Spatio temporal patterns of human-elephant conflict and its economic costs in and around Chebra Churchura National Park, Southwestern Ethiopia

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An investigation on human-elephant conflict was carried out in Chebra Churchura National Park Ethiopia between March, 2021-2022. Data was collected from 6 Park adjacent villages (25%) (Chebra, Seri, Yora, Keribela, Menta and Gudumu). Actual measurements of the damages and estimation of the monetary value of the damage at local market was carried out. A total of 378 household samples 25% from 20 Park adjacent villages were identified for interview. The purpose of this investigation was to identify the spatial patterns of human-elephant conflict in the area. 95% of the total respondents from 3 Park adjacent villages (Keribela, Menta and Gudumu) confirmed that they have never had any kind of conflict with the elephants while, 96% from the remaining three Park adjacent villages (Chebra, Seri and Yora) reported that they had severe human-elephant conflicts. A total of 378 respondents from the six villages were selected and measurements of the damages and estimation of the monetary value was made. Among the respondents 85.9% reported crop damage as the main cause of human-elephant conflict, while 4.8% reported loss of livestock and 4.6% reported effect on human life. Crop damages were mainly on banana, maize and yam. A total of 61 crop raid and 20 elephant attacks on humans and domestic animals were recorded with 7 human deaths in the study period. The majority of elephant attack 65% was against human followed by cattle (35%). The total annual loss of years 2020 and 2021 due to human elephant conflict was estimated at 12,452,120 ETB or USD 270,698 of which 12,399,619 ETB or USD 269,557 (99.5%) was from crop loss while only 52,500 ETB or USD 1,130 (0.5%) was due to loss of domestic animals. Total loss/household was estimated at 24, 805 ETB or 539.2 USD.

Key Words: *Human-elephant conflict; Conservation; Probocidea; Habitat loss*

INTRODUCTION

African elephants were widely distributed across the continent prior to colonial times and were widespread in all over sub-Saharan Africa in diverse habitats ranging from tropical forests to semi-arid bush and desert. However, at present they have highly reduced both in number and range, due to human induced factors mainly poaching for ivory and habitat loss and fragmentation. At present African elephants occur only in 38 range States. In Africa, the African elephant is the only surviving species from order Probocidea. Currently, two subspecies of African elephants recognized the savanna elephant, Loxodonta africana africana, and the forest elephant, Loxodonta africana cyclotis. Currently they are treated as separate species by IUCN and listed the savanna elephant, "endangered" and the forest elephant, as "critically endangered" species due to the huge decline both in their number and range [1].

Ethiopia is one of the African countries that harbour elephant [2-4]. However, well-known historical information about elephants for Ethiopia before the 1960s is lacking. In the 1970s, the status of elephants in Ethiopia was estimated to number from 6000 to 10,000 [4,5]. However, intensive poaching, habitat loss and fragmentation in the country resulted in approximate loss of 90% of the total elephant with total extirpation from 6 of 16 sites since 1980s [4]. The total national population is currently estimated at between 1850-1900 animals occurring in 6 main populations of Omo, Mago, Gambella, Kafta-Sheraro, Chebera Churchura National Parks and the Babille Elephant Sanctuary [6].

Even though human beings are responsible to protect threatened wildlife, the habitats that are located in close proximity with human settlements lack the capability to support the survival of the wildlife when the population recovers, ending up in human-wildlife conflict [7]. At present, most of the populations of African and Asian elephants live in overlapping habitats with humans due to loss and fragmentation of their natural habitats and ranges all over due to modification for different developmental activities [8,9].

According to Kaiwen [7], in developing countries developmental activities often involve alteration of natural wildlife habitats into farmlands, human settlements and industries. Altering natural lands for such developmental activities often leads to fragmentation and loss of natural habitats. Such activities finally end up in humans and wildlife living in close proximity with escalating human–wildlife conflict as a result [7]. Negative interaction between human and elephants have become known as human- elephant conflict. According to Mubaga [9] human-elephant conflict has been identified as top priorities that needs equal attention regarding the African elephant conservation.

