number of sightings of grivet monkey at different distances from the transect center-line during two survey periods (2019 and 2020) in Konasa-Pulasa community conserved forest.

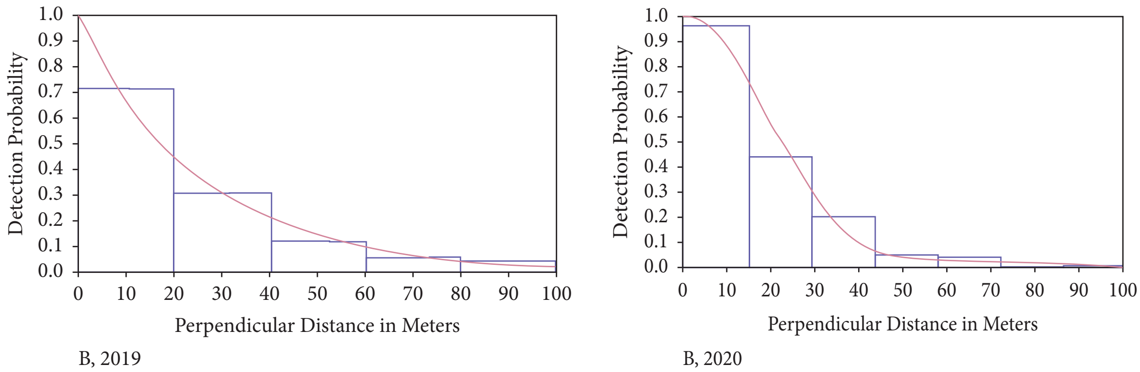


Figure 3: Number of sightings of Anubis baboon at different distances from the transect center line during two survey periods (2019 and 2020) in Konasa-Pulasa community conserved forest.

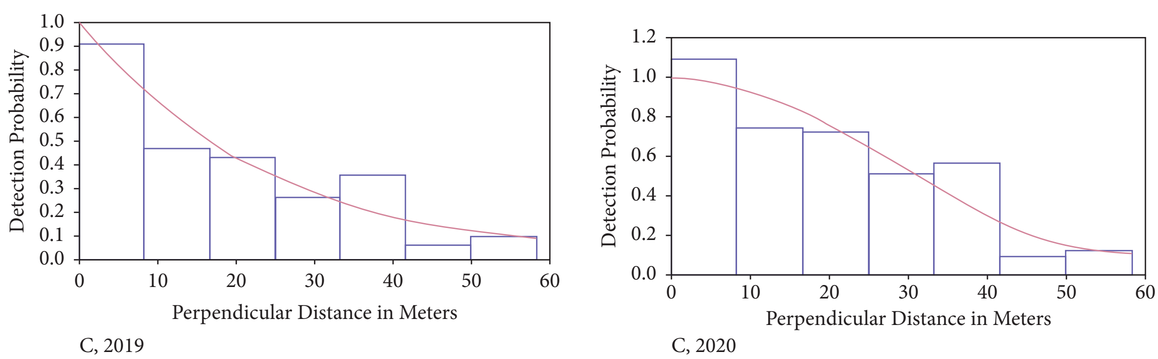


Figure 4: Number of sightings of porcupine at different distances from the transect centerline during two survey periods (2019 and 2020) in Konasa-Pulasa community conserved forest.

predation incidents were reported on mules (1.1%, $n = 3$). High livestock depredation was observed in the closest villages such as Wonchiro (0.5–1 km) and Mehal (1-2 km) villages. The livestock loss caused by predators also significantly differed across the study villages ($F_{42} = 2.75$, df = 4, $p < 0.05$) (Table 6).

Most depredations were reported in Wonchiro (0.5–1 km) (37.6%), followed by Mehal (1-2 km) (25.5%), Damota (2-3 km) (17.7%), Sutancho (3-4 km) (12.5%), and Sorto (4-5 km) (6.6%) villages. The frequency of livestock predation was significantly different among the surveyed villages ($\chi^2 = 125.93$, df = 4, $p < 0.05$). The spotted hyena (35%, $n = 102$) was the most frequently reported predator responsible for livestock depredation, followed by black-backed jackals (24%, $n = 71$) and leopards (16%, $n = 46$) (Table 7).

Total economic losses caused by livestock depredation in the study area were US $24,395.92, as reported from five villages in two years. The annual estimated loss of different livestock types was $12,197.96. An average estimated economic loss of domestic animals was US$42.06 loss per year

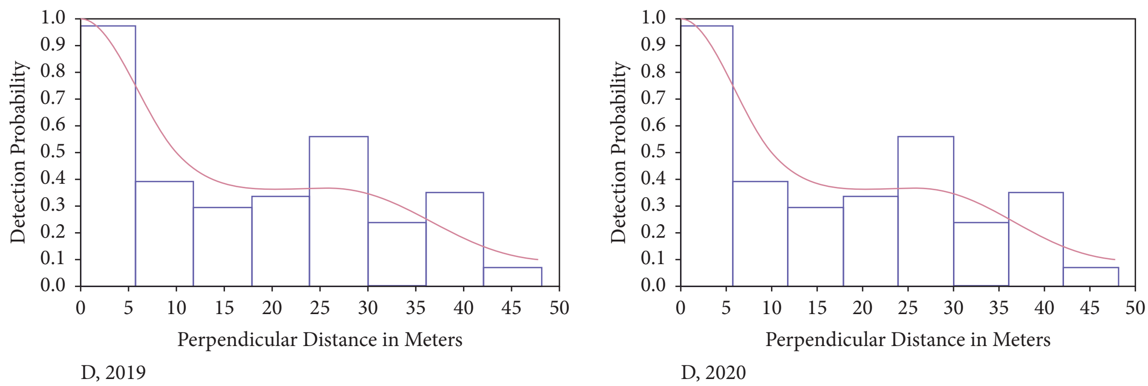


Figure 5: Number of sightings of spotted hyena at different distances from the transect center line during two survey periods (2019 and 2020) in Konasa-Pulasa community conserved forest.

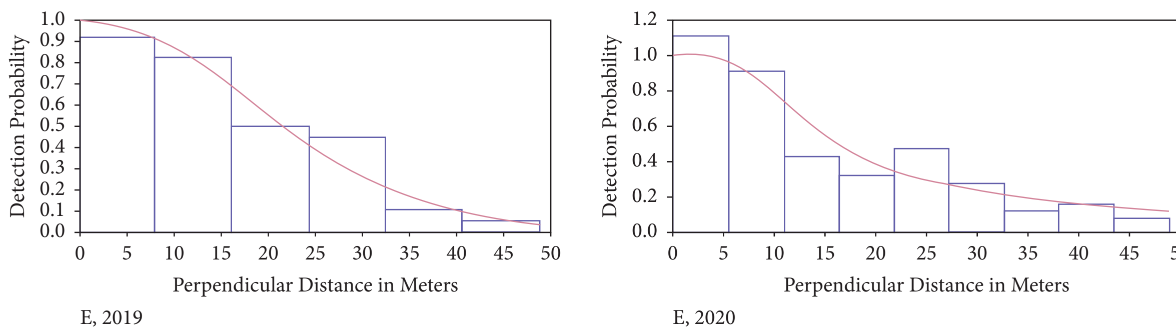


Figure 6: Number of sightings of black backed jackals at different distances from the transect center line during two survey periods (2019 and 2020) in Konasa-Pulasa community conserved forest.

