Study on Human–elephant (*Loxodonta africana*, Blumenbach, 1797) conflict, prevention and mitigation in Babile Elephant Sanctuary, Eastern Ethiopia

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ABSTRACT

The focus of this paper is to study the Human-Elephant Conflict (HEC), Prevention, Mitigation methods in Babile Elephant Sanctuary, Eastern Ethiopia. Purposive and random sampling methods were used for primary data collection. Accordingly, a total of 138 Households were selected from four Peasant Associations that were close to the sanctuary for interview. Moreover, Focus group discussion, site observations, and secondary data of the last five years (2016-2020) related to HEC. The result showed, 87.7% of respondents thought that crop-raiding by elephants and 85% of them viewed, death of 16 elephants by humans were the cause for conflict. Above 54.3% and 37.7% of them also thought as 22 human and 24 livestock died respectively. Besides, 27% of them indicated, 647.32 quintal of Zea mays (31.27 %) and Sorghum bicolor (46.22%) costing, 67,107.2 ETB-Ethiopian Birr (out of 87,657.27 ETB or 2,369.62 USD) were lost. However, all (100%) of them thought that there was no compensation given for the lost crops. Visual signals (setting fire and lighting torches) and hitting metal objects (acoustic methods) were used as a major mitigation measure. While beehives fences and digging trenches were identified as minor preventive measures. Based on the study results, the following inference is drawn: identifying and documenting the existence of HEC information to build the knowledge gaps on areas where these challenges prevails and implementing various measures of technical(biological and physical methods: farming of cash crops which is less attractive to elephants, fencing), socio-economic (building community owner ship and educational programs to school, benefit community by employee in development works),and financial strategy set up (compensation losses and revenue sharing) are crucial methods to reducing conflict and co-exiting human and elephant.

Keywords: *Compensation, Crop-raiding, Human-elephant conflict, Sanctuary, Prevention and Mitigation.*

1. INTRODUCTION

The African elephant (*Loxodonta africana*) is the largest land-living mammal, highly social, and intelligent (Piera *et al., 2017*). This species has an important ecological role in the African savannahs and forests (Thomas *et al*., 2019; Cardoso *et al*., 2020), by modifying their surrounding landscapes through feeding activities (Brand *et al*., 2020; Redmore *et al*., 2020). However, they are under threat and categorized as vulnerable by the IUCN Red List of threatened species (Gobush *et al*., 2021). Human-elephant conflict is a part of human-wildlife conflicts. It is widely occurring across the world and poses a great challenge to elephant conservation (Shaffer *et al*., 2019). In Africa, HEC is a scattered problem and often leads to damage of crops, livelihoods, negative perceptions towards it, and sometimes human injuries and death (Shaffer *et al*., 2019). The conflict leads to undesirable results in elephant conservation (Guru and Das, 2021). Presently, Ethiopia's Protected Areas (PAs) are facing conservation challenges that mainly stem from population growth around the PAs, leading to settlement, agricultural expansion, habitat loss and destruction, overgrazing, deforestation, soil, degradation, and misuse of natural resources (Tessema *et al*., 2019; Mureithi *et al*., 2019). Besides, unwise utilization of resources, as well as habitat destruction and fragmentation (Mekonen *et al*., 2017; Yilak and Debelo, 2019). For instance, According to Sintayehu *et al.* (2016), Due to human-elephant conflict, about47elephants died in the sanctuary in the past two years. Besides human-elephant conflict, other human activities like deforestation for needing agricultural land, charcoal production, sand excavation, Livestock grazing, and poaching were other impacts that were affecting the Sanctuary (BES) (Tessema *et al*., 2019; Taye Lemma and Girma Mengesha, 2021). Understanding human-elephant conflict, its prevention, and mitigation is vital for the conservation and management of the vulnerable species and promotes the co-existence of humans and wildlife in an area.

DOI: 10.54756/IJSAR.2022.V2i3.2

Moreover, understanding how both co-exist, without much negative impact on each other, is very important in the area and could help to conserve elephants in particular and other wildlife resources in general in and around the sanctuary. Some studies might be investigated with regards to Human-Wildlife Conflict (Sintayehu and Merkebu , 2019;Tessema *et al*., 2019) and conservation threats in the sanctuary (Reddy and Workeneh, 2014; Taye and Girma, 2021). However, the past studies were not focused on the issues of prevention and mitigation measures to reduce the conflict. Hence, this study was important to indicate both the interaction of Humans and elephants as well as how to prevent and mitigate the conflict happening and to promote the harmonious co-existence between them.

