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# Human-elephant conflicts in northern Tanzania: Determinants and the perceived effectiveness of local mitigation strategies

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## Abstract

Human-elephant conflicts (HEC) is the major challenge to agropastoral communities who resides within and around protected areas (PAs) in northern Tanzania. Efforts to abate HECs challenges has led communities to adopt a range of tradition elephant deterrence methods. Our study employed 156 household survey and 8 key informant interviews to identify determinants of HEC and assess the perceived effectiveness of the existing traditional mitigation measures in villages around the Enduimet Wildlife Management Area (WMA) in Longido District, Northern Tanzania. The study results show that occupation (agropastoral and pastoral) have significant impact on occurrence of HEC incidences (X-squared = 25.078, df = 7, p-value = 0.000735 suggesting that the area is dominated by agro-pastoral communities and were more likely to experience the conflict with elephants. Of the human-elephant cases reported in the study area, crop raids accounted for 62% of the elephant incidences, infrastructure damage contributed to about 22% and human fatalities accounted for 5%. Also, increase in elephant has been demonstrated to have a favourable and substantial impact on the occurrence of HEC suggesting that an increase in elephant population is associated with a higher likelihood of HEC. Beehive fence and explosives were considered effective in reducing elephant damage. We propose conservation efforts to focus on education, with focus on diversify resident's income to reduce dependence on agriculture and livestock keeping, which is the risky occupations around protected areas due their high exposure to wildlife.

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## Introduction

People and elephants have been interacting for thousands of years; hence the conflicts arising from this interaction are not new (Goswami *et al.*, 2013). However, the prevalence of human-elephant conflicts (HEC) has intensified in recent decades mainly due to competing resource needs, climate change, and increase in human population (Goswami *et al.*, 2013; IUCN, 2021). The escalation of HEC calls for effective mitigation strategies to minimize the negative impacts and promote harmonious existence between humans and Elephants. In Tanzania, HEC is attributed to the continuous growth of human population, increased elephant population (Chakraborty and Paul, 2021) and increased human activities adjacent to the wildlife-protected areas (Kideghesho, 2008). The increase in the interactions between humans and elephants exacerbates incidences of crop raids, damage to properties and infrastructure (e.g water pipes, storage facilities and water sources), and human injuries and death (Hoare, 2015). Between 2012 and 2019, over a thousand incidences of human-wildlife conflicts including injuries and fatalities were documented across the country, with elephants a being a major nuisance and a cause of casualties to rural inhabitants (Ministry of natural resources and Tourism, 2023).

Communities' efforts to mitigate HEC have prompted the development of several traditional techniques to deter elephants from causing damage to human and assets (Graham *et al.*, 2020). The traditional mitigation techniques range from acoustic methods including chasing elephants by shouting, drum-beating, noise-making, use of fire crackers, lights and torches, to construction of elephant barriers such as rubble walls, ditches and canals, biological and electric fences, deployment of alarms, and use of extremely advanced technologies, like satellite telemetry, and compensation and insurance schemes (Fernando *et al.*, 2008, Hoare, 2015; Shaffer *et al.*, 2019; Sitati and Walpole, 2006a). However, the long-term effectiveness of individual traditional methods or their combination is not well understood. Besides, approaches that utilizes barriers like fences are said to be effective (including electric, chilli, solar, and thorn fences) but can be expensive and ecologically challenging as they prevent elephants and other wildlife from reaching seasonal resources beyond their boundaries (Enukwa, 2017). The physical barriers could potentially disrupt genetic flow, negatively impacting breeding patterns, and interfere with the natural structure of the ecosystem (Durant, 2015; Rowan, 2005; Campbell, 2000). Furthermore, the effectiveness of most of the traditional mitigation techniques decreases as elephants become habituated with increased exposure to these deterrents (Runyoro, 2019).

Recently beehives fences, a traditional elephant deterrence method has gained the attention of both rural communities and conservationist. Strategically placing of beehives around agricultural fields or settlements deter elephants, as when disturb the bees would sting elephant (King, 2017). The benefit of beehives as deterrence technique is threefold: first it deters elephant from approaching residents and farms, second, diversify income and nutrition and third, provide pollination services (Chang'a *et al.*, 2016).

Our study assessed determinants, magnitude of conflicts between human and elephant and the perceived efficiency of local mitigation methods used by agro-pastoral and pastoral communities in three villages of Longido district, northern Tanzania. We highlight the determinants and magnitude of HECs in each study village to assist conservation agencies and communities in designing mitigation measures suited to address the unique challenges faced by local communities based on locality.