Table 2: Sociodemographic information and attitudes of the respondents towards wild animals in Konasa-Pulasa community conserved forest.

	Attitudes of respondents towards wild animals					
Category	Variables	Respondents	Percentage	Positive	Negative	Neutral
Sex	Male	243	84	116	96	31
	Female	47	16	24	17	6
Age	18–30	51	18	27	18	6
	31–45	106	36	50	42	14
	46–60	73	25	38	26	9
	61 and above	60	21	31	21	8
Educational status	Illiterate	95	33	34	49	12
	Literate 1–8	113	39	59	39	15
	Literate 9–12	59	20	31	19	7
	Literate ≥12	23	8	19	1	3
Family size	1–4	70	24.2	36	25	9
	5–8	117	40.3	50	52	15
	9 and above	103	35.5	37	54	12
Farming practice	Mixed farming	195	67	81	89	25
	Crop cultivation	52	18	27	19	6
	Livestock rearing	41	14	21	15	5
	Other activity	2	1	1	1	0
The size of farm land in hectare	0.5–1	153	52.7	71	63	19
	1.1–2.5	77	26.5	40	28	9
	2.6–4	49	17.0	25	18	6
	4.1 and above	11	3.8	6	4	1
Percentage (%)				47.4%	40.0%	12.5%

Table 3: Causes of conflict between humans and wild animals in the villages of Konasa-Pulasa community conserved forest.

Villages	N	Causes of human-wild animal conflict: Crop damage only	Livestock depredation	Livestock and crop damage	Human attacks	Transmit disease
Wonchiro	57	16 (28.1)	13 (22.8)	20 (35.1)	5 (8.8)	3 (5.3)
Mehal	115	32 (27.8)	27 (23.5)	48 (41.7)	6 (5.2)	2 (1.7)
Damota	57	14 (24.6)	15 (26.3)	24 (42.1)	3 (5.3)	1 (1.8)
Sutancho	26	7 (26.9)	5 (19.2)	10 (38.5)	2 (7.7)	1 (3.8)
Sorto	35	10 (28.6)	7 (20.0)	17 (48.6)	1 (2.9)	0 (0)
Total (%)	290	27.2	23.1	41.0	5.9	2.8

The number in bracket represents the percentage of respondents.

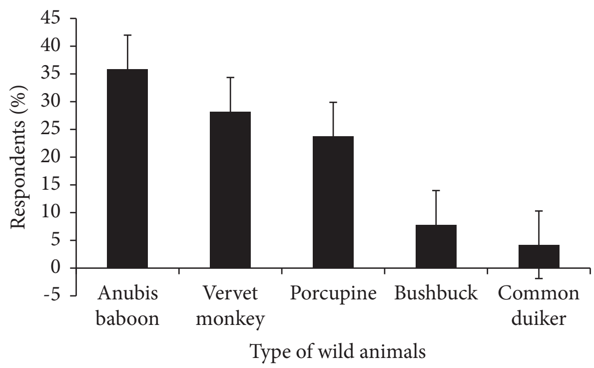


Figure 7: Crop raiding animals ranked by the respondents in Konasa-Pulasa community conserved forest.

Table 4: The most frequently raided crops by wild animals ($n = 290$).

Crop types preferred by the crop raider	Frequency	Percent	Rank
Maize (*Zea mays*)	77	26.6	1
Enset (*Ensete ventricosum*)	57	19.7	2
Haricot beans (*Phaseolus vulgaris*)	43	14.8	3
Potato (*Solanum tuberosum*)	37	12.8	4
Wheat (*Triticum aestivum*)	25	8.6	5
Pea (*Pisum sativum*)	20	6.9	6
Barely (*Hordeum vulgare*)	18	6.2	7
Teff (*Eragrostis tef*)	13	4.5	8
Total	290	100	

per household. The effects of predators were different from village to village. The economic loss was higher near the forest villages than in the villages far from the forest (Table 8).

3.4. Mitigation Methods Practiced by Local Farmers. The respondents used different indigenous methods to mitigate conflicts with wild animals. Most of the respondents perceived physical guarding (32.8%, $n = 95$) as an effective strategy to protect crops and domestic animals, followed by chasing (25.2%, $n = 73$), fencing (19.7%, $n = 57$), scarecrows (16.9%, $n = 49$), and other techniques, including chilling, animal dung, and noise (Figure 8). The respondents did not use only one method alone; they combined and integrated local methods to prevent crop raiding and livestock predation. Therefore, there was a significant difference in the mitigation methods used by the respondents among the villages ($\chi^2 = 93.724$, df = 4, $p < 0.05$).

4. Discussion

4.1. Population Density. It is essential to assess the ecological aspects of wild animals in order to monitor population trends. Management decisions are made by conservationists as a result of their understanding of species' ecology and conservation status [47]. Crop raiders and predators have low densities in KPCCF compared to those estimated in other parts of Africa, except for spotted hyenas. This could be due to human activities such as urban expansion, agricultural activities, overgrazing, unlawful hunting, and other impacts on wild animals, as

Table 5: The estimated economic loss of various crops (in kilograms) caused by wild animals in five villages in the last two years (2019-2020) in the Konasa-Pulasa conserved forest.

Crop type	Village distance to the forest and estimated loss of crops in kg							
	Wonchiro (0.5–1 km)	Mehal (1-2 km)	Damota (2-3 km)	Sutancho (3-4 km)	Sorto (4-5 km)	Total loss in kg	Average market price per kg in US$	Total loss in US$
Maize	399	297	256	225	187	1,364	0.82	1,118.48
Enset	285	263	245	217	222	1,232	0.96	1,182.72
Bean	293	213	222	217	204	1,149	1.18	1,355.82
Potato	220	197	195	190	170	972	0.78	758.16
Wheat	202	185	170	168	163	888	1.09	967.92
Pea	188	172	160	155	140	815	1.23	1,002.45
Barely	195	187	173	163	156	874	1.09	952.66
Teff	200	196	175	171	165	907	1.51	1,369.57
Total loss in kg	1,982 (24.17%)	1,710 (20.85%)	1,596 (19.46%)	1,506 (18.36%)	1,407 (17.16%)	8,201		8,707.78

Note. 1 US$ is worth 36.48466 Ethiopian Birr during the study period.