2. MATERIALS AND METHODS

2.1. Study Area

Babile Elephant Sanctuary (BES) was established in 1970, with an area of 6,982 km^2. Geographically it is found within the latitudes of 08^{o}22'30"-09^{o}00'30"N and longitudes of 42^{o}01'10"- 43^{o}05'50" E (WGS 1984 UTM Zone 38N) (Figure1). BES has been known to support over 250 viable populations of elephants (Belayneh *et al*., 2011) and 30 other mammals and 191 birds species (Miheret Ewnetu *et al*., 2006). Topographically, BES occurs at an altitudinal range of 850 meters above sea level (m.a.s.l.) to 1,785 m.a.s.l. and 84% of the land is flat to gentle slopes, while others as complex valleys and deep gorges (Yirmed Demeke,2008).The vegetation of the sanctuary was represented by *Acacia Commiphora* woodland, semi-desertscrubland, and evergreen scrub ecosystems and with high endemicity of various plants and grasslands (Yirmed Demeke *et al*., 2006). However, presently due to anthropogenic impacts (for instance, deforestation, settlement, illegal fire, livestock grazing, and expansion of invasive species), most of the woodland configuration has been converted to bushlands (Taye Lemma and Girma Mengesha, 2021), and the riparian forest, woodland and bush land habitats of elephants used were reduced (Sintayehu and Kassaw, 2019). The sanctuary has tropical rainfall types of middle latitude and a tropical arid climate. And, has the highest (32.39 ^{o}C) and lowest (9.66 ^{o}C) mean monthly temperatures (Source: National Metrological Station Agency (NMSA) data from 2002 to2016; Cited in Taye Lemma and Girma Mengesha, 2021). The rainfall in the sanctuary occurs during two rainy seasons (i.e., bimodal rainfall): Has a high variation of rainfall (i.e., from 442 mm to 1302.9 mm/yr.) with the mean annual rainfall of 802 mm (Source: NMSA data from 2002 to 2016; Cited in Taye Lemma and Girma Mengesha, 2021), the short rainy season occurs between March and May, and the long rainy seasons between August and November (Source: NMSA data from 2002 to 2016; Cited in Taye Lemma and Girma Mengesha, 2021). Local communities in the area earn their livelihood, mainly through subsistence agriculture (i.e., crop production and livestock husbandry) (Taye Lemma and Girma Mengesha, 2021). In the area, various types of crops were produced by rain-fed agriculture and irrigation (in some places). For instance, the plant species (*Catha edulis*) was locally named "Chat" and local fattening of oxen was popular and used as a major income in the study areas (Taye Lemma and Girma Mengesha, 2021).

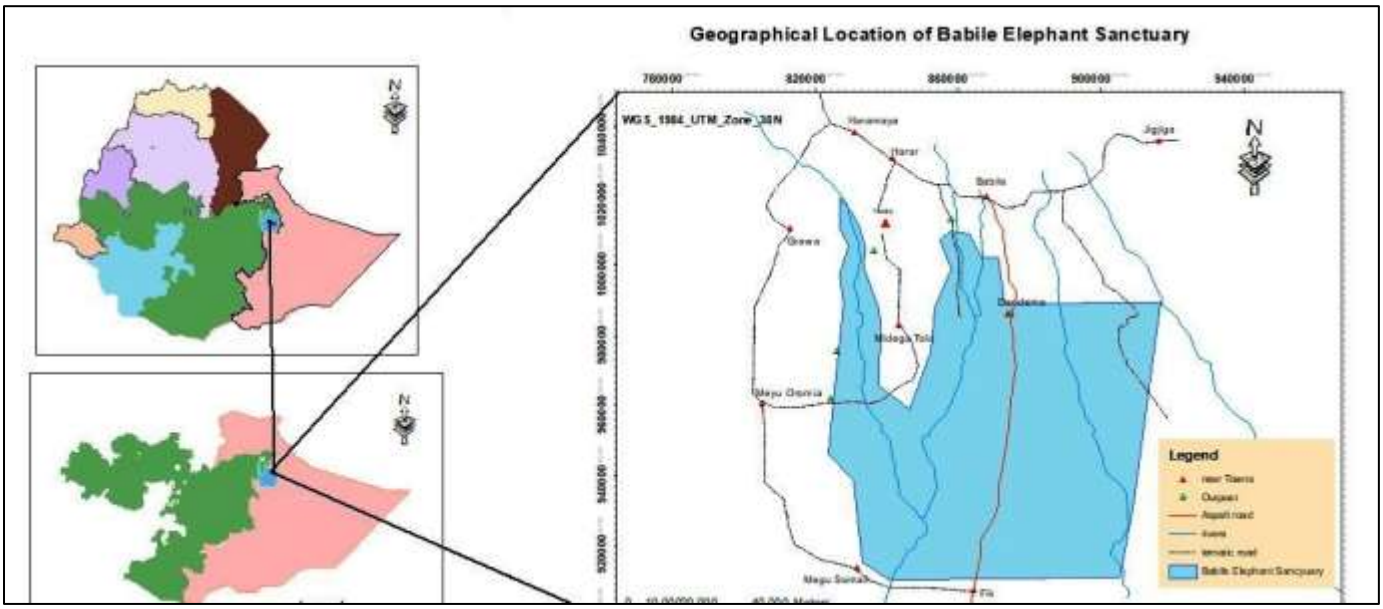

Figure 1. Map of Babile Elephant Sanctuary

2.2. Methods

Reconnaissance surveys were carried out on 15 March 2020 and 10 April 2020. During the reconnaissance surveys, discussion with concerned individuals at the sanctuary and local experts, information on elephant's movement pattern and impact of elephants