## Materials and methods

We collected primary data through household interviews, key informant interviews, and camera traps, and secondary data through review of public records and literature. We employed simple random and systematic sampling techniques to select participants from existing household list obtained from the village office. The village register was verified by a group of village officials and residents selected from different sub-villages and were familiar with the socioeconomic and political situation of the village. A total of 156 household were interviewed, with 73, 41 and 42 from the villages of Tingatinga, Leran'gwa, Olmolog respectively. We conducted semi-structured questionnaire survey to gather data on HECs. A total of 3, 3, 2 Key informants from Arusha District Office, Village chairpersons, and Tanzania Elephant Foundation officers, respectively were chosen on the basis of their experience on the area, willingness to share information, and knowledge of HEC occurrences and mitigation methods used.

Data collected include socio-demographic information, experience with elephant incidents, types of mitigation measures applied, determinants of HEC and perceived effectiveness towards elephant deterrents approaches. GPS coordinates were recorded during the household interviews to show sampling points. Direct observation of nearby farms was conducted to identify HEC mitigation measures in study villages. Total of 12, 8, 5 farms were visited in village Tingatinga, Lerang'wa and Olmolog respectively.

Secondary data were collected from records and reports provided by local government authorities. Data on crop raiding incidents and the financial impact of crop damage caused by elephant raids were recorded between 2019 and 2023. The cost was estimated based on the typical yield from one hectare of a specified crop (such as potatoes, maize, wheat, and beans) and its market value.

*Study area*

Our study village is located within Enduimet WMA in Longido district, north-west of Mt. Kilimanjaro. The WMA is an essential link between the Kilimanjaro-Amboseli ecosystems (Riggio and Caro, 2017) (Fig. 1). Enduimet WMA has an area of 751 km² and with annual rainfall between 500 - 600mm. Enduimet WMA is bordered by nine villages includes Olmolog, Sinya, Kitendeni, Tingatinga, Elerai, Ngereyani, Lerang'wa, Irkaswa, and Kamwanga. The area is home to about 175,915 people, mostly of Maasai origin who are pastoralists or agro-pastoralists (NBS, 2022). Large herds of African elephants (*Loxodonta africana*) populations migrating between Kilimanjaro National Park in Tanzania and Amboseli National Park in Kenya utilize the Enduimet WMA as a migrating route, as well dispersal and feeding area (Mukrimaa *et al.*, 2016). Since the establishment of the WMA in 2007, elephant-related conflicts have increased in villages around the area due to the effective restoration of the wildlife habitats in the area as a result of WMA conservation efforts, and the associated increase in competition of natural resources (food and water) due to increase in wildlife populations and climatic changes (Ministry of Natural Resources and Tourism, 2020).

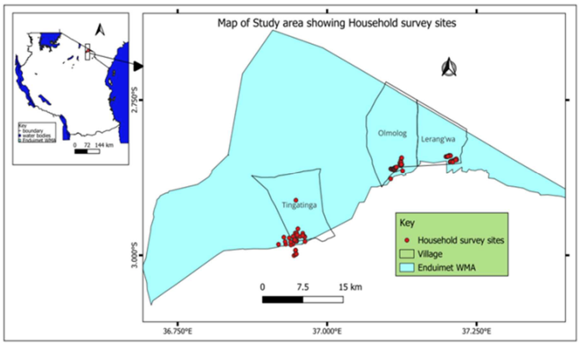


**Fig. 1.** A map of the study area showing the location of study villages around Enduimet WMA, in Northern Tanzania

*Data analysis*

The data collected was organized, processed in an Excel sheet and exported to R version 4.2.1 (R core Team, 2022) for analysis. We used descriptive statistics to summarize data, and chi-square tests to explore the association of different factors on the HECs. We applied analysis of Variance (ANOVA) to evaluate the variations in the mitigation methods between villages. Variables for mitigation methods analyzed include beehive fence, pepper powder, flashlights, communal guards, fireworks, noise-making, shouting, throwing stones, cowbells, burning cow dung, and a combined measure of mitigation strategies. A generalized linear model with a quasi-poisson distribution was carried out in order to determine the relationship between human-elephant conflicts as the response variable and several explanatory variables (village location, water scarcity, shortage of food, increase in the elephant population, increase in human population and climate change). The logistic regression model was fitted using the "glm" function in R, for binary outcome (effective or not effective). The monetary value of the losses was determined by projecting the expected output of the affected farm area and multiplying it by the market prices of the respective crop variety for that year. We present our results in tables, bar plots and photos to enhance clarity.