Table 6: The number of livestock depredated in the last two years (2019-2020) in the Konasa-Pulasa conserved forest.

Types of domestic animal	Number of attacks by the predator					
	Spotted hyena	Jackal	Leopard	Baboon	Others*	Total kill
Poultry	2	70	0	25	23	120
Sheep	50	10	30	8	0	98
Cattle	14	2	4	0	0	20
Horse	9	1	2	0	0	12
Goat	12	0	0	0	0	12
Donkey	6	0	0	0	0	6
Mule	3	0	0	0	0	3
Total	96	83	36	33	23	271
Percentage	35.4	30.6	13.3	12.2	8.5	100

Note. *Unidentified predators other than listed.

Table 7: Rank of wild animals based on the extent of predation on domestic animals ($n = 290$).

Wild animal species	Frequency	Percentage (%)	Rank
Spotted hyena (*Crocuta crocuta*)	102	35	1
Black-backed jackal (*Canis mesomelas*)	71	24	2
Leopard (*Panthera pardus*)	46	16	3
Anubis baboon (*Papio anubis*)	28	10	4
Serval cats (*Leptailurus serval*)	20	7	5
Genets (*Abyssinica genetta*)	15	5	6
White-tailed mongoose (*Galerella flavescens*)	8	3	7
Over all	290	100	

Table 8: Economic loss due to domestic animals' depredation in the last two years (2019-2020) around Konasa-Pulasa conserved forest.

Types of livestock	Economic loss (US$) due to livestock depredation and distance of villages (km)							
	Wonchiro (0.5–1 km)	Mehal (1-2 km)	Damota (2-3 km)	Sutancho (3-4 km)	Sorto (4-5 km)	Total	Average price per livestock in US$	Total loss in US$
Poultry	48	30	19	13	10	120	6.87	824.4
Sheep	29	26	21	15	7	98	54.82	5,372.36
Cattle	9	5	3	3	0	20	465.94	9,318.8
Horse	5	3	2	2	0	12	411.13	4,933.56
Goat	6	4	1	0	1	12	68.52	822.24
Donkey	3	0	2	1	0	6	274.08	1,644.48
Mule	2	1	0	0	0	3	493.36	1,480.08
Total	102	69	48	34	18	271		24,395.92
Percent	37.6	25.5	17.7	12.5	6.6			

Note. 1 US$ is worth 36.48466 Ethiopian Birr during the study period.

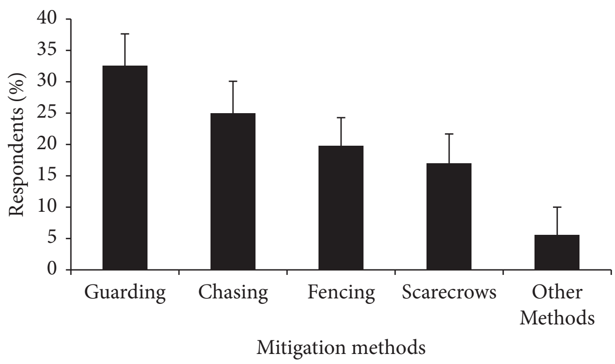


Figure 8: Mitigation methods used by the respondents to protect crop and domestic animal damage in Konasa-Pulasa community conservation forest.

indicated by Rovero et al. [56]. Even though crop raiders and predators have a low density in the current study area, they have a greater economic impact on the local people. The mean density of spotted hyena in the present study area was 0.58 ± 0.15 individuals/km^2. This result is almost similar to the estimations of spotted hyenas in Wukro district, northern Ethiopia, by Yirga et al. [57], which were 0.52 individuals/km^2. However, this is greater than the estimates of spotted hyena by Trinkel [58] in Etosha National Park in Namibia, and Holekamp and Dloniak (2006) reported a density of 0.07 individuals/km^2 in Hwange National Park, Zimbabwe. But, it is less than that of Sillero-Zubiri and Gottelli [59], whose density estimate is 1.34 individuals/km^2 in Aberdare National Park in Kenya, and Yigrem et al. [21] reported a density of 0.83 individuals/km^2 of spotted hyena in Damota community managed forest in Southern Ethiopia. The high number of spotted hyenas in the current study area could be explained by the availability of prey species, the presence of carcasses of livestock that perished from disease or accident, and the predation of living domestic animals and human-originated organic waste around the communities. Solid trash is thrown along roadsides and in open areas of Ethiopia due to the country's poor waste management practices. The rubbish that people discard benefits spotted hyenas, and it also offers a waste-clearing service to human settlements. The recognized function of hyenas in clearing trash and carrion from homes and urban dumps is another factor that influences their relative abundance. Hyenas control rodent and insect populations, as well as offensive odors by eating trash [21, 59].

The Anubis baboon density estimates for the present study area are considerably higher than those estimated by Ségniagbeto et al. [60] but substantially lower than those of Kiffner et al. [61], which were 132.5 individuals/km^2. Grivet monkey densities estimated for the current research area are considerably lower than those estimated by Israel and Balakrishnan [62], who estimated 133.1 individuals/km^2. In the current study area, there could be a strong anthropogenic influence and food scarcity that might be the root causes of this disparity.

The mean density estimate of black-backed jackals in the current study area was 0.65 individuals/km^2, which is lower than the density estimate of Rowe-Rowe [63], and 2.9 individual jackals/km^2 in the Drakensberg Mountains of South Africa's Serengeti National Park. In regions with an abundance of resources, such as the proximity of the seal colony in Namibia's Cape Cross Seal Reserve, jackal concentrations may be higher. In contrast to this, our study reveals that the shortage of resource availability, habitat loss, and severe anthropogenic activities may lead to low density estimation. Our study is nearly similar to the density estimate of black backed jackals in the Drakensberg Mountains of South Africa, which was 0.5 individuals/km^2, and in the Serengeti National Park [63], Melville and Strauss [64], reported 0.59 individuals/km^2 in grassland habitat on Telperion Nature Reserve.

The current estimated density of porcupines is 0.89 individuals/km^2, which is higher than that estimated by Franchini et al. [65]. The porcupine is considered a "potentially problematic species" because it damages crops and is subjected to persecution by local farmers. Seeds, fruits, epigeal parts, roots and other underground stems such as enset constitute the staple of the diet of the porcupine in the study area. However, maize, potatoes, and haricot beans are consumed by porcupines, thus reducing the tolerance of local farmers. Porcupines are killed for their traditional medicine, for their meat, and because they are widely considered crop raiders in the study area. Assessing its density is even more important to delineate adequate conservation and management actions.