DOI: 10.54756/IJSAR.2022.V2i3.2

(Sultan *et al*., 2017; Das *et al*., 2020) were identified in addition to familiarizing self with the study area. The study was designed by including field observation and socio-economic survey (i.e., through questionnaire survey and face to face), and an interview was conducted (Saloniki *et al*., 2019). The survey encompassed interviews, participant observations, and the use of archive data (i.e., secondary data sources) (Turner *et al*., 2017) to get an overview of human-elephant interactions. In this study, four districts (Babile, Fedis, Midhega tola, and Mayu muluke) were selected by considering the nature of proximity to the sanctuary. From the districts, in turn, the most adjoining/nearby "Kebelles" (divisions within a district) to the sanctuary based on prevalent occurrences of HEC incidents to the other sites were selected (i.e. There were 4 "Kebelles"). Four "Kebelles", one from each district was selected. These were Erer ebada, Bilisuma, Anani, and Alola "Kebelles" from Babile, Midhega Tola, Fedis, and Mayu Muluke districts respectively. From the "Kebelles" close to the sanctuary, respondents selected were Key Informants (KIS), Focus group discussants (FGD), and Households (HHS). The selections of respondents were based on the purposive sampling technique (Muchaendepi *et al*., 2019). Among the respondents, the key resource persons were the local peoples who were lived in the nearby villages around the sanctuary.

2.2.1. Data Collection

For the actual data collection, primary and secondary data collection methods were used. The primary data collection was carried out through interviews and questionnaires (Adhabi and Anozie, 2017). Semi-structured interviews (De Jonckheere and Vaughn, 2019) following the nature and extent of occurrence of HEC were designed. The questionnaires were prepared in English language and translated to the local language "Afaan Oromo" (Bovis *et al*., 2018; Muhoozi *et al*., 2018). Field visits were also conducted in addition to questionnaires. Data on quantification of the losses incurred were also collected in the four study districts. Thought of local peoples on incidents that were happened while HEC in each "kebeles" was perceived. The primary data collection was carried out through interviews and questionnaires prepared for this purpose (Adhabi and Anozie, 2017). Semi-structured interviews (DeJonckheere and Vaughn, 2019) following the nature and extent of occurrence of HEC were designed. During data collection, materials: Standard questionnaires, relevant published and unpublished literature, topographic map of the area and its surroundings, computer, calculator, GPS handset, binoculars, digital camera, measuring tape, and compass were used for this study.

2.2.1.1. Key informant interview and Focus group discussion

Key informants from four districts (two in each) were systematically selected and interviewed. They were worked in their "kebeles" or Peasant Association leader during different seasons, and know the status of the people in their corresponding sites. Moreover, community development workers in the "kebeles" were also selected with the help of rangers who were working in the sanctuary. Four Focused Group Discussion (FGD) consisting of 12 individuals. They were composed of experienced three farmers in each "kebele" including the elderly, traditional leaders, and school youths. Four groups, each having 12 individuals in each "kebele" participated in FGD (Hartling *et al*., 2017). The purpose of the FGD was to provide additional information following the nature and extent of occurrence of Human-Elephant Conflict.

2.2.2. Sampling size and Households selection

As farmers' ability to maintain and their knowledge in managing HEC on the agricultural landscape depend on the socio-economic status of the farmers and a wealth ranking that was used to stratify farmers' households for the selection purpose of sample households (Bluwstein *et al*., 2018). The criteria used by the key informants to classify the households into different wealth categories (poor, medium and rich) were mainly based on number of cattle, amount of annual crop production and type/standard of housing. The key informant's wealth ranking method by classifying the number of livestock population was indicated below (Table 1).

Table1. Summary of wealth ranking criteria done by the key informants for the selected study sites

Livestock	Anani PA			Alola PA			Bilisuma PA			Ererebada PA		
	Rich	Medium	Poor	Rich	Medium	Poor	Rich	Medium	Poor	Rich	Medium	Poor
Cows	>7	1-3	≤ 1	>20	10-15	≤ 5	>10	6-8	≤ 5	>10	5-10	≤ 4
Donkey	>2	1-2	≤ 1	-	-	-	>2	1-2	≤ 1	>5	3-4	1-2
Goats	>20	10-15	≤ 4	>20	10-15	≤ 5	>15	10-15	≤ 2	>15	10-15	≤ 5
Sheep	>4	1-3	≤ 1	-	-	-	>8	5-8	≤ 5	10-15	5-8	≤ 2
Camels	≥1	≤ 1	absent	>20	10-15	≤ 5	≥7	5-7	≤ 2	>5	2-4	≤ 1
Hens	-	-	-	-	-	-	>15	5-10	<5	>20	10-15	≤ 5

Where, PA=peasant Association

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The key informants (KIs) helped in classifying farmers into socio-economic status. The criteria used by the key informants to classify the Households (HHs) into different wealth categories (Crowley, 1997) (poor, medium, and rich) were mainly based on some cattle, amount of annual crop production, and type/standard of housing. The key informant's wealth ranking method is used by classifying the number of livestock population. A random selection procedure was used to obtain samples of individual HHs from each wealth category to have a systematic approach. Irrespective of whether there are HEC victims or not summing up to 138 HHs interviewed in four districts of their corresponding "kebeles" around the boundary of the sanctuary (Table 2). A semi-structured questionnaire was administered to respondents aged 25 years and above, who had lived in the respective location for at least five years or more. A stratified sampling procedure was used to obtain samples of individuals HHs from each wealth category. The population of study areas was taken from the members' register of 2020. The total Households of the four "kebeles" was 4518; of which 1490, 1479,762, and 787HHs were for Erer ebada, Anani, Bilisuma, and Alola PeAs respectively (Table 2). The list of an ultimate sampling sample frame of the household living in four study areas holds persons who own at least a plot of farmland of their own. The number of sampled households that were included in the study areas was determined from the sampling frame following (Kothari, 2004).