## Results

*Demographic characteristics of respondents*

A total of 156 respondents were interviewed, where 49% of respondents were female, and 51% were male (Table 1). The chi-square test (X-squared = 5.060e-32, df = 1, p-value = 1) indicated that the sex distribution of respondents showed no notable disparity in relation to the reported occurrence of HEC incidences. The age distribution shows that 8% of respondents were aged 18 –24 years, 27% were aged 25–34 years, 28% were aged 35–44 years, 14% were aged 45–54 years, and 22% were aged 55 and above. The chi-square test (X-squared = 4.9027, df = 4, p-value = 0.2974) indicated no notable disparity in the age distribution of respondents in relation to the reported occurrence of HEC incidences.

**Table 1.** Demographic characteristics of respondents by village in the study area

| Variable | Village | | | Total (%) | Chi-square | p-value |
|---|---|---|---|---|---|---|
| | Lerang'wa | Olmolog | Tingatinga | | | |
| Sex | | | | | | |
| Female | 21 | 17 | 38 | 49 | 5.060e-32 | 1 |
| Male | 19 | 26 | 35 | 51 | | |
| Age | | | | | | |
| 18-24 | 6 | 2 | 5 | 8 | | |
| 25-34 | 9 | 20 | 13 | 27 | | |
| 35-44 | 14 | 15 | 15 | 28 | 4.9027 | 0.2974 |
| 45-54 | 5 | 1 | 16 | 14 | | |
| 55< | 6 | 5 | 24 | 22 | | |
| Education | | | | | | |
| Primary | 18 | 21 | 33 | 46 | | |
| Secondary | 6 | 3 | 11 | 13 | | |
| College/University | 2 | 0 | 3 | 3 | 1.7091 | 0.6349 |
| No formal education | 14 | 19 | 26 | 38 | | |
| Occupation | | | | | | |
| Agriculture | 3 | 0 | 7 | 6 | | |
| Livestock keeping | 0 | 0 | 3 | 2 | | |
| Employed | 0 | 0 | 2 | 1 | 25.078 | 0.001 |
| Agric & livestock keeping | 29 | 34 | 54 | 75 | | |
| Agric, livestock & business | 4 | 6 | 5 | 10 | | |
| Agric, livestock & employed | 3 | 3 | 1 | 5 | | |
| Livestock & employed | 1 | 1 | 1 | 2 | | |

In terms of education level, a large proportion of the respondents (46%) had primary education, 13% had secondary education, 3% had college or university education, and more than a third of the population (38%) had no formal education. The chi-square test (X-squared = 1.7091, df = 3, p-value = 0.6349) indicated no significant difference in education level distribution in relation to incidences of HECs.

Occupation distribution varied significantly between the villages in relation to reported occurrence HEC incidences (X-squared = 25.078, df = 7, p-value = 0.000735). The results show that 6% of respondents were engaged in agriculture only, 2% in livestock keeping only, 1% were employed and 75% of the respondents were engaged in crop cultivation and livestock keeping, 10% in agriculture, livestock, and business, 5% in agriculture, livestock, and employment, and 2% in livestock and employment. This significant variation suggested that occupations differed notably in relation to reported occurrence HEC incidences.

*Perceived determinants of HEC*

After examining the influence of individual explanatory variable (village location, water scarcity, shortage of food, increase in the number of elephant, increase in human population and climate change) on the response variable, we employed generalized linear model with a quasi-poisson distribution (Table 2) to determine the relationship between HECs as the response variable and the explanatory variables listed above. The analysis indicates that an increase in elephant populations (coefficient = 0.1269, p = 0.0275) has a positive and significant effect on the occurrence of HECs, suggesting that an increase in elephant population is associated with a higher likelihood of HECs. Other factors, such as climate change, food/forage shortage, water scarcity, and human population had p-values > 0.05 suggesting no significant effect on HECs. In comparison to Lerang'wa village (reference category) and other villages (p > 0.05) indicate that location was not significantly associated with HECs levels.