4.2. Human-Wildlife Conflict. The growing human population and the associated increasing demand for a limited and unevenly distributed pool of natural resources are the main drivers of biodiversity loss and environmental degradation [66]. The distribution of species and ecological systems are greatly impacted by habitat change, which is mostly caused by changes in land cover. The change in land use/land cover is the rapid influence and response of human activities on nature, with significant consequences. Rapid changes in land cover due to agricultural expansion, particularly in developing countries such as Ethiopia, result in a reduction in natural vegetation cover, which in turn reduces wildlife habitat and escalates conflicts between people and wildlife [67].

Human-wildlife conflict is a global issue that receives the widespread attention of conservationists [5, 9]. Most of the local people around the KPCCF area depend on agriculture for subsistence and livestock rearing. The results of this study show that there was a conflict between wild animals and farmers living around the area. Mainly, crop damage and livestock predation are the causes of conflict in the study area, as indicated by Anthony [68]. More crop and livestock damage occurred in villages close to the forest. This is because villages close to protected areas face more contact with wild animal species. 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 [12, 28, 34, 49].

4.2.1. Crop Losses. In the study area, crop raiding was the major challenge to the survival of local people. Our results showed that maize, enset, and haricot beans were the most raided crops by wild animals in the area. This might be due to their nutritional content and palatability compared to other crops. Similar studies have been reported in different study areas where maize, bean, enset, wheat, potato, cassava, banana, and sorghum were highly favored crops by primates [11, 36, 40, 49]. Crop damage and crop raiding patterns are more prevalent near forests than farther away. The study shows that the severity of crop raiding is highly pronounced in villages where agricultural fields are found close to forests. Living close to protected areas not only imposed costs, such as loss of crops and livestock by wild animals, but people also spent their time and resources guarding their properties against the wild animals' attack, as reported by Ango et al. [49] and Yilmato and Takele [40]. Similarly, due to the strong negative interactions in these areas, the negative perception towards wild animals is found to be more significantly close to forests than in faraway villages.

The most frequently reported wild animals responsible for crop raiding and causing damage were Anubis baboons, followed by grivet monkeys and porcupines. This may be due to their high population density, shortages in the availability of food within the forest, weak farm protection methods, or relatively palatable and nutritious crop varieties cultivated in the area. They posed severe livelihood threats to the surveyed households. Primate crop raiding animals are the most common and appear to be the best able to exploit the edge between forest and agriculture [36, 37, 49, 69]. The damage caused by bushbuck and common duiker was less significant. Of the identified crop raiders, grivet monkey, Anubis baboon, and common duiker are reported as diurnal crop raiders, while bushbuck and porcupine are reported as predominantly nocturnal crop raiders in the study area. The group discussants reported that Anubis baboon and grivet monkey caused damage to crops at all stages, from the time of germination to the time of harvest, while bushbuck and duiker affected crops early in the seedling stage. Root portions and grains of maize and potato tubers were eaten by porcupines, as reported by Mojo et al. [31], Yilmato and Takele [40], and Temesgen et al. [32]. The foraging range of Anubis baboons and grivet monkeys is farther away from forest edges when compared with those of other crop raiders and has caused huge damage to crops and disrupted the livelihood of farmers, as reported by Datiko and Bekele [41]. Traditional methods to prevent these primate crop raids generally have only limited success in the study area.

An estimated average loss of 4201 kg of crop loss, equivalent to US $153,968.82, was reported from five villages in two years, which affects a significant amount of household income in the villages. 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. Kwaslema et al. [14] reported a loss of approximately $154 per household due to crop damage in Northern Tanzania's Kwakuchinja Wildlife Corridor.

4.2.2. Livestock Depredation. Domestic animal depredations by wild animals were a commonly reported problem and are the major consequence of human-wild life conflicts in the study area. In the present study area, livestock plays an important role in the economies of local people. Therefore, carnivore attacks on livestock are a major problem for rural communities. Spotted hyena, black-backed jackal, and leopard were considered the major livestock predator animals in the study area [21, 23, 70]. Poultry and sheep suffered the highest level of predation. High livestock losses by wild animals were recorded in the closest villages, such as Wonchiro and Mehal, and the least livestock predation was recorded in distant villages, such as Sorto village. The focus group discussions also revealed that most of the killings occurred when the animals were left to graze in the forest, which is far from the dwellings. The expansion of human settlements adjacent to the forest boundary and farms surrounding the forest may be one of the major reasons why carnivores shift their diet to livestock, which are easier to capture and have limited escape options due to low antipredator skills, as well as poor livestock husbandry practices by farmers [28]. In addition, poor construction of night enclosures is associated with high losses of livestock [71]. All respondents kept their livestock in poor-quality huts or tin houses (livestock kraals) at night. During the daytime, most respondents keep their livestock in a group within pasture areas or around the forest. The livestock attacks during the daytime might be associated with poor herding methods, as reported by Ogada et al. [71].

Spotted hyenas could easily penetrate the grass hut and drag out livestock animals in the settlement at night. There might also be a scarcity of natural prey or food sources available in the area, which leads to wild animals seeking alternate sources. Various studies have demonstrated that livestock depredation is more common in areas with low prey abundance [19, 21, 24]. Local people occasionally react with retaliatory killings of those predators. Improving livestock management practices and kraaling the livestock at night in strong enclosures may be important methods of reducing predation in the area.

The total economic losses caused by livestock depredation in the study area are valued at roughly US $24,395.92, as reported by five villages in the last two years (2019-2020). The estimated annual loss of different types of livestock was $12,197.96. The effects of predators were different from village to village. The economic loss was higher in the villages near the forest than in the far villages. The spotted hyena caused most depredation incidents, followed by black-backed jackals, as indicated by Mwakatobe et al. (2014) and Nyahongo (2009). Poultry was mainly preyed upon by black-backed jackals and baboons. This could be due to the lack of proper guarding of stocks during the day and night around the field. Similar findings were reported by Dickman [72], Kwaslema et al. [14], and Merkebu and Yazezew [17]. The focus group discussion also revealed that livestock losses caused by wild animal conflicts might represent an economic concern for livestock owners. This might create negative views towards wild animals and reduce the coexistence between humans and wild animals in the study area.

4.3. Mitigation Methods Practiced by Local Farmers. The local people of the present study area deployed various traditional methods to protect their crops and livestock from wild animals. They used repellents in the form of fire, noise, and the construction of different protective materials from wood and grass, such as a watching tower, thorny and bamboo fence, guarding, and fear-provoking stimuli such as scarecrows to deter crop raiding and livestock predation by wild animals. The respondents did not use only one method alone; they combined and integrated local methods. During the focus group discussion, the group discussants also suggested that deterrent methods work better in combination with one another and are unlikely to be effective when used alone, as reported by Ocholla et al. [73], Matseketsa et al. [28], Merkebu and Yazezew [17], and Mekonen [25]. Plant hedges of various species and fences made of dead thorny branches were also used as traditional barriers against most carnivores and ungulates in the present study area, but these did not deter baboons and grivet monkeys because the fences and trenches were not strong enough to hold these animals. The behavior and preference of each of the wild animals are quite different [74]. Therefore, none of these methods provides complete protection. Respondents perceived that guarding, when used with other methods, is an effective method for larger animals to control crop losses and livestock depredation in the study area. Beyond visible impacts, human-wildlife conflict has indirect impacts. Losses might generate other costs for household members, including an increased need to guard fields, disruption of schooling because children are needed to help guard family fields, and an increased risk of injury from wildlife. Barua et al. [75] also noted that human-wildlife conflict has a wide-ranging negative social impact. Other studies have reported various protection methods, such as fencing [71], using dogs [76], and scarecrows [73].