The population of African elephant in Chebra Churchura National Park (CCNP) has been increasing and there is a huge concern for escalating conflict with the local community [10]. At present, CCNP is a very well protected Park with very minimum effect of human influence. Poaching elephants for ivory was one of the top conservation problems in CCNP [3]. However, following the crackdown of ivory poaching after the establishment of the National Park in 2005, the elephant population has been increasing for the last sixteen consecutive years, at the cost of increasing conflict with local communities living around the Park [10]. Unlike the earlier reports by Admasu [3], who mentioned that the extent of human-elephant conflict around CCNP, including crop raiding, human injuries and deaths were relatively small compared to other herbivore species in the area, Datiko [11] noted that elephants were responsible for most of human-wildlife conflicts in and around CCNP including crop raiding.

Killing and injury of humans and livestock and crop raiding highly affect the local communities and their livelihoods. Moreover these human-elephant conflicts highly aggravate negative perceptions on elephant conservation and the Park management among the local communities. Monitoring and management of human-elephant conflict will require coordinated and complementary efforts [10].

Thus, understanding elephant ecology, behavior, spatial and temporal patterns of human-elephant conflict and local livelihoods are valuable and

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timely to identify the principal driving causes of the conflicts [7]. Information about the spatial and temporal patterns of human-elephant conflict in and around CCNP is inadequate or totally lacking. Thus, this study can be a baseline data for the Park, local communities and all concerned governmental and nongovernmental stakeholders about the main causes, the spatial and temporal patterns of human-elephant conflicts, crops preferred by elephants and its annual economic value. It is extremely useful information for the park management, local communities and other concerned GOs and NGOs to develop and implement appropriate conflict mitigation strategies and human-elephant conflict management plans that can help in minimizing the conflicts and ensure sustainable and long term co-existence between the elephants and the local communities in and around CCNP.

MATERIALS AND METHODS

Study area

Chebera Churchura National Park (CCNP) is located in the southwestern part of Ethiopia, in the newly established South Western Ethiopia Administrative Region. The Park is located between Dawro and Konta Zones. It covers an area of 1410 km2 and lies between the coordinates 36°27'00"-36°57'14"E and 6°56'05"-7° 08'02"N (Figure 1) [12].

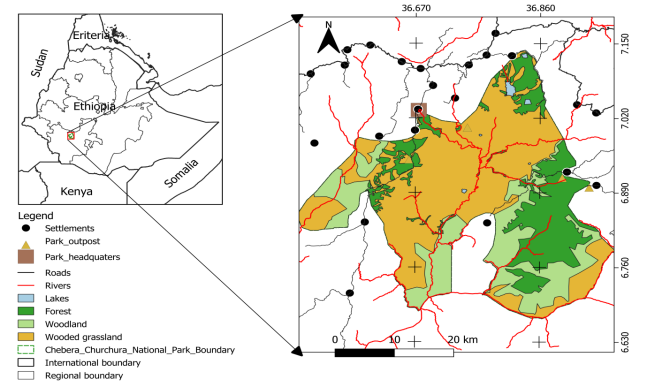

Figure 1) *Map showing the location of the Chebera Churchura National Park. Note: (●) Settlements; (▲) Park_outpost; (■) Park_headquaters; (—) Roads; (—) Rivers; (■) Lakes; (■) Forest; (■) Woodland; (■) Wooded grassland; (■) Chebera_Churchura_National_Park_Boundary; (■) International boundary; (■) Regional boundary*

Chebera Churchura National Park is home to one third of the national elephant population and has a high diversity of flora and fauna. Chebera Churchura is characterized by relatively hot climatic conditions. The average amount of annual rainfall in the area varies from 1000 to 3500 mm. The area has a uniform and extended rainfall season (between March and September with a peak in July). The dry season is from November to February, with mean maximum temperatures varying between 27 and 29°C. The hottest months are January and February while, the coldest months are July and August with the mean maximum and minimum temperatures of 28°C and 12°C, respectively [13].

The vegetation cover of the area is categorized wooded grassland, woodland, montane forest and riparian forest. Wooded grassland accounts for 55.6% of the study area. It covers most of the undulating landscapes above the floor of the valleys and gorges. Although the grass species show local variation, the dominant grass species the elephant grass *Pennisetum sp* [12].

The tree species are deciduous and include *Combretum sp*. in association with *Terminalia albiza*. Woodland habitat covers about 13.2% of the total area while the riparian forest habitat covers only 3% of the total area of the Park. The montane forest habitat covers about 27.2% of the total area of the Park. Dawro and Konta Nationalities are the major ethnic groups the live around CCNP with other minority groups Tsara, Menja, Mena and Bacha. Dawro ethnic group inhabits the eastern highland and few areas of the southeastern lowland areas.