**Table 2.** Coefficients of factors influencing human-elephant conflicts

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | -0.0791 | 0.0528 | -1.499 | 0.136 |
| Olmolog | 0.0016 | 0.0546 | 0.03 | 0.976 |
| TingaTinga | -0.0146 | 0.0546 | -0.267 | 0.7896 |
| Water scarcity | -0.0141 | 0.0454 | -0.31 | 0.7571 |
| Food/forage shortage | 0.0344 | 0.044 | 0.782 | 0.4355 |
| Increased human population | -0.0958 | 0.0657 | -1.459 | 0.1467 |
| Increased elephant population | 0.1269 | 0.057 | 2.226 | 0.0275 * |
| Climate change | 0.0207 | 0.0496 | 0.418 | 0.6762 |

**Table 3.** Occurrence of human-elephant's conflicts across villages

| Source of variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Human elephants' conflicts | 4369.733 | 4 | 1092.433 | 19.1543 | 0.000369 | 3.837853 |
| Villages | 1057.733 | 2 | 528.8667 | 9.27294 | 0.008248 | 4.45897 |
| Error | 456.2667 | 8 | 57.03333 | | | |
| Total | 5883.733 | 14 | | | | |

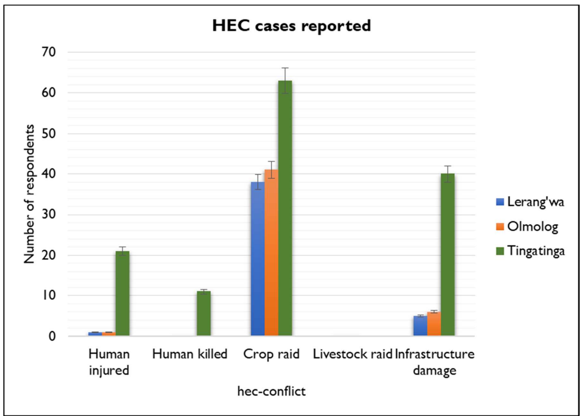


**Fig. 2.** Type of conflict cases reported in Olmolog, Lerang'wa and Tingatinga.

*Human-elephant conflicts in the study area*

Human injuries and death, crop raids and damage to infrastructure were reported as the main human-elephant conflicts in the study villages (Fig. 2). From 2019 to 2023 on human injuries showed that 1 person was injured in Lerang'wa, 1 in Olmolog, and 21 in Tingatinga, making up 11% of the total HEC incidences. For human fatalities, there were no deaths reported in Lerang'wa or Olmolog, while 11 deaths were reported in Tingatinga, accounting for 5% of the total elephant incidences reported. Crop raids account for 62% of the total elephant incidences recorded in the study area. Infrastructure damage contributed to about 22% of the total elephant incidence reported. ANOVA results shows significant differences between the types of HECs, including human injuries, human fatalities, crop raids, and infrastructure damage (Table 3). The calculated F-value of 9.2729, with a p-value = 0.0082, suggests that conflict types varied significantly across the three villages (Lerang'wa, Olmolog and Tingatinga).

Additionally, there were no records of retaliatory killings of elephants by the local community.

*Magnitude of loss of crop raid from elephants*

Over five years (2019 -2023), the total losses due to crop damage (beans, maize, potatoes, tomato, sunflower, banana, wheat and peas) as a result of elephant raids in Lerang'wa, Olmolog, and Tingatinga combined amounted to 525.7 Hectares of cropland. These losses represented an average of approximately 21% of the total crop area cultivated each year in the three villages (Fig. 3). This shows the significant economic impact and ongoing challenges posed by the cumulative losses experienced in the study area (Districts Reports, 2023). Olmolog recorded the highest losses in 2023 compared to previous years indicating higher prevalence in the year as compared to other villages in study area.

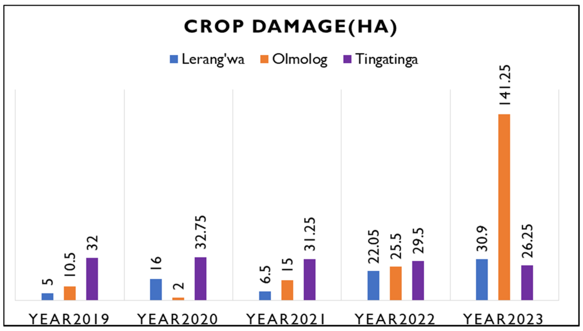


**Fig. 3.** Area of cultivated crop damaged by elephant raid in the study area between 2019 and 2023

Using secondary data recorded between 2019 and 2023, the monetary impact of crop damage caused by elephant raids was estimated based on the typical yield from one hectare of a specified crop (such as potatoes, maize, wheat, or beans) and its market value. The losses were calculated by determining the area of land on which a specific crop was grown and subsequently raided by elephants, the expected yield, and multiplying it by market prices of the respective crop for that year.