4.4. Attitudes of Local People. Human-wildlife conflict is a social issue, and the attitude of local people's is critical to solving or mitigating the problem. Therefore, the assessment of peoples' attitudes and perceptions towards wild animals has become an important aspect in many studies of wildlife conservation [37, 77]. In the present study area, most of the respondents displayed positive attitudes towards wild animals despite the losses they experienced in terms of livestock depredations and crop damage, as indicated by Hill and Wallace [78]. In contrast to the findings of Eshete et al. [79], who found that even low levels of livestock predation could lead local people to develop negative attitudes towards wild animals, and this could have significant implications for wild animal conservation in some areas. Of the respondents who had a positive attitude towards wild animal species, they indicated that the species attract tourists, clean the environment, are a source of food during critical food shortages, have aesthetic benefits, and will have value for future generations. Similarly, respondents who reported negative attitudes towards wild animal species viewed wild animal species as a potential threat. They considered wild animals to be crop raiders, livestock depredators, and carriers of diseases, and the remaining were neutral and did not justify any reason for concern about wild animal species. Those households that were furthest away from the forest displayed relatively more positive attitudes towards wild animals, which revealed that distance was a factor in how communities felt towards wild animals. Focus group discussions also revealed that local residents generally had positive attitudes toward wild animals and the nearby forest. Reasons given for the importance of wild animals across the forest included their attraction to tourists, hunting opportunities during drought, and the enjoyment derived from viewing wildlife. They also indicated that local people send their livestock to search for fodder and water during critical dry seasons. The grivet monkey and Anubis baboon were the most notorious crop raiders in the area; hence, they were perceived negatively by most of the local people. These animals live in troops. They tended to raid crops surrounded by large trees and rocky hillocks, which provided cover for them. These advantage points provided them with accessible escape routes and made it difficult for guards to follow them. The socio-demographic variables such as age, sex, and education are affecting respondents' attitudes towards wild animal conservation in the study area. Respondents with better education had more positive outlooks towards wildlife conservation than illiterate respondents. Knowledge varied with age among people around the study area. Middle-aged people (31–45 years) indicated more awareness of wild animal conservation in the area due to a better understanding of the importance of wild animals [11]. Other factors, such as occupation and number of family members, income, and amount of land owned, did not play a significant role in predicting the attitudes of the local people. These findings agree with Biset et al. [35] and Mekonen [25], who reported that respondents with formal education had more positive views on wildlife conservation, and as the level of education increases, the level of negative outlook towards conservation activities decreases [80].

This study contributes to the existing human-wild animal conflict studies by using mixed-approach methods to determine various patterns and factors that best explain farmers' vulnerability and their preventive actions against wild animal crop-raiding and livestock depredation in the KPKF. It shows that household questionnaire data and a population estimate of wild animal techniques can improve our understanding of human-wild animal conflict patterns in the area. There is still a need for further studies using different analysis techniques for analyzing these complex human-wildlife conflict patterns and for providing information to improve conflict management, which, as a result, will strengthen the food security of smallholder farmers.

The limitations of the study are that, as with most questionnaire-based studies, it relies on self-reported assessments that are necessarily subjective. In the future, more objective evaluations, such as the assessment of the real impact of wild animals through the use of camera traps, should ideally be combined with questionnaires to provide a more reliable assessment. During the survey, some respondents exaggerated crop damage and livestock losses, either deliberately or due to an inability to ascertain the cause of damage. The overreporting is revealed by cross-checks. Problems were encountered during damage the estimation for crops and livestock. However, involving farmers in the exercise helped a lot with estimation.

5. Conclusions

Crop-raiding and livestock depredation has been known to have a significant impact on subsistence farmer livelihoods in developing countries [81, 82]. The conflicts and costs generated by livestock depredation and crop damage can reduce tolerance of wildlife and undermine management plans [83]. Therefore, understanding and addressing these "conflicts" are key management issues for wildlife conservation [5]. In the study area, farmers perceived both crop raiding and livestock depredation by wild animals as a great hindrance to their livelihood and income. As long as farmers believe the effect to be significant, we did not investigate whether the farmers' assessments were accurate. The local people close to the forest boundaries were highly vulnerable to wild animals. The techniques adopted by farmers to prevent crop raiding and livestock predation were traditional and viewed as ineffective. Conflicts with wild animals are recurrent in this conservation area; thus, we suggested that it is necessary to guarantee social participation in the construction of effective and appropriate usage of wild animal management strategies and human-wild animal conflict mitigation approaches. Measures taken by the management can provide remedies to reduce the people-wildlife conflict by improving mitigation strategies and developing alternative income-generating activities and compensation fee to the local community for lost crops and livestock. A wise strategy for the KPCCF management would be to support local farmers with their traditional protection measures, which may be a more practical way of comanagement.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Ethical Approval

The study was approved by the Institutional Research Review Committee of Wolaita Sodo University. Damote Gale district administrative officials approved conducting research in the selected kebeles (the lower administrative body).

Consent

By respecting their beliefs, norms, and culture, the respondents were informed about the purpose of the study and their agreement. Informed consent for all illiterate participants was obtained from their parents and/or their legal guardian(s). For the remaining participants, informed consent was obtained from all subjects and/or their legal guardian(s).

Disclosure

This study is based on estimation, questionnaire survey, and observation or assessment of the crops damaged and livestock depredation caused by wild animals and did not involve human subjects, animal experimentation, or the collection of specimens.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Mesfin Matusal conceptualized the study, prepared the methodology, validated the study, wrote the original draft, and reviewed and edited the study. Abreham Megaze conceptualized the study, prepared the methodology, validated the study, supervised it, wrote, reviewed, and edited the study, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the paper, and approved the final draft. Taye Dobamo conceptualized the study, prepared the methodology, validated the study, wrote the original draft, reviewed and edited the study, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the paper, and approved the final draft.

Acknowledgments

We sincerely thank Damot Gale District and Wolaita Sodo University for their logistics support. We also want to thank the people in the surrounding area for their kindness and hospitality in sharing their knowledge about our inquiry.