Methods

The present study was carried out in 20 Park adjacent villages in general and in three Park adjacent villages that had human-elephant conflict in particular. Questionnaire and focus group discussion were conducted by modifying the methods of Newmark [14] and Datiko [11]. Procedures were followed according to relevant laws, guidelines of the country and permission was given by all the concerned institutions. Before the actual data collection, the study methods were well examined and approved by all concerned governmental institutions including the Ethiopian Wildlife Authority, the Regional Tourism Bureau, CCNP Office and local administrator. Participatory discussions based on full willingness of the respondents were made. Actual measurement of the damage caused by elephants was carried out following the method of Hore [15], a standardized system developed by IUCN African Elephant Specialist Group's Human-Elephant Conflict Working Group. The study was aimed to assess the temporal and spatial patterns of human-elephant conflicts and its economic costs in CCNP between 2020 and 2021. Before the actual data collection, reconnaissance survey was carried out during May 2019. Necessary information about the Park, livelihoods of the local communities, spatial and temporal patterns of the elephant habitats and human-elephant conflict was collected.

Data about the livelihood of local communities and the existing human-elephant conflict were collected. The questionnaires mainly focused on three main areas. (1) Crop commonly grown and palatable for the elephants (crops preferred by elephants among commonly cultivated crops) (2) Types of conflicts they had (crop raid, injury and death of human and domestic animals) and (3) Seasonal, spatial and temporal patterns of human-elephant conflicts and its economic costs (particular villages where human-elephant conflict exists, the relationships between distance from the Park and intensity of the conflict and seasonal variations)

A total of 378 household samples 25% from 6 Park adjacent villagers were identified for interview. The purpose of this investigation was to identify the spatial patterns of the elephant habitats and human-elephant conflict, types of conflicts they had and the level of conflicts. A total of 189 respondents from the three villages confirmed the existence of human-elephant conflicts confirmed (Chebra, Seri and Yora) while the remaining 189 respondents from (Keribela, Menta and Gudumu) villages reported that they have never had conflict with elephants. Interview, focal group discussion, and actual measurements of the damages and estimation of the monetary value of the damage were made for the households.

The structured questionnaires were administered to the member of household at a random manner excluding household member age less than 18 years based on first come first served bases [11,14]. Focus group discussion was also conducted in the villages to discuss the experience of people in human elephant conflicts. Actual measurements on the amount of crop damage, human and domestic animal injury and death were carried out using the method of Hore [15]. Measurements including the area of damage by m2, the proportion of damage, growth stages of crops, locations and distance from the Park boundary were made.

Based on the data collected on actual measurement of the damage, total economic loss due to elephants was estimated in terms of monetary value based on current price of each crop at the local market. Information on the current price of crops and estimated values of domestic animals were collected from 21 sellers 7 from each village and the average price was used to calculate the monetary value of total losses. Seasonal variations in the level of damage and the amount of crop loss/damage were compared for crops available both during both wet and dry seasons. During the study period, crop damages reported were mainly on three crop types' banana, maize and yam. Actual measurements of the damage and estimation of monetary value at local markets was calculated using different methods for each as follow:

Banana

Each individual banana tree consumed by elephants was counted and recorded. The productivity of the plant was considered as good, medium and low. The average number of banana/individual plant was calculated. Data on the price of each banana at local markets were also collected. Monetary value of the total damage was calculated as total number of banana consumed by elephants × average number of banana/individual tree × average unit price at the local market.

Maize

Loss of maize was calculated by recording the total size of damage in hectare.

Number of individual plant from a total of 18 sample plot 2 × 2 m size were counted from high, medium and low productive farms. The average number of maize counted from 2 × 2 m sample area individual plants and an average dry weight from the sample area were calculated. The average production /ha was estimated by multiplying total size of the farm damaged × average weight of estimated product/ha. The average price/kg at local market was estimated. Total loss due to human-elephant conflict was estimated by multiplying total size of farmlands consumed in ha x estimated product in kg x average unit price/kg at the local market.

Yam

Loss of yam was calculated by recording the total size of damage in hectare. Average product collected from a total of 18 sample plots 2 × 2 m size were weighed 6 from each village 2 samples from high, low and medium productive areas, respectively. The average weight of product measured from 2 × 2 m sample areas and an average weight from the sample areas were calculated.