The highest crop-specific loss was reported in maize fields (110 Ha), followed by bean fields (77 Ha) in 2023, estimated at USD 90,459.26. The lowest incurred loss was recorded in 2020 at USD 651.85 (Fig. 4). Olmolog village recorded significant crop damage in 2023, this is attributed to the large maize cultivation area affected while Tingatinga had the highest damage in 2020 (16,299.25 USD). Overall, Olmolog had the highest cumulative crop damage over the five years (112,270.58 USD), followed by Lerang'wa, despite having lesser maize fields affected, incurred losses of (64,733.33 USD) and Tingatinga with high potato crop damage (62,435.9 USD). This explains the economic losses caused by elephant raids with varying levels of crop damage experienced in each village and the type of crop cultivated.

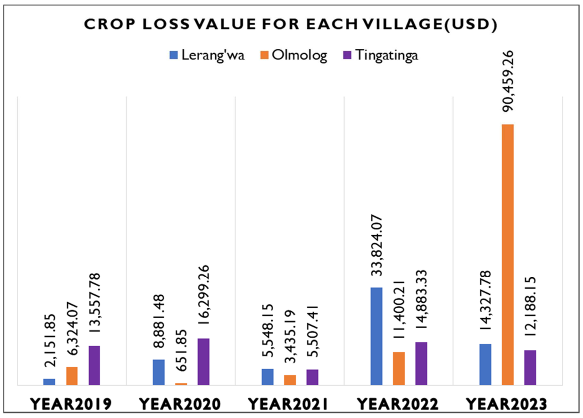


**Fig. 4.** Monetary value of crop losses caused by elephant raids in the study area by year

*Traditional human elephant conflicts mitigation measures*

Based on the survey and field visits, mitigation measures used by local communities were flashlights, bee hives fence, fireworks/explosives, drum beating, noise/shouting, community guard, cowbell, pepper powder, and burning cow dung. The adoption of mitigation methods between villages varied considerably (Fig. 5&6). Flashlight was the most commonly employed mitigation measure, reported by 62% of respondents. The analysis of variance (Table 4) showed no significant variation (p-value = 0.2974, F-value= 0.4952) in the use of flashlight mitigation strategies between villages. Noise/shouting was used by 46% of respondents, but there was no significant difference between villages (p-value = 0.05037, F-value= 3.064). The low f-value suggests that village factors moderately affect the use of the mitigation measure. A significant difference was observed on the use.