References

[1] J. Travers, R. Romero-Ortuno, J. Bailey, and M. T. Cooney, "Delaying and reversing frailty: a systematic review of primary care interventions," *British Journal of General Practice*, vol. 69, no. 678, pp. 61–69, 2019.

[2] B. Goldsmith, *Monitoring for Conservation and Ecology*, Chapman & Hall, London, UK, 1991.

[3] A. Plumptre and D. Cox, *Counting Primates for Conservation: Primate Surveys in Uganda*, Springer, Singapore, 2006.

[4] T. A. Messmer, "Human wildlife conflicts: emerging challenges and opportunities," *Human-Wildlife interaction*, vol. 3, no. 1, pp. 10–17, 2009.

[5] A. J. Dickman, "Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict," *Animal Conservation*, vol. 13, no. 5, pp. 458–466, 2010.

[6] T. Girmay and T. Zeyede, "Human ‑ wildlife conflict in and around chofa forest, hawzien woreda, eastern tigray, northern Ethiopia; implication for conservation and conflict resolution," *International Journal of Science and Research*, vol. 6, no. 3, pp. 1763–1771, 2015.

[7] H. Tesfaye, "Human_ wildlife interaction: wildlife crop raiding conflict in Ethiopia," *International Journal of Science and Research*, vol. 5, no. 5, pp. 1188–1191, 2016.

[8] G. Teklay and Z. Teshome, "Human-wildlife: challenges and Management in Ethiopia: a review," *International Journal of Emerging Trend science and Technology*, vol. 4, no. 2, pp. 5004–5009, 2017.

[9] D. O. Gemeda and S. Meles, "Impacts of human-wildlife conflict in developing countries," *Journal of Applied Sciences & Environmental Management*, vol. 22, no. 8, pp. 1233–1238, 2018.

[10] E. Fairet, *Vulnerability to Crop-Raiding: An Interdisciplinary Investigation in Loango National Park, Gabon. Dissertation*, Durham University, Durham, UK, 2012.

[11] C. M. Hill, "Conflict of interest between people and baboons: crop raiding in Uganda," *International Journal of Primatology*, vol. 21, no. 2, pp. 299–315, 2000.

[12] F. Lamarque, J. Anderson, R. Fergusson, Lagrange, Y. Osier-Owusu, and L. Bakker, "Human-wildlife conflict in Africa: cause, consequences and management strategies," *FAO Forestry Paper*, Food and Agriculture Organization of United Nations, Rome, Italy, 2009.

[13] M. M. Fenta, "Human– wildlife conflicts: case study in wondo genet district, southern Ethiopia," *Agriculture, Forestry and Fisheries*, vol. 3, no. 5, pp. 352–362, 2014.

[14] M. H. Kwaslema, D. Robert, R. K. Jafari, and R. Eivin, "Assessing crop and livestock losses along the Rungwa-katavi wildlife corridor, Southwestern, Tanzania," *International Journal of Biodiversity and Conservation*, vol. 9, no. 8, pp. 273–283, 2017.

[15] C. Sillero-Zubiri and D. Switzer, *Crop Raiding Primates: Searching for Alternatives, Human Way to Solve Conflict with Farmers in Africa, People and Wildlife Initiative*, Oxford University, Oxford, UK, 2000.

[16] S. M. Makindi, N. Mark, N. Mutinda, K. W. Olekaikai, W. L. Olelebo, and A. Abdillahi, "Human–Wildlife conflicts: causes and mitigation measures in tsavo conservation area, Kenya," *International Journal of Science and Research*, vol. 3, pp. 1025–1031, 2014.

[17] S. Merkebu and D. Yazezew, "Assessment of human– wildlife conflict and the attitudes of local communities to wild animal conservation around borena sayint national Park, Ethiopia," *International Journal of Ecology*, vol. 2021, Article ID 6619757, 8 pages, 2021.

[18] T. Holmerna, J. Nyahongoa, and E. Røskafta, "Livestock loss caused by predators outside the Serengeti national Park, Tanzania," *Biological Conservation*, vol. 135, pp. 534–542, 2007.

[19] G. Yirga and H. Bauer, "Prey of peri-urban spotted hyena (*Crocuta crocuta)* in south eastern tigray, northern Ethiopia," *Asian Journal of Agricultural Sciences*, vol. 2, no. 4, pp. 124–127, 2010.

[20] W. O. Ogara, J. Nduhiu, S. A. Gitahi et al., "Determination of carnivores prey base by scat analysis in Samburu community group ranches in Kenya," *African Journal of Environmental Science and Technology*, vol. 4, no. 8, pp. 540–546, 2010.

[21] D. Yigrem, M. Aberham, T. Wondimagegnheu, D. Taye, and L. Herwig, "Population estimation and livestock loss by spotted hyena (*Crocuta crocuta*) in Damota community managed forest, Southern Ethiopia," *Global Ecology and Conservation*, vol. 34, pp. 1–11, 2022.

[22] S. Takele and A. J. S. Raju, "Diet composition of black-backed jackal, *Canis mesomelas* in nech sar national Park, Ethiopia," *Journal of Nature Conservation*, vol. 23, pp. 16–18, 2011.

[23] J. F. Kamler, U. Klare, and D. W. Macdonald, "Seasonal diet and prey selection of black- backed jackals on a small-livestock farm in South Africa," *African Journal of Ecology*, vol. 50, no. 3, pp. 299–307, 2012.

[24] A. Atickem, G. Simeneh, A. Bekele et al., "African Wolf diet, predation on livestock and conflict in the Guassa Mountains of Ethiopia," *African Journal of Ecology*, vol. 55, no. 4, pp. 632–639, 2017.

[25] S. Mekonen, "Coexistence between human and wildlife: the nature, causes and mitigations of human wildlife conflict around Bale Mountains National Park, Southeast Ethiopia," *BMC Ecology*, vol. 20, no. 1, p. 51, 2020.

[26] A. Alemayehu and M. Temesgen, "Approaches to human-–wildlife conflict management in and around Chebera-Churchura National Park, southern Ethiopia," *Asian Journal of Conservation Biology*, vol. 4, no. 2, pp. 136–142, 2015.

[27] A. Megaze, M. Balakrishnan, and G. Belay, "Human– wildlife conflict and attitudes of local people towards conservation of wildlife in Chebera-Churchra National Park, Ethiopia," *African Zoology*, vol. 52, no. 1, pp. 1–8, 2017.

[28] G. Matseketsa, M. Never, G. Edson, M. K. Davidson, and C. Gladman, "An assessment of human– wildlife conflicts in local communities bordering the western part of Save Valley Conservancy, Zimbabwe," *Global Ecology and Conservation*, vol. 20, pp. 1–10, 2019.

[29] G. Leta, H. Debela, and M. Tariku, "Identification of crop raiding species and the status of their impact on farmer resources in gera, southwestern Ethiopia," *International Journal of Sciences: Basic and Applied Research*, vol. 22, pp. 66–82, 2015.