Yam as a root plant total loss due to elephant was estimated by multiplying total size of farmlands consumed in ha x estimated product in kg/ha x average unit price/kg at the local markets. Total loss per house hold was calculated as total annual loss/total number of households. Quantitative data obtained from the local people responses were analyzed using chi-square test. Qualitative data obtained through focus group discussion and interviews were analyzed by content analysis method.

RESULTS

The spatial patterns of human-elephant conflict

(47.83%) of the total respondents confirmed the existence of human-elephant conflict while the remaining (52.16%) reported the absence of conflict of which, 97.5% from 3 villages (Keribela, Menta and Gudumu) confirmed that they have never had any conflict with the elephants while 93.3% of respondents from 3 Park adjacent villages (Chebra, Seri and Yora) reported the presence of severe human-elephant conflicts (Figure 2). The difference was statistically significant (χ^2=51.4, df=5, P<0.05).

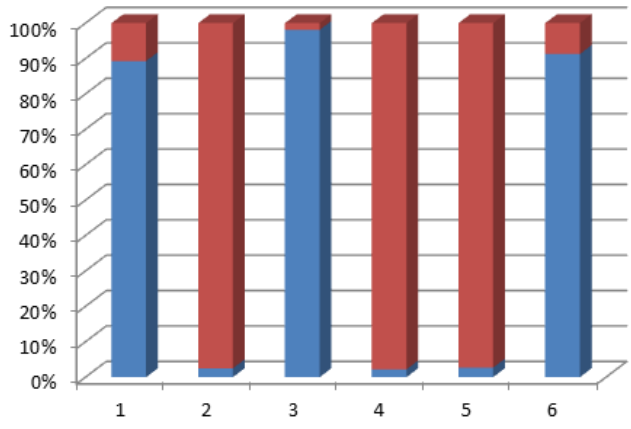

Figure 2) *The spatial patterns of human-elephant conflicts in and around CCNP*

The main causes of human-elephant conflict

378 individuals from the 6 villages confirmed the presence of both elephants and severer human-elephant conflicts in their area. The threat included crop loss, human and livestock injuries and deaths. Most of the respondents reported that elephants caused damage on crops, livestock and humans. Among the respondents, 45.2% reported crop damage, 3.1% loss of livestock, 2.45% injury and death to human life and 48.76% no conflict at all (Figure 3). The difference was statistically significant (χ^2=53.38, df=2, P<0.05).

Most of the respondents (96%) on average confirmed that among the widely cultivated crops Teff, maize, banana, yam and sorghum were palatable and were preferred by the elephants. While spices such as ginger, cardamon, and fruits such as avocado was confirmed to be unpalatable by the elephants (Figure 4). The difference was not statistically significant (χ^2=43.67, df=9, P>0.05).

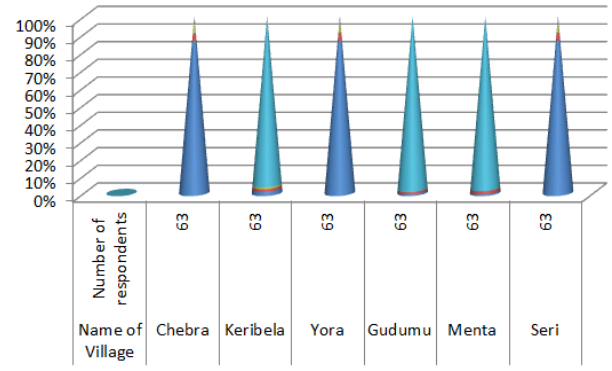

Figure 3) *The main causes of human-elephant conflict in CCNP*

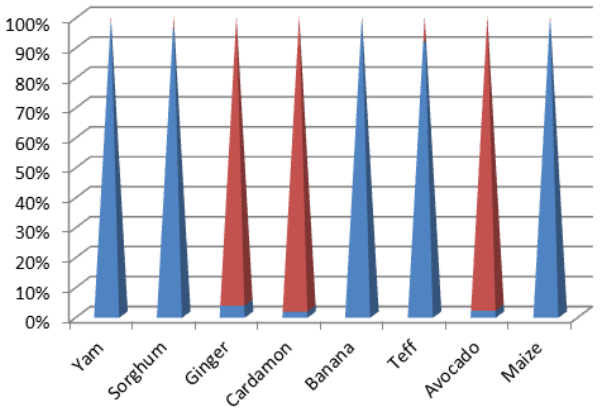

Figure 4) *Commonly cultivated crops and palatability to the elephant*

Measurement of crop damage, injury and death of human and domestic animals

During the present study period crop damages were reported mainly on three crop types; banana, maize and yam from the three villages.