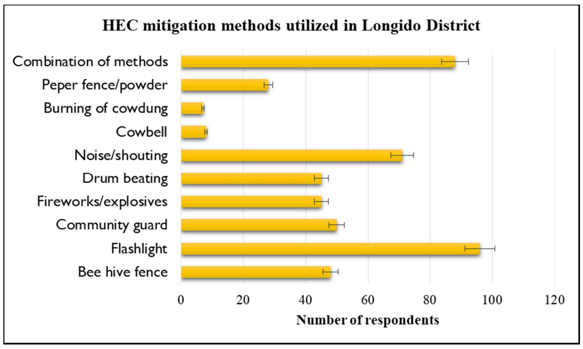


**Fig. 5.** Local HEC mitigation measures used by communities in the study area

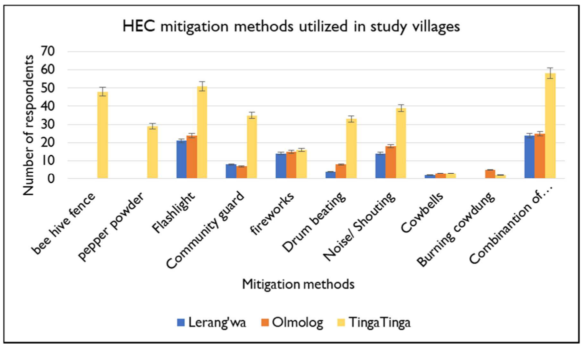


**Fig. 6.** Local HEC mitigation measures used in each village

*Perceived effectiveness of the existing measures*

Multivariate logistic regression analysis, based on survey data collected in the study villages, shows that among the specific mitigation methods, the coefficient for beehive fences is 2.5514, indicating a significant positive impact on the effectiveness of deterring elephants ($p < 0.00001$). Similarly, the use of fireworks/explosives shows a coefficient estimate of 1.8745, suggesting a significant positive impact on effectiveness ($p = 0.000139$). In contrast, the coefficient estimate for the use of flashlights is 0.6766, ($p = 0.140183$), implying that flashlights may not have a significant effect on effectiveness (Table 5). Furthermore, the use of drums exhibits a coefficient estimate of 1.1202, signifying a significant positive association with effectiveness ($p = 0.041508$). Conversely, shouting shows a coefficient estimate of -1.2828, indicating a significant negative impact on effectiveness ($p = 0.015951$), suggesting that shouting is not considered an effective elephant deterrent. The coefficients for the use of cowbells and communal guarding measures are -0.0169 and 0.7047 ($p > 0.05$) respectively, suggesting that these methods may not have a substantial impact on effectiveness.

**Table 4.** Analysis of mitigation methods and village variations in human-elephant conflict management

| Measure | Df | Sum Sq | Mean Sq | F value | Pr(>F) |
|---|---|---|---|---|---|
| Beehive fence | 2 | 3.7957 | 1.89787 | 24.293 | 1.386e-09 |
| Fireworks/explosives | 2 | 0.000 | 0.000019 | 1e-04 | 0.9999 |
| Flashlights | 2 | 0.2521 | 0.12603 | 0.4962 | 0.6101 |
| Drum beating | 2 | 0.2071 | 0.10354 | 0.9061 | 0.4068 |
| Noise/ shouting | 2 | 1.294 | 0.64702 | 3.064 | 0.05037 |
| Communal guarding | 2 | 0.1125 | 0.056251 | 0.4058 | 0.6674 |

**Table 5.** Logistic regression for mitigation methods in human-elephant conflict management

| Coefficients: | Estimate | Std. Error | z value | Pr(>\|z\|) |
|---|---|---|---|---|
| (Intercept) | -1.9437 | 0.4268 | -4.555 | 5.25e-06*** |
| Bee hive fence | 2.5514 | 0.5791 | 4.406 | 1.05e-05*** |
| Fireworks /explosives | 1.8745 | 0.4920 | 3.810 | 0.000139*** |
| Flashlights | 0.6766 | 0.4587 | 1.475 | 0.140183 |
| Noise/drums | 1.1202 | 0.5495 | 2.038 | 0.041508* |
| Shouting | -1.2828 | 0.5323 | -2.410 | 0.015951* |
| Cowbells | -0.0169 | 0.9374 | -0.018 | 0.985619 |
| Communal guard | 0.7047 | 0.5472 | 1.288 | 0.197796 |

## Discussion

*Demographic and socio-economic characteristics of (HEC)*

Demographic and socio-economic factors significantly influence attitudes, beliefs, and willingness to participate in elephant conservation efforts (Nad and Basu-Roy, 2024). Occupation had a significant association with the likelihood of experiencing HEC, while gender, age, and education had a non-significant association with HEC events. The majority of households (75%) relied on agriculture for sustenance and livelihood, making them vulnerable to losses due to crop raiding. This vulnerability makes agricultural communities less inclined to accept elephants with unwavering tolerance (Chang'a *et al.*, 2016; Hoffmeier-Karimi and Schulte, 2015; Mmbaga *et al.*, 2017; Montero-Botey *et al.* 2024; Sitati and Walpole, 2006b). The lower level of education among respondents in the study area could be due to socio-economic barriers within agro-pastoral communities in Tanzania, potentially leading to negative perceptions regarding elephants. Education plays a crucial role in raising awareness about wildlife conservation for sustainable biodiversity (Nad and Basu-Ro, 2024). Communities with higher levels of education tend to have a positive perspective towards elephants, possibly influenced by diversified income sources beyond agriculture. However, individuals with lower educational backgrounds, particularly those with no formal education or limited primary education, tend to display negative tolerance towards elephants compared to their more educated counterparts (Malley and Gorenflo, 2023).