[30] Z. Kifle and A. Bekele, "Human–gelada conflict and attitude of the local community toward the conservation of the southern gelada (*Theropithecus gelada* obscurus) around borena saynit national Park, Ethiopia," *Environmental Management*, vol. 65, 2019.

[31] D. Mojo, M. Alebachew, and J. Rothschuh, "Farmer's perception of the impacts of HWC in their livelighood and natural resource management efforts in Cheha Woreda Gurage Zone, Ethiopia," *Human wildlife interaction*, vol. 8, no. 1, pp. 67–77, 2010.

[32] Z. Temesgen, G. Mengesha, and T. B. Endalamaw, "Human–wildlife conflict in the surrounding districts of alage college, central Rift Valley of Ethiopia," *Ecology and Evolution*, vol. 12, no. 2, pp. 1–11, 2022.

[33] M. Tamrat, A. Atickem, D. Tsegaye et al., "Human–wildlife conflict and coexistence: a case study from Senkele Swayne's Hartebeest Sanctuary in Ethiopia," *Wildlife Biology*, vol. 2020, no. 3, pp. 1–10, 2020.

[34] K. A. P. Graham, A. P. Beckerman, and S. Thirgood, "Human-predator-prey conflicts: ecological correlates, prey losses and patterns of management," *Biological Conservation*, vol. 122, no. 2, pp. 159–171, 2005.

[35] A. Biset, G. Mengesha, and Z. Girma, "Human-wild life conflict in and around borena sayint national Park, northern Ethiopia," *Human–Wildlife Interaction*, vol. 13, no. 1, pp. 111–124, 2019.

[36] E. A. Eniang, H. M. Ijeomah, G. Okeyoyin, and A. E. Uwatt, "Assessment of human – wildlife conflicts in filinga range of Gashaka Gumti national Park, Nigeria," *Production Agricultures and Technology (PAT)*, vol. 7, no. 1, pp. 15–35, 2011.

[37] B. Gebo, S. Takele, and S. Shibru, "Knowledge, attitude and practice of the local people towards human–carnivore coexistence in Faragosa–Fura Land scape, Gamo Zone, Southern Ethiopia," *Wildlife Biology*, vol. 2022, no. 2, pp. 1–10, 2022.

[38] L. Naughton-Treves and A. Treves, "Socio-economic factors shaping local support for wild life: crop-raiding by elephants and other wild life in Africa," in *People and Wild Life: Conflict or Coexistence?*, R. Woodroffe, S. Thirgood, and A. Rabinowitz, Eds., pp. 252–277, Cambridge University Press, New York, NY, USA, 2005.

[39] M. Yihune, A. Bekele, and Z. Tefera, "Human– wildlife conflict in and around the simien Mountains national Park, Ethiopia," *Sinet: Ethiopian Journal of Science*, vol. 32, no. 1, pp. 57–64, 2009.

[40] A. Yilmato and S. Takele, "Human wild life conflict around midre-kebid abo monstry, gurage zone, southern Ethiopia," *International Journal of Biodiversity and Conservation*, vol. 11, no. 8, pp. 212–229, 2019.

[41] D. Datiko and A. Bekele, "Conservation challenge: human-herbivore conflict in chebera-churchura national Park, Ethiopia," *Pakistan Journal of Biological Sciences*, vol. 16, no. 23, pp. 1758–1764, 2013.

[42] Central Statistical Agency, *Addis Ababa, Ethiopia Population Profile*, Eastern Commission, Addis Ababa, Ethiopia, 2007.

[43] World Vision Ethiopia, *The Sodo Community Managed Reforestation (forest Regeneration Project "many Species, One Planet and One Future") Submission to the Climate, Community and Biodiversity Standard Report*, World Vision Australia, Victoria, Australia, 2010.

[44] World Vision Ethiopia, *The Sodo Community Managed Reforestation (Forest Regeneration) Project. Wolaita Zone, Sodo Zuria and Damot Gale Woredas Southern Highlands of Ethiopia*, World Vision Australia, Victoria, Australia, 2006.

[45] S. T. Buckland, D. R. Anderson, K. P. Burnham, and J. L. Laake, *Distance Sampling. Estimating Abundance of Biological Populations*, Chapman & Hall, London, UK, 1993.

[46] K. P. Burnham, D. R. Anderson, and J. L. Laake, *Estimation of Density from Line Transect Sampling of Biological Populations*, Wiley, Hoboken, NJ, USA, 1980.

[47] S. W. Wang, "Estimating population densities and biomass of ungulates in the temperate ecosystem of Bhutan," *Oryx*, vol. 44, no. 3, pp. 376–382, 2010.

[48] T. Yamane, *Statistics, an Introductory Analysis*, New York University, New York, NY, USA, 1967.

[49] T. G. Ango, L. Börjeson, and F. Senbeta, "Crop raiding by wild mammals in Ethiopia: impacts on the livelihoods of smallholders in an agriculture forest mosaic landscape," *Oryx*, vol. 51, no. 3, pp. 527–537, 2017.

[50] A. S. Tadesse and T. N. Zewde, "The knowledge of local people on Human-Wildlife conflict and their attitudes towards problematic wildlife around Wof-Washa forest Northern Shewa Administrative Zone, Ethiopia," *Greener Journal of Biological Science*, vol. 9, no. 2, pp. 43–58, 2019.

[51] R. Likert, "A technique for the measurement of attitudes," *Archives de Psychologie*, vol. 22, pp. 140–155, 1932.

[52] T. M. Madox, *The Ecology of cheetahs and other large Carnivores in Pastoralist- Dominated buffer zone*, Ph.D. thesis, Institute of Zoology, London, UK, 2003.

[53] W. M. Margaret, I. Hellen, and W. K. John, "The cost of livestock lost to lions and other wildlife species in the Amboseli ecosystem, Kenya," *European Journal of Wildlife Research*, vol. 63, pp. 1–11, 2017.

[54] S. T. Buckland, D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas, *Introduction to Distance Sampling*, Oxford University Press, Oxford, UK, 2001.

[55] F. J. Mkonyi, A. B. Estes, M. J. Msuha, L. L. Lichtenfeld, and S. M. Durant, "Socio-economic correlates and management implications of livestock depredation by large carnivores in the Tarangire ecosystem, northern Tanzania," *International Journal of Biodiversity Science, Ecosystem Services & Management*, vol. 13, no. 1, pp. 248–263, 2017.

[56] F. Rovero, A. Mtui, A. Kitegile, and M. Nielsen, "Hunting or habitat degradation? Decline of primate populations in Udzungwa Mountains, Tanzania: an analysis of threats," *Biological Conservation*, vol. 146, no. 1, pp. 89–96, 2012.