Banana

A total of 32,092 individual banana trees from 156 households in the 6 villages were consumed by elephants. The price of a single banana fruit was 1ETB on the average at the local markets. The average product per banana tree was estimated at 173. The total estimated cost of the damage was 5,554,580 ETB, of which 2,917,126 ETB (52.51%) was from Yora village, 1,538,316 ETB (27.69%) from Seri and 1,099,138 ETB (19.78%) were from Chebra village (Table 1). Total loss/household was estimated at 35,606 ETB or 774.0 USD. None was consumed and reported from Keribela, Menta and Gudumu Villages. The difference was not statistically significant (χ^2=7224, df=3, P>0.05).

Based on developmental stage of the trees most of the banana trees consumed 22,190 trees (69.02%) were matured and with ripened banana fruit, 5,297 trees (16.39%) were intermediate and 4,603 (14.5 %) were seedlings (Table 1). The difference was not statistically significant (χ^2=8439, df=2, P>0.05).

Distance from the Park boundary and trend in crop raid were presented in Table 1. There was an inverse relationship between distance from the Park boundary and the quantity of crop damage. Out of the total 32,092 banana trees consumed 9,832.9 (30.64%) where from the farm lands less than 1km distance from the Park boundary, 9,836 (30.65%) were from distances between 1-3 km while, 8,626 trees (26.88%) were from farm lands between 3-5 km, 3,796 (11.8%) were from farmlands between 5-7 km. Non were consumed from farm lands more than 7 km distance from the Park boundary (Table 1). The difference was not statistically significant (χ^2=2163, df=4, P>0.05).

TABLE 1

Distance from the park, developmental stage, and annual amount consumed by elephants and estimated cost

Stage of growth	Distance from the park in km	Name of village and number of banana tress consumed								Total
		Chebra		Gudumu		Seri	Menta	Yora	Keribela	
Seedling	0-1	318		-		386	-	300	-	1, 004
	1-3	222		-		349	-	388	-	959
	3-5	152		-		223	-	1879	-	2, 254
	5-7	-				-	-	386	-	386
										4, 603
Intermediate	0-1	681		-		664	-	500	-	1, 782
	1-3	400		-		630	-	632	-	1, 662
	3-5	222		-		347	-	620	-	1,189
	5-7	-				-		664	-	664
										5, 297
Matured	0-1	1947.4		-		2625	-	1961	-	6, 534
	1-3	1494.7		-		2337	-	3065	-	6, 897
	3-5	1013		-		526	-	2443	-	3, 928
	5-7	-	-			2443	-	2625	-	5, 068
										22, 190
Average		6353.4		-		8892	-	10470	-	32, 092

Maize

The average number of maize counted from the plots 2 × 2 m sample areas was 11.3 individual maize trees. The average dry weight of maize found from the sample areas was 0.76 kg. The average dry maize production was estimated at 3,800 kg/ha. The average price of the product/kg at local markets was estimated at 19 ETB (Table 2). A total of 35.7 ha maize farm from 169 households in the 6 villages were damaged by elephants. The total cost of the damage was estimated at 2,577,540 ETB of which 18.56 ha (52.0%) of the 1,340,320 ETB was from Yora village, 11.3 ha (31.7%) with estimated cost 817,080 ETB were from Seri while; 5.8ha (16.3%) with estimated cost 420,139 ETB were from Chebra village. None was consumed and reported from Keribela, Menta and Gudumu Villages. The difference was statistically significant (χ^2=8.22, df=2, P<0.05). Based on developmental stage most of the plants consumed 28.1ha (77.8%) were during maturity, 5.8 ha (16.2%), were at intermediate stage while; 3.8 ha (10.5%) were seedlings. Total loss/household was estimated at 15,251.7 ETB or 331.5 USD. The difference was not statistically significant (χ^2=10.21, df=2, P>0.05). Distance from the Park, maize consumed and monetary value is given in Table 2.