*Human-elephant conflicts in the study area*

Elephant-induced crop raiding (HEC) is the most significant form of HEC, causing severe direct costs on households in the three villages. About 95% of respondents reported losses attributed to elephants, with 92% related to crop raids which have been observed to vary significantly across study villages in Enduimet WMA consistent with findings in studies by (Kiffner *et al.*, 2021; Mukeka *et al.*, 2018). Tingatinga experienced the most significant number of human casualities and injuries as villagers protected their farms at night and grazing livestock close to protected areas. Infrastructure damage was more common in Tingatinga, suggesting a greater level of human-elephant interaction. The lack of reported retaliatory elephant killings suggests covert or discreet acts, making it challenging to detect or document such incidents in the area (Runyoro, 2019). Similarly, (Pastorini *et al.*, 2011) highlights the variation in HECs types across different regions, with crop raiding being the most common type in one area and human-elephant encounters being more prevalent in another. Our findings emphasize the importance of localized approaches to managing HECs.

*Determinants of HEC*

Over the past three decades, research has focused on understanding the factors for human-elephant conflicts (Graham *et al.*, 2009; Hoare 1999; Osborn and Parker, 2003; Sitati *et al.*, 2003). Our found a significant positive correlation (coefficient = 0.1269, p = 0.0275) between an increase in elephant populations and the occurrences of HECs, in line with studies by (Chakraborty and Paul, 2021) and (Hoare, 2000). In West Kilimanjaro for example, elephant population increased from 150 elephants to 400 in 2003 to 600 in 2010, possibly due to conservation measures supported by Non-Government Organizations (Abbot *et al.*, 2007; Blanc *et al.*, 2007; Kikoti *et al.*, 2010). Comparison of HECs between villages showed no significant differences in their impact on elephant conflicts. Our findings suggest that factors beyond village location play a role in human-elephant conflicts, emphasizing the necessitating for a better understanding of these complex interactions.

*Perceived effectiveness of the existing measures*

Our study reveals a range of mitigation practices in reducing the impact of HECs on agricultural activities. Mitigation measures, such as flashlights, beehives fence, fireworks, drum beating, noise/shouting, community guard, cowbell, chili powder, and burning cow dung, are used by local communities to deter elephants from their farms. The effectiveness of these mitigation measures varied with beehive fence being considered more effective than other methods. (King *et al.*, 2011; Scheijen *et al.*, 2019) suggest that beehive fence mitigation technique has a potential to prevent elephants from entering the farms. Elephants tend to flee from their location upon encountering bee sounds due to the painful sting by bees (King *et al.*, 2023). However, the presence of beehive fence alone does not entirely keep elephant from entering the farm (Cook *et al.*, 2018; Hariohay *et al.*, 2020; Kiffner *et al.*, 2021).

The most commonly employed strategy among three villages was the use of flashlights. This method is preferred because elephants typically avoid bright lights, making flashlights an effective deterrent against their presence. However, this approach may not be feasible during daylight hours, and due to its limitations, particularly the high cost of acquiring LED flashlight (55 USD). Additionally, sounds and lights are less effective strategies (Sitati *et al.*, 2005), as respondents perceive that elephants become accustomed to them. We also found that a "combination of methods" had the second highest number of respondents, suggesting that communities often employed a mix of different mitigation approaches rather than relying on a single approach. Our results are consistent with studies by (Hariohay *et al.*, 2020; Sitati *et al.*, 2005; Sitati and Walpole, 2006b) who suggested that a combination mitigation technique can succeed over extended periods, reducing the chance for elephants to habituate a specific strategy.

**Conclusion**

HECs is a significant challenge agropastoral villages bordering wildlife rich landscapes in Tanzania, with resident high dependence on agriculture being a significant factor influencing conflict occurrence. We show that factors such as gender, age, location, and education do not influence conflicts. We also show that villagers use various strategies, such as flashlights, bee hives fences, fireworks, drum beating, noise, community guards, cowbells, pepper powder, and burning cow dung to deter elephants, yet the methods do not completely eliminate the challenge. The challenges are exacerbated by lower level of education among residents, growth of elephant populations, climatic changes and the rapid increase of human population. Holistic approaches therefore are needed to abate HECs. We emphasize the need for increased education that can promote the diversification of individual residents' income portfolio by reducing their dependence of agriculture.

**Recommendation(s)**

Given that this study focused on traditional mitigation methods employed as elephant's deterrent in agriculture settings, there is a pressing need for further investigations to explore utilization of advanced technologies such as smart-mobile phones, satellite imagining, drones, and artificial intelligence for real-time monitoring of elephant movement and early warning detection of potential conflict zones.

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