[57] G. Yirga, W. Ersino, H. H. De Iongh et al., "Spotted hyena (*Crocuta crocuta*) coexisting at high density with people in Wukro district, northern Ethiopia," *Mammalian Biology*, vol. 78, no. 3, pp. 193–197, 2013.

[58] M. Trinkel, "A keystone predator at risk? Density and distribution of the spotted hyena *Crocuta crocuta* in the Etosha National Park Namib," *Journal of Canadian Zoology*, vol. 87, pp. 928–935, 2009.

[59] C. Sillero-zubiri and D. Gottelli, "Population ecology of spotted hyaena in an equatorial mountain forest," *African Journal of Ecology*, vol. 30, no. 4, pp. 292–300, 1992.

[60] G. H. Ségniagbeto, K. H. Atsri, A. Delagnon et al., "Local distribution and density estimates of primates in the trans boundary reserve of the mono river, Togo (west Africa)," *Revue d'Ecologie*, vol. 73, no. 3, pp. 363–374, 2018.

[61] C. Kiffner, F. M. D. Paciência, G. Henrich et al., "Road-based line distance surveys overestimate densities of olive baboons," *PLoS One*, vol. 17, no. 2, Article ID e0263314, 2022.

[62] P. M. Israel and M. Balakrishnan, "The effect of Habitat on Density, Feeding Behaviour and activity of Heller's vervet monkey (*Chlorocebus pygerythrus arenarius*, Heller, 1913): a case study in Arba Minch forest, Ethiopia," *Research Journal Chemistry Environment Science*, vol. 4, no. 3, pp. 24–31, 2016.

[63] D. T. Rowe-Rowe, "Home range and movements of black-backed jackals in an African montane region," *South African Journal of Wildlife Research*, vol. 12, pp. 79–84, 1982.

[64] I. A. Haemish, S. Melville, and W. M. Strauss, "Trialling a simple camera-trap based method to estimate Black-backed jackal population density on Telperion Nature Reserve in Mpumalanga Province," *Indago*, vol. 37, pp. 77–87, 2021.

[65] M. Franchini, A. Viviano, L. Frangini, S. Filacorda, and E. Mori, "Crested porcupine (*Hystrix cristata*) abundance estimation using Bayesian methods: first data from a highly agricultural environment in central Italy," *Mammal Research*, vol. 67, no. 2, pp. 187–197, 2022.

[66] W. Steffen, K. Richardson, J. Rockström et al., "Sustainability. Planetary boundaries: guiding human development on a changing planet," *Science*, vol. 347, no. 6223, Article ID 1259855, 2015.

[67] H. Briassoulis, *Analysis of Land Use Change: Theoretical and Modeling Approaches*, Regional Research Institute, West Virginia University, Morgantown, WV, USA, 2000.

[68] B. Anthony, "The dual nature of parks: attitudes of neighbouring communities towards Kruger National Park, South Africa," *Environmental Conservation*, vol. 34, no. 3, pp. 236–245, 2007.

[69] H. Alemu, G. K. Shankargouda, and H. Ibrahim, "Assessment of human– wildlife conflict in and around gemshat forest area, wollo, amahra region, Ethiopia," *Abyssinia Journal of Science and Technology*, vol. 2, no. 2, pp. 1–10, 2017.

[70] M. Mesfin and M. Aberham, "Diet of Black-backed Jackal (*Canis mesomelas*, Schreber, 1775), impacts on livelihood and perceptions of farmers in Konasa Pulasa community conserved forest, Omo valley of Ethiopia," *BMC Zool*, vol. 8, pp. 1–27, 2023.

[71] M. O. Ogada, R. Woodroffe, N. O. Oguge, and L. G. Frank, "Limiting depredation by African carnivores: the role of livestock husbandry," *Conservation Biology*, vol. 17, no. 6, pp. 1521–1530, 2003.

[72] A. J. Dickman, *Key determinants of conflict between people and wild life, particularly large carnivores, around Ruaha National*

Park, Tanzania, Ph.D. thesis, University College London and Zoological society of London, London, UK, 2008.

[73] G. O. Ocholla, J. Koske, G. W. Asoka et al., "Assessment of traditional methods used by the samburu pastoral community in Human wild life conflict Management," *International Journal of Humanity and social science*, vol. 3, pp. 292–302, 2013.

[74] T. M. Gehring, K. C. VerCauteren, and J. C. Landrey, "Livestock protection dogs in the 21st century: is an ancient tool relevant to modern conservation challenges?" *BioScience*, vol. 60, pp. 715–721, 2010.

[75] M. Barua, S. A. Bhagwat, and S. Jadhav, "The hidden dimensions of human–wildlife conflict: health impacts, opportunity and transaction costs," *Biological Conservation*, vol. 157, pp. 309–316, 2013.

[76] P. M. Castelli and S. E. Sleggs, "Efficacy of border collies to control nuisance Canada geese," *Wildlife Society Bulletin*, vol. 28, no. 2, pp. 385–392, 2000.

[77] W. D. Newmark, D. N. Manyanza, D. M. Gamassa, and H. I. Sariko, "The conflict between wild life and local people living adjacent to protected areas in Tanzania: human density as a predictor," *Conservation Biology*, vol. 8, no. 1, pp. 249–255, 1994.

[78] C. M. Hill and G. E. Wallace, "Crop protection and conflict mitigation: reducing the costs of living alongside non-human primates," *Biodiversity & Conservation*, vol. 21, no. 10, pp. 2569–2587, 2012.

[79] G. I. Eshete, C. L. Sillero-Zubiri, E. L. Cieraad et al., "Does livestock predation reflect in negative local perceptions of Ethiopian wolves in South Wollo?" *Tropical Ecology*, vol. 59, no. 1, pp. 11–19, 2018.

[80] F. G. Vodouhê, O. Coulibaly, A. Adégbidi, and B. Sinsin, "Community perception of biodiversity conservation within protected areas in Benin," *Forest Policy and Economics*, vol. 12, no. 7, pp. 505–512, 2010.

[81] L. J. Findlay and R. A. Hill, "Baboon and vervet monkey crop-foraging behaviors on a commercial South African farm: preliminary implications for damage mitigation," *Human-wildlife interaction*, vol. 14, p. 19, 2021.

[82] Yeshey, R. J. Keenan, R. M. Ford, and C. R. Nitschke, "How does conservation land tenure affect economic impacts of wildlife: an analysis of subsistence farmers and herders in Bhutan," *Trees, Forests and People*, vol. 11, Article ID 100378, 2023.

[83] J. Baker, R. Bitariho, A. Gordon-Maclean et al., "Linking protected area conservation with poverty alleviation in Uganda: integrated conservation and development at Bwindi Impenetrable National Park," in *National Parks: Sustainable Development, Conservation Strategies and Environmental Impacts*, pp. 47–103, NOVA, New York, NY, USA, 2013.