There was an inverse relationship between distance from the Park boundary and the quantity of crop damage/ha. Out of the total 35.7 ha maize damage in the three villages, 13.27 ha (37.10%) were from farm lands located within less than 1km distance from the Park boundary, 11.1 ha (31.09%) were from farm lands located within 1-3 km distance from the Park boundary while, 9.2 (24. 5%) was from farm lands located within 3-5 km. The least 2.2 ha (6.1%) was within 5-7 km distance from the Park boundary and none was reported from the farm lands located at distance more than 7 km far from Park boundary (Table 2). The difference was not statistically significant (χ^2=3.71, df=4, P>0.05).

Yam plant

The average amount of product/2m^2 plots was 800 kg. The average product/ha was estimated at 40,000 kg. The average price/kg at the local markets was estimated at 3 ETB/kg. A total of 36 ha of damage on yam farm lands from 177 households were recorded from the 6 villages. The total cost of the damage was 4,320,000 ETB of which 16 ha (44.5%) with estimated value 1,920, 000 ETB was recorded from Yora village, 11 ha (30.5%) 1,320,000 ETB was from Seri while, 9 ha (25%) 1,080,000 ETB was from Chebera village. None was consumed and reported from Keribela, Menta and Gudumu villages. The difference was statistically significant (χ^2 = 6.51, df=5, P>0.05). Based on the developmental stage of the yam plant most of the plant 27 ha (74%) of the damage was on the matured stage 5.8 ha (16.0%) at intermediate stage while 3.8 ha (10.0%) was at seedling stage (Table 3). Total annual loss/household was estimated at 24,406.74 ETB or 530.58 USD. The difference was statistically significant (χ^2=12.48, df=2, P>0.05).

Distance from the Park and trend of the raids were presented in Table 3. There was an inverse relationship between distance from the Park and the quantity of crop damage/ha. Out of the total 36 ha damage of yam farm land in the villages 14.65 ha (40.69%) were from the farm lands located within less than 1 km distance from the Park boundary, 12.75 (35.41%) were from 1-3 km distances while; 8.55 ha (23.75%) were from farm lands located between 5-7 km distance from the Park boundary. No damage was reported from farm lands located at more than 7 km distance from Park boundary (Table 3). The difference was not statistically significant (χ^2=5.12, df=4, P<0.05).

The total annual loss of years 2020 and 2021 due to human elephant conflict was estimated at 12,452,120 ETB or USD 270,698 of which 12,399,619 ETB or USD 269,557 (99.5%) was from crop loss while only 52,500 ETB or USD 1,130 (0.5%) was due to loss of domestic animals (Table 4). Total loss/household was estimated at 24,805 ETB or 539.2 USD.

TABLE 2

Annual total amount of maize consumed by elephants in ha and the estimated cost

	Growth stage and maize consumed by elephants in ha												
	Seedlings				Intermediate				Mature				Total
Name of the Village	Chebra	Seri	Yora	Total	Chebra	Seri	Yora	Total	Chebra	Seri	Yora	Total	ha
Distance in km													
0-1	0.2	0.4	1.2	1.8	0.51	1.5	2.1	4.1	1.47	2.8	3.1	7.37	13.27
03-Jan	0.17	0.6	1.5	2.27	0.42	0.9	1.3	2.6	1.23	2.1	2.9	6.23	11.1
05-Mar	0.11	0.5	1.1	1.71	0.27	0.5	1.1	1.87	0.82	1.1	2.1	4.02	9.2
07-May	-	-	-	-	-	-	1.1	-	-	-	1.1	1.1	2.2
Above 7	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0. 48	1.5	3.8	5.78	1.2	2.9	5.5	8.57	3.52	6	9. 2	18.72	35.7

TABLE 3

Annual total amount of yam plant in ha damaged by elephants and estimated monetary value

