***Elephants**: Moving from Conflicts to Coexistence with People in Enduimet Wildlife Management Area, West Kilimanjaro*

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Project team:

John Erasto Sanare
Kimani Mollel
Kisota Laizer
Rehema Mosses

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Executive Summary

Elephants face threats, from ivory poaching, negative human-elephant interactions and habitat loss. Poaching has been responsible for the drastic reduction of elephant populations across Africa, from an estimated one million in 1970 (Douglas, 1987) to 400,000 in 2016 (Chase,2016). In 2009 Africa's human population hit one billion, having doubled since 1982, and it is expected to double again, by 2050 (UNDESA, 2017). The associated conversion of natural habitats into human-dominated landscapes squeezes wildlife into smaller isolated land, where resource availability is reduced, subsequently human-elephant conflicts (HECs). Elephants are known to enjoy maize, beans, banana and other crops. They can also cause damage when they enter settlement areas, water points destruction and other property which can occur when they get during migratory movements. Expanding agriculture in Enduimet Wildlife Management Area (EWMA) is understood to be driving conflicts levels higher. Since 2016, EWMA has recorded an increase in crop damage incidents by elephants (56 in 2016 to 186 in 2020). Controlling conflict is difficult as elephants are smart and use different tactics to raid crops while avoiding mitigations from farmers and wildlife rangers. From our analysis results shown that the areas at higher risk of HECs are farms located within 11 km from protected area where elephant reside and also corridor connecting Kilimanjaro and Arusha National Parks in Tanzania and Kenya respectively, implying that anthropogenic activities destroyed elephant habitat and blocked elephant migratory corridor.

Acknowledgments

We acknowledge the Rufford Foundation for providing funding for this project. We are grateful to the Tanzania Wildlife Research Institute (TAWIRI) and Tanzania Commission for Science and Technology (COSTECH) for granting the research permit. Thanks also to District Executive Officer (DEO) of Longido District, Enduimet Wildlife Management Area (EWMA) and Village Executives Officers (VEOs) for allowing household surveys to be conducted in their communities and granting us the research permit and access to the field work.

1.0 INTRODUCTION

Tanzania's protected area network covers about 32.5% of it is land surface 307,800 km^2 (Hariohay *et al.,* 2020), where the African elephant (*Loxodonta africana*) home range and movement patterns are estimated to cover about 41% of the country's land (Kioko, 2011). In the early 1950s, Tanzania's elephant population was believed to found in 90% of the entire country's land area and was estimated at 80,000 individuals (Thouless *et al.,* 2016). They have experienced more than 50% overall decline of their population size within the last 30 years from 1989 to 2019 (Gubbi, 2012; Mwakatobe, Nyahongo *et al.,* 2014; Naughton-Treves, 2019), enough to be listed as "*endangered*" under IUCN red list 2020 (IUCN, 2020; Thouless *et al.,* 2016). However, since 2014, the elephant population in Tanzania slightly increased to approximately 60,000 individuals in 2019 (Gubbi, 2012; Mwakatobe, Nyahongo *et al.,* 2014; Naughton-Treves, 2019).

In Tanzania elephants mainly resides in protected areas (PAs), where intensive conservation practices are conducted (Mwakatobe, Nyahongo, *et al.,* 2014). Nevertheless, they spend considerable time outside PAs, especially during dry season in search for scanty resources such as water and forage. While outside the PA boundaries, elephants have always been facing significant conservation challenges such as poaching and increased human-elephant conflicts (HECs) (Jones *et al.,* 2012). Several studies reported that HECs are becoming more frequent, since part of the African elephant's range lies outside of PAs, overlapping with human activities is an unavoidable phenomenon (Graham *et al.,* 2009; Hariohay *et al.,* 2020; Sitati *et al.,* 2003; Tiller *et al.,* 2021). In Tanzania, the human-elephant interface, at which conflicts can occur, is rapidly expanding due to population pressures and escalating demand for natural resources compounded by rapid demographic, socio-economic, Land Use/Land Cover (LULC) changes and conflicting national policies (Kioko, 2011). In addition, land conversion because of growing human populations has increasingly fragmented the wildlife habitat decreasing the space available to elephants and other wildlife in many areas of the country (*Graham et al.,* 2009). This has hampered the connectivity between PAs, leading to increased levels of HECs, ranging from mild forms of conflict over elephant impact on their natural environment to more severe forms where both human and elephant lives have been lost (Mukeka *et al.,* 2019).

Fragmentations and loss of wildlife habitats in the vicinity