The formula to determine the sample size for a finite population is indicated below.

$$n = \frac{Z^2 * p * q * N}{e^2 (N- 1) + Z^2 * p * q}$$

Where, n= sample size,
Z = 95% confidence limit (interval) under the normal curve, i.e. 1.96.
p = 0.1(proportion of the population to be included in the sample, i.e.10%)
q = non-occurrence of event which is equal to (1- 0.1), i.e. 0.9.
N = Total number of population or Households
e = margin of error or degree of occurrence (acceptable error term) 0.05.

Based on the above formula after calculation, the sample size of the household members that were subject for four "kebeles" of study areas were 138HHs; of which the sample size 46, 23, 45, and 24HHs were identified as sampled HHs in Ere ebada, Bilisuma, Anani and Alola "kebeles" respectively. Of which, the wealthy category of Erer ebada, Bilisuma, Anani, and Alola "kebeles" obtained were 23, 18, 10 and 14HHs were poor; 19, 15, 8 and 7HHs were medium and 4, 12, 5 and 3HHs were rich respectively. All of the HHs from each of the three stratified wealth categories in the "kebeles" was interviewed. Based on wealth ranking, about 82% of the sampled HH farmers in the study areas are medium and poor farmers, indicating a subsistence type of farming system and livestock production for earning their livelihood income. Relatively, the numbers of sampled HHs in Bilisuma (23HHs) and Aloola "kebeles" (24HHs) were less than others. And also there was less number of poor HHs in Bilisuma (43.5%) and Anani (40%) PeAs (Table 2). In general, from the total sampled HHs (138HHs), 17.5% were rich, 35.5% were medium and (47%) were poor (Table 2).

Table 2. The number of selected HHs (based on wealth status) for the study

Name-of PeAS/Kebelles	Total Pop.No.	Total No.of HHs	Total no. of HHs distributions			No. of selected sampled HHs			
			Rich	Medium	Poor	Rich	Medium	Poor	Total
Erer ebada	8851	1490	149	596	745	4	19	23	46
Anani	7027	1479	400	500	579	12	15	18	45
Bilisuma	7267	762	169	273	320	5	8	10	23
Alola	955	787	93	240	454	3	7	14	24
	24100	4518	811	1609	2098	24	49	65	138

2.4. Data analysis

The data were analyzed by using simple descriptive or qualitative and quantitative or numerical methods. The in-depth information obtained based on people's perceptions and attitudes was summarized and interpreted through descriptive statistics (such as percentage and frequency) to understand different trends. Besides, the Chi-square test ($\chi 2$) was conducted on the frequency of reported HEC in all study divisions for all years and the types of conflicts that were reported in BES over the consistent past five years. Finally, the results were interpreted or represented using tables, graphs, and charts.

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3. RESULTS AND DISCUSSION

3.1. Demographic and Socio-economic characters

In this study, the local people had an average landholding size of 2.47 ha (Table 3). In terms of educational level, 71 (51.45%) of respondents were illiterate while 67 (48.55%) were literate (Table 3). And, 58 (42.03%) and 9 (6.52%) of the sampled HHs were educated with primary & secondary school level status respectively (Table 3). The average family size is five & the entire HHS head's according to all (100%) of the respondents, the livelihood people in the area comes from agriculture (i.e., land cultivators (N= 108, 78.26%) & livestock production (N=30, 21.74%)(Table 3).

Table 3. Demography and Socio-economic characteristics of the Households in the selected study sites

S/N	Characteristics	Unit	Erer ebada (N=46)	Anani (N=45)	Bilisuma (N=23)	Aloola (N=24)	Total (N=138)
1	Sex	Pop.					
	Male	No.	4927	3443	3468	690	12528
	Female	No.	3924	3584	3799	265	11572
		Sub total	8851	7027	7267	955	24100
2	Number of house holds	No.	1490	1479	762	787	4518
3	Average landholding size	Ha	1.75	1.48	5.75	0.9	2.47
5	Average family size	No.	6	5	10	1	5
6	Average Age	Year	43	40	40	40	41
7	Education level						
	Cannot read and write	No.	9	27	16	19	71
	Can read and write	No	37	18	7	5	67
	Elementary school (1-8 grade)	No	32	16	6	4	58
	High school (9-12 grade)	No	5	2	1	1	9
8	Occupation	No					
	Agriculture(land cultivators)	No	46	31	14	17	108
	Domestic animal husbandry	No		14	9	7	30