Name of the village	Growth stage and total size of yam plant consumed in ha												
	Seedlings				Intermediate				Matured				
	Chebra	Seri	Yora	Total	Chebra	Seri	Yora	Total	Chebra	Seri	Yora	Total	Sum
Distance													
0-1	0.4	0.45	0.34	1.2	0.6	0.7	1.25	2.55	2.7	3.7	4.5	10.9	14.65
03-Jan	0.35	0.3	0.6	1.25	0.6	0.5	1	2.1	2.2	3.1	4.1	9.4	12.75
05-Mar	0.25	0.25	0.5	1	0.4	0.5	0.25	1.15	1.5	1.5	3.4	6.4	8.55
07-May	-	-	-	-	-	-	-	-	-	-	-	-	-
Above 7	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1	1	1.4	3.45	1.06	1.6	2.5	5.8	5.8	6.4	8.3	26.7	36

TABLE 4

Number of humans and domestic animals killed and injured by elephants

Time and types of the incidence	Name of Villages		
	Chebera	Seri	Yora
Month/Year	February 2020 and	Feb-20	Feb-21
Distance in km	1.1 km	1 km	6 km
Domestic animals killed	2 cows	2 bulls	2 cows and 1 bull
Average Value in ETB	7,000 or 152.2 USD	8,000 ETB or 173.9 USD	7,500 ETB or 163 USD
Total Loss/village	14,000 or 304.3 USD	16,00 ETB or 346.8 USD	22,500ETB or 489 USD
Human injury	2	2	2
Human death	2	2	2
	7 km	September 2021	1
Elephant killed	-	1	-
Total loss	52,500 or 1,141.3 USD		

DISCUSSION

In the study area, human-elephant conflict was identified as the top conservation challenge both for the elephant population and local communities living around the Park posing huge problem on the long term co-existence of elephants with the local community. AFESG [16] and WWF [17] also noted that human-elephant conflict as one of the five big issues with equal priority that needs attention regarding the African elephant conservation.

During the present study, injury and death of human and livestock and crop raid by elephants were identified as the main causes of human-elephant conflict and the top conservation challenge. Crop damage was the most pressing problem followed by loss of livestock and injury and death of humans in the conflict areas of Chebera, Seri and Yora villages. This result goes in line with the findings of Kaiwen [7] who mentioned that injuries and deaths of human and livestock, crop raid and damage on properties were the main causes of human-elephant conflicts around the National Nature Reserve. Elephants were perceived as the most responsible animals regarding human-wildlife conflict and account to the damages experienced on human lives and livelihoods in Rombo National Park areas, Tanzania [9].

This study confirmed that elephants were perceived as the most dangerous animals in Chebera Churchura National Park areas. In some areas, farmers around CCNP abandoned their crops entirely and recently gave up growing crops especially in Seri and Yora villages because elephant damage was so huge. The result of this study also showed that human-elephant conflict resulted in huge economic loss in those three villages where human-elephant conflict was confirmed. This result goes in line with Mubaga [9] who noted that some people in Rombo abandoned their crops entirely and farmers recently gave up growing crops because elephant damage was so high [9]. The result of this study showed that the cost of average annual crop loss was about 23, 175 ETB or 503.8 USD per household. This is relatively less compared to other studies like in Tanzania where the cost of elephant raiding was 50 to 1000 USD per month equivalent to annual loss from 600 to 12,000 USD. But it is a huge sum for poor farmers around CCNP.

During the present study, the incidence of human-elephant conflict as not uniform along the Park's perimeter due to the presence of different factors and the existence of topographic features that determine the movement of wild animals in the area. The spatial patterns of human elephant conflicts showed similar patterns. Out of a total of 6 adjacent villages, 3 villages did not experience human-elephant conflict. These villages were located far from the habitats, corridors and home ranges of elephants. The presence of human-elephant conflict was confirmed for only three Park adjacent villages (Chebra, Seri and Yora) located close to high elephant density, area coinciding with previous migration corridors. This finding goes in line with the findings of Mekonnen [18] and Datiko [11] who noted that the incidence of human-wildlife conflicts in general were not uniform along the Park's boundary due to the presence of different factors that determine the movements of wildlife and the existence of topographic features.

During the present study period, elephants were frequently observed trying to cross the same places and areas in these villages that were proposed to be their previous corridor between the Park and Kaffa Biosphere Reserve which was their wet season home range, located at the western and southwestern parts of the National Park and currently encroached by these villagers People also confirmed during focus group discussions that these areas were the common habitats and corridors of elephants before the human settlements and are currently blocked due to the demarcation process of the Park boundary in 2005. They also claimed that proper attention was not given to include the elephant natural habitats, corridors and home ranges and the demarcation process was carried out without adequate knowledge or information about the natural home range and corridors of the elephants. The main focus of the demarcation process was making suitable farmlands available for local communities and finding natural features such as mountains and rivers to make clear and permanent boundaries of the Park, which resulted frequent conflict between elephants and local communities in these three villages [19]. The farmers were also settled in these habitats without knowing the cost and consequences of settling in the elephant habitat and thus blocking their corridors. At present the original virgin forest has been completely and permanently removed, and it is no longer the food source of elephants. The habitat has become fragmented and lost as dispersal area for elephants.

This result goes in line with the findings of Mubaga, et al. [9] who noted that blockage on migratory routes and corridors of elephants resulted increased human-elephant conflict incidents in lowland areas of Rombo, Tanzania. This study showed that food preference, crop growth stage and distance from the Park were found to be the principal factors that determined the level of human-elephant conflict in these three villages. There was an inverse relationship between distance from the Park boundary and the quantity of crop damage, injury and death of humans and domestic animals. As distance from the Park boundary increased, the amount of crop damage, injury and death of humans and livestock decreased. These results agree with the findings of Newmark, et al. [14] who mentioned that conflicts between local people and wildlife were the most serious problem in the closely located areas. Conflicts were particularly common in cultivated farmlands due to wild animals wandering around villagers from the protected areas when agricultural farm lands are expanded near to the periphery of protected areas [7]. The proximity of a village or field to a protected area increases the likelihood of being affected by elephants and other wild animals [9].

The result of this study also showed that the amount of crop damage resulted in variation between the different developmental stages of crops. Most of the crop damage caused by elephants was matured ones while seedlings were found to be the least consumed. Human–elephant conflict occurred throughout the year, but the high incidence period was from April to November, which is the maturation period of the main crops and due to seasonal availability of crops like maize and yam only during the wet season. This may be due to the preference of elephants for food that are palatable and had good nutritive value. Similar findings were also reported by Su, et al. [7].

In CCNP, all crop types commonly grown around the villages do not equally attract elephants. The study showed that among the widely cultivated crops teff, maize, banana, yam, and sorghum were palatable and preferred by elephants, while spices such as ginger and cardamom, fruits such as papaya, mango, and avocado were found to be unpalatable to elephants. Even though teff, maize, banana, yam, and sorghum were reported as palatable and crops preferred by elephants, confirmed crop damages reported from the three villages during both dry and wet seasons for the years 2020 and 2021 banana, maize and yam of which only banana was available during both dry and wet seasons. This information agrees with the findings of Barnes [2] who reported that some food items/crops were particularly palatable and attract wildlife, Maize and cassava attracted particularly elephants among the crops planted outside the Kakum National Park (Ghana). However, unlike the crop raid, most of the injury and death of domestic animals and humans were recorded during the dry season. This may be due to the scarcity of diverse food sources in their foraging habitats during the dry season until the beginning of a new growing grass. Studies in other localities also showed similar results where human-elephant conflict and crop raiding occur in agricultural fields to meet dietary requirements [20-31]. The findings of this study also agrees with Tsegaye, et al. [12] who mentioned that during the dry season forest fires were common in CCNP and wild animals move to be confide in riparian forest habitats and adjacent farmlands where there is no fire until the onset of new growth of moist green grass.

CONCLUSION

Even though CCNP is a very well protected area and known for harboring diversified fauna and flora, human-elephant conflict is an increasing concern that needs urgent solution in the area. Only limited studies have ever been conducted in human-elephant conflict in CCNP area. This study can be used as a baseline. This study showed that human-elephant conflict hotspots are located in only three Park adjacent villages. This study also confirmed that the attack is associated with few seasonal crops especially maize, banana and yam. The peak of the conflict is at maturity stages of the crop. The findings of this study also confirmed that food preference and distance from the Park were the main factors that determined the level of human-elephant conflicts. Damage prevention should focus on the seasonal crops mentioned above especially at maturity and harvesting time. This study also showed that the major causes of the conflict are crop damage, injury and death of human and livestock. Development and implementation of effective human-elephant conflict mitigation measures are urgently needed in the identified high conflict areas to minimize the level of conflict and schemes where local people perceive tangible economic benefits to tolerate the conflict on the surroundings. It is also important to monitor conflict situations over time.

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CONFLICT OF INTEREST

The authors have not declared any conflict of interests.

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