3.2. Human-elephant conflict incidents

Based on the majority of 87.7 % respondents' perception crop raiding was the major cause of HEC in the study sites area (Table 4) (Figure 2). According to 12.3% of respondents viewed; crop-raiding was not a cause for them. Instead, poachers entered in to the sanctuary to kill elephants; during this time some elephants moved out from sanctuary to nearby farmlands then crop-raiding happened as the revenge of the poachers. The second cause was elephant death. About 85% of respondents thought there were 19 elephants, out of which 16 have died and 3 injured. The injured were died after some time due to absence of care to them as respondents replied (Table 4). According to 54 % and 38.4% of respondents, 22 humans have died and 15 injured by elephants respectively. Moreover; 37.7% and 36.23% of respondents were also thought 24 livestock were killed and 11 injured (Table 4). Based on all (100%) of the respondent from each "kebeles", a total of 244 incidents (out of which; 225 incidents/92%) were brought by an elephant on human possession, were observed in the study areas over the last five years (2016-2020) shown in the (Table 4). Of all respondents, 108(78%) oppose the existence of the elephant conservation system (i.e., this might contribute to the prevalent occurrence), while 30(22%) stated the existence (Table 4). There was a significant difference in the attitude of a local community toward crop raiding *($\chi 2$ =7.8, DF= 3, P <0.05)*. However, the number of incidents in crop-raiding was higher than other incidents (Table 4). The result showed the Elephants have negatively affected local communities attacking and killing humans and livestock, destroying irrigation materials, food stores, and crops. This finding is similar to (Munyao *et al*., 2020; Manoa *et al*., 2021) which have shown that the level of destruction of the elephants ranges from severe crop-raiding to killing of people, in which the species become the most dangerous and damaging. Moreover, from observation during the present study, various crops (such as vegetables, fruits, oilseeds, and cereal crops) were damaged by elephants during the day and night periods in all four study sites(Eree ebada, Bilisuma and Alola)"kebeles" due to trampling (Figure 4). This findings was similar to (Pozo *et al*., 2018; Branco *et al*., 2019; Compaore *et al*., 2020) who reported that elephants and other wildlife can destroy most crops in a field a single day or night. For instance, in this study, most of the yield losses trends were decreasing when we go to from 2016 to 2020 G.C (Figure 4). However, the cumulative impact was significant.

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Table 4. Respondents' view on the total number of incidents that occurred by HEC over the last five years in BES (2016-2020)

Causes to incidence	Number of incidents	Total number & % of respondents
Humans death	22	75(54.3%)
Injured human	15	53(38.4%)
Killed Live stocks	24	52(37.7%)
Livestock injured	11	50(36.23%)
Damaged on water taps/structure	7	10(7.24%)
Damaged on irrigation materials	7	17(12.32%)
Damaged on food stores	31	36(26.1%)
Destroyed crops (crop raiding)	108	121(87.7%)
Elephant death (by man)	16	117(85%)
Elephant injured(by man)	3	21(15%)
Supporting the existing elephant conservation	-	30(21.74%)

Note: the numbers before the parentheses indicate frequencies (number of respondents); those inside parentheses Show the percentages. The number of HEC incidents were collected during the study was from field observation, questionnaire survey, and recorded annual reports of the sanctuary.

Figure 2. The elephant died due to crop-raiding on nearby agricultural land and human villages inside BES (Anani PA)

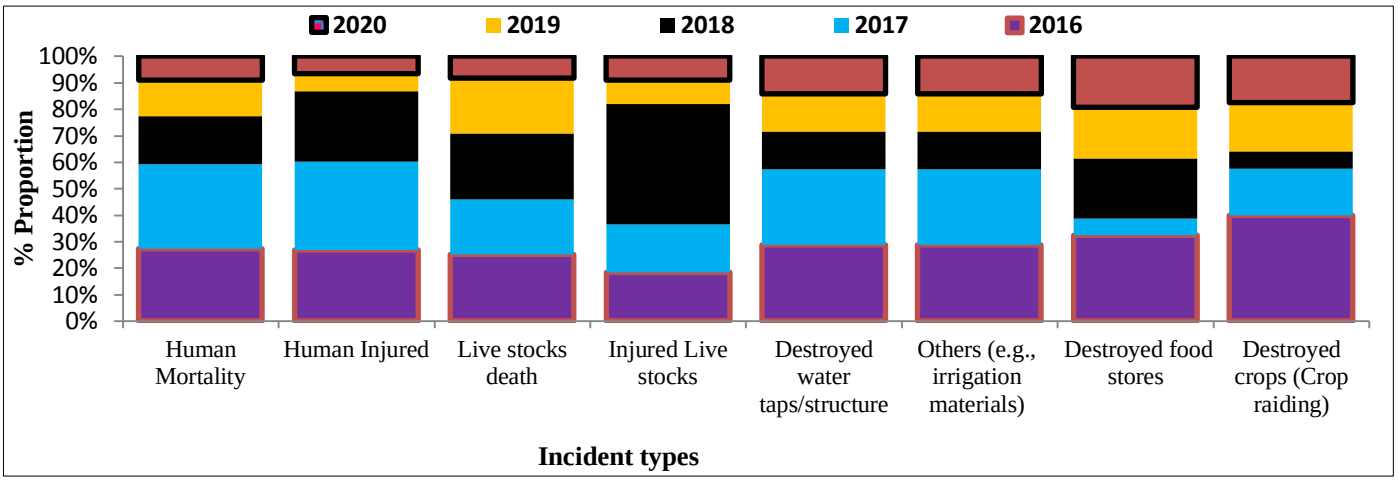

Figure 3. Percentage Proportion of Incident types for the last five years in BES (2016-2020)

The result of this study showed, from all respondents, 87.7% of them perceived as crop-raiding were the major challenge of HEC incidents occurred in BES). According to 27% of respondents thought the Sorghum (*Sorghum bicolor*) and Maize (*Zeal Mays*)

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crops were the two major crops that are impacted by elephant (Table 5)(Figure 3).This study agrees with findings by Mmbaga *et al*.(2017) in Tanzania (Serengeti), 82% of respondents perceived that maize crops were more preferable for elephants than other crops. Similarly finding by Matsika, *et al*. (2020) were reported that, crops such as maize, sorghum and safflower were easily attracted by elephants in the eastern Okavango Panhandle(Botswana). While in Ghana cocoa and cassava was most attractive (Dakwa*et al*., 2016); in India, coffee seemed to attract elephants (Thammaiah and Vijaya Kumara, 2018) and in Asia paddy (Pokharel *et al*., 2019). In this study, only 22 people were killed within five years (2016-2020G.C) (Table 4). It is small as compared to a similar study in Asia where human mortality through elephants was high up to 50 to 70 people/year (Gunawardhana, 2018). The result indicated that 63.67% of respondents agreed on a variety of crops that were damaged by elephants in all study sites (as crop-raiding) with a total loss of 835.2Qt, costing 87,657.27 Birr (2,369.62USD) (Table 5) from 51.3ha of land within five years (2016-2020). However, the cumulative impact was significant *($\chi 2 = 0.98$, DF= 1, $P < 0.05$)*.

Table 5. Respondents view on total estimated yield loss, coverage area, and cost of production in each crop that consumed by elephants in study areas (2016-2020)

Crops type	Number of respondents and percentage (N=138)	yield loss (Qt)	Area (Ha)	Cost of production (ETB)
Mangifera indica	10(7.25%)	42.45	4	3665
Saccharum officinarum L	2(1.45%)	30.07	0.75	1262.5
Carica papaya	6(4.35%)	23.87	2.4	2015
Psidium guajava	4(2.9%)	20.15	4.55	870
Citrus aurantifolia	1(0.72%)	1	0.2	180
Musa paradisiaca	8(5.8%)	17.08	4.3	3068
Sorghum bicolor	19(13.76%)	386.1	16.1	32800
Zea mays	18(13.04%)	261.22	12.4	34307.2
Ipomoea batatas	8(5.8%)	15.06	1.2	2765
Arachis hypogaea	1(0.72%)	3	0.1	6624.5
Capsicum annuum	11 (8%)	34.17	5.3	100
Total	88(63.76%)	835.2	51.3	87657.25

Notes: The frequency/number of respondents (outside) and its percentage (inside) the bracket designated. Where ETB indicates Ethiopian Birr. In this study, the cost of crop production was calculated by adding the labor and variable costs (such as the cost of the ingredients like fertilizer, seed, and herbicides). Due to the absence of necessary information, no other costs were estimated in all study sites

In this study,37 (26.8%) of respondents thought that 67,107.2 ETB (i.e., 76.55% of the total cost of production) was lost from *Sorghum bicolor* (32800ETB) and *Zea mays* (34307.2ETB) due to crop damage by elephants (Table 5). Generally, the most two dominant crops were easily attracted and sensitive to elephants, and also more produced by local people. Besides, there was no compensation were given for the lost crops by elephants as all respondents explained. HEC frequency in the study area was strongly seasonal. For instance, sorghum and maize were sowed in the early month of May and crop-raiding also occurred when the maturity of the crop between August and September occurred. A similar result by Mukeka *et al*. (2018) reported, in Kenya; crop damage through raiding by elephants was highest in August when crops had just matured. In this study, the founded estimated costs of crop loss were about 50 USD per ha (i.e. Exchange rate- during the study was 37Birr/1Dollar). This is relatively very less loss compared to another study by Zu den Autorenanteilen (2017) reported that the yearly cost of elephant raiding in Africa and Asia was 197.44 USD/Year for citronella and lemongrass, and 1270.10 USD/ha for turmeric. The results show that elephants were highly attracted by crops and, hence, HEC was most common in farmlands compared to other land use areas.

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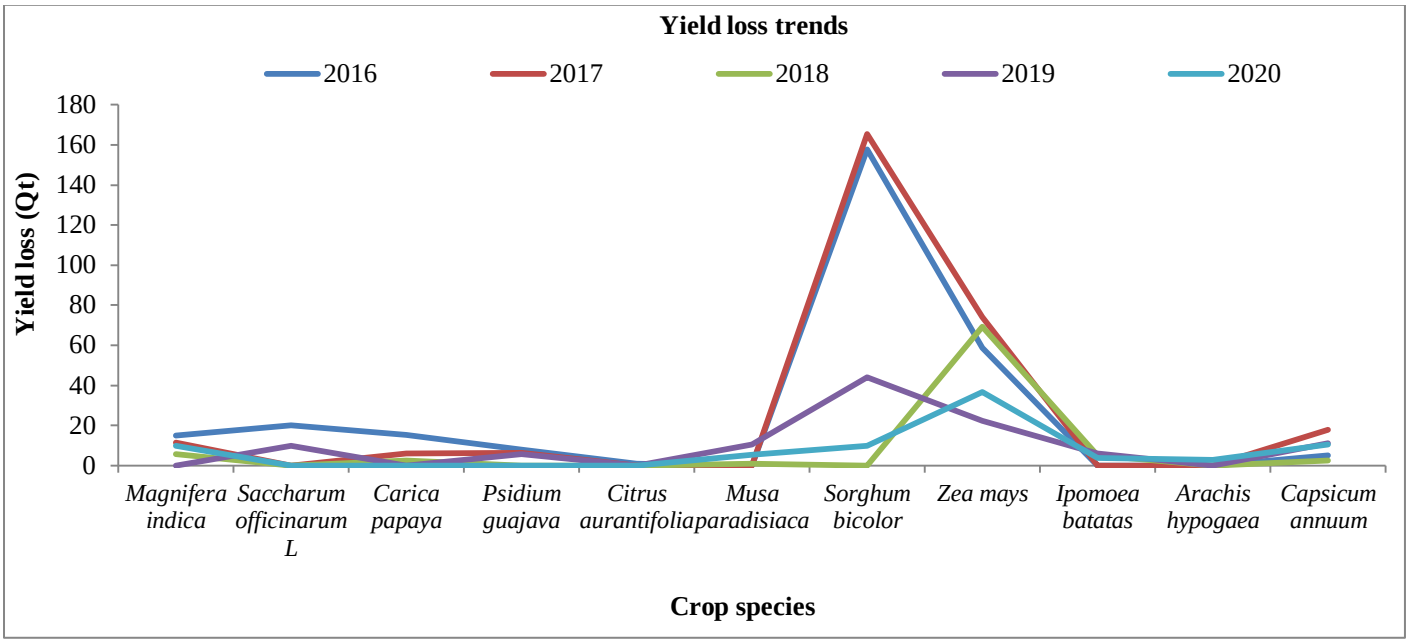

Figure 4. Yield loss trend on each damaged crop by elephants for the last five years in BES (2016-2020)

The field surveys showed that the HEC hot spots in (Ere ebada, Anani, Bilisuma, and Alola) "kebeles" divisions were concentrated at lowland areas, which were dominated by seasonal crops, especially sorghum and maize as well as mixed with only a few settlements. Based on the interview, meetings, and collected data from BES, the lowland areas dominated by farms were reported to have many conflict incidents and were closer (about 5 to 10 km) to the border of the sanctuary (BES). In the study sites, the nearby village or field to the sanctuary increases the likelihood of being affected by elephants. This is similar to the studies conducted by Bhuyan and Kar (2018) and Hariohay *et al.* (2020) in which they concluded that the proximity of a village or field to a protected area might be affected by elephants and other wild animals. The study found that in BES most HEC hotspots were in farmlands adjacent to the sanctuary, which is in agreement with Mmbaga *et al*., 2017 that found high HEC adjacent to protected areas.

3.3. Perception of HEC Prevention and Mitigation Measures

In this study, most respondents 31(67.4%) in Erer ebada "kebele" thought that conserving the sanctuary resources was important to generate an indirect benefit through wildlife tourism (e.g., they thought as some of their children were employed when there are vacancies either seasonal or permanent jobs), during construction and maintenance of some developmental works (such as- roads, local bridge, house of scout and others). Even, they benefited more from the sanctuary than other sites due to nearness (Table 6). There was a significant difference among respondents, through indirect benefit wildlife Protected Areas ($\chi 2$ =70.1, DF= 3, $P < 0.05$). Based on total respondents viewed, 102(74%) of them were thought of as the local community participation (through adult and youth learning system) and less than half (41%) of them viewed, educational programs in schools (through education raising the local people's awareness) were used social services measures (acting as prevention and mitigation) to reduce the HEC. 34(25%) of total respondents thought that fencing the farmlands through beehives (due to the roaming sound of bees) and 18(13%) of them also viewed chili fences (because of natural smelling effect) can chase away elephants when coming to their neighborhood areas. In general, 58% of respondents were supporting the prevention and mitigation measures to be held in the sanctuary to reduce the conflict (Table 6). This view also agreed with (Gross, 2019) who described, in Mozambique, communities started to grow more chili pepper plants after making the discovery that elephants dislike and avoid plants containing capsaicin. So, it is an important farming method to prevent HEC in some peripheral parts of the sanctuary in the areas where local irrigation systems are observed and also cultivate the chili pepper during rainy seasons. Less than 24(17%) of respondents were thought, some digging trenches are importantly practiced to prevent the movement of elephants around their farmlands. Similarly, Nyamwamu (2019) reported that some covered trenches in Uganda on the southern boundary of Queen Elizabeth National Park and the community trenches in India with shallow overlain with branches and leaves have been effective at keeping elephants out of the fields.

In this study, 135 (97.8%) of respondents were arguing that hitting metal objects (i.e., acoustic methods) are essential technical practices to mitigate or reduce the impact when elephants enter into their farmlands. Besides, more than 136(98%) of all respondents were thought of as burning fire and occasional lighting torches (i.e., visual signals) were necessary practiced to mitigate/reduce the impact when elephants entered into their compounding areas (Table 5). The result shows, in the Erer ebada site, all of the respondents (100%) were argued that the acoustic methods and the visual signals techniques were used as mitigation measures (Table 5). This finding is similar to the study reported by (Urio, 2020), the traditional methods, e.g. drums

DOI: 10.54756/IJSAR.2022.V2i3.2

and fire, were carried out by local farmers for mitigation measures of HEC in some African countries (e.g., Central Africa, Ghana, and Southern Africa). According to 132(96%) of all respondents viewed, the watchtowers guarding methods were important to mitigate or make less the HEC impact (i.e., through easily observing the movement of elephants from a remote distance, serving an alarm for the local peoples and then save their possessions (e.g. crops, livestock's, human being and others resources) (Table 5). In this study, all of the respondents (100%) were explained as there were no financial strategies (compensation losses and revenue sharing) that are budgeted to reduce the HEC (Table 5). Most of the African countries were have no financial strategies. However, compensation strategies have been employed in Botswana (Urio, 2020). So, HEC compensation policy at the country level is very important to subsidize local people's possessions that were damaged by elephants. This might imply the long future to conserve the resources and to create a sense of ownership on local peoples. This might reduce the human impact on elephant conservation. Besides community a conservation area are also being practiced for the future and creates faith between government and local communities around sanctuary regarding conservation. Even there was a lack of local participation, or a failure by the government to provide timely payments (Urio, 2020). Hence, implementations of social, financial, and technical measures are important to prevent and/or mitigate the HEC.

Table 6. Perception of respondents (N=138) in prevention and mitigation of HEC

S/N	Activities	Erer ebada (N1=46)	Anani (N2=45)	Bilisuma (N=23)	Alola (N=24)	Total Sum (N=138)
1	Establishment of local rules and regulation	12(26.1%)	9 (20%)	6(26.1%)	7(29.2%)	34(24.6%)
2	Building strong community ownership	12(26.1%)	9(20%)	7(30.4%)	14(58.3%)	42(30.4%)
3	Community outreach (working on relationships, awareness)	17(37%)	12(26.7%)	19(82.6%)	21(87.5%)	69(50%)
4	Participation of local community	39(85%)	27 (60%)	17(73.9%)	19 (79.2%)	102(74%)
5	Education programmes in schools (raising awareness & education)	28(60.9%)	15 (33%)	6 (26.1%)	7 (29.2%)	56(40.6%)
6	Compensation loses	0	0	0	0	0
7	Revenue sharing	0	0	0	0	0
8	Indirect benefit through wildlife tourism	31(67.4%)	9(20%)	3(13%)	7 (29.2%)	50(36.2%)
9	Farming of cash crops (less attractive) to elephants	9 (20%)	6(13.3%)	12(52.2%)	12(50%)	39(28.3%)
10	Chilli fences	6(13%)	4 (8.9%)	3(13%)	5 (20.8%)	18(13%)
11	Beehives fences	9(19.6%)	7(15.5%)	13(56.5%)	6(25%)	35(25.4%)
12	Trenches	6(13%)	5(11%)	4(17.4%)	9(37.5%)	24(17.4%)
13	Guarding using watchtowers	46(100%)	43(93.5%)	22 (96%)	21 (87.5%)	132(96%)
14	Acoustic methods (shouting, hitting metal objects)	46 (100%)	45 (100%)	22(95.6%)	22 (91.7%)	135(98%)
15	visual signals (burning fire and lighting torches)	46(100%)	45 (100%)	22(95.6%)	23(95.8%)	136(98%)
16	Supporting mitigation & prevention	19 (41.3%)	19 (42%)	10 (43%)	10 (41.7%)	58 (42%)

Key: the numbers before the parentheses indicate frequencies (number of respondents); those inside parentheses show the percentages

4. CONCLUSION

The result revealed that HEC incidents occurred in the study area and negatively affected the livelihoods of the local community in the surrounding areas of the sanctuary. The major identified HEC incidents were crop-raiding, human and elephant deaths and injuries as well as depredation of livestock. Maize and sorghum were more affected by elephants than other raided crops. Besides, There was no compensation were subsidized for the lost crops. Based on the study; local peoples were used different techniques such as shouting and hitting metal objects (acoustic methods), burning fire, and occasional lighting torches (visual signals) to reduce the HEC (as mitigation measures). Moreover, fencing the farmlands with beehives and chili besides digging some trenches were used as another technique to prevent the conflict. Even, they used the watchtowers guarding and provision of social services (local community participation and educational programs in schools for awareness) for both mitigation and/or prevention measures depending on the incident that happened. In general, to solve the problems, the observed HEC incidents have to be lowered through combined social, financial as well as technical (prevention and mitigation) measures to increase the coexistence between humans and elephants.

ACKNOWLEDGEMENT

First of all, we would like to express our gratitude to the Eastern Harerge Zone districts and Kebeles offices of Babile, Fedis, Midega tola, and Mayu muluke for their valuable assistance to make the focus group discussants obtainable. Besides, we thank the

DOI: 10.54756/IJSAR.2022.V2i3.2

key informants and the focus group discussants and individuals who assisted during data collection. Our special thanks also go to the staff and scouts of Babile Elephant Sanctuary who helped us while collecting data.

DECLARATION

Abbreviations: HEC- Human-Elephant Conflict, BES-Babile Elephant Sanctuary, HHs-Households, FGD-Focus Group Discussion, NMSA-National Meteorological Service Agency, PA-Peasant Association

Competing interest: All the authors do not have any possible conflicts of interest

Ethical approval and consent to participate: Not applicable

Consent for publication: Not applicable

Ethical approval and consent to participate: Not applicable

Funding: Addis Ababa University for its financial support.

Author contribution: All data collection, analysis, writes up of the draft paper was done by the corresponding author while finalizing, and approving the whole document was by both authors.

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DOI: 10.54756/IJSAR.2022.V2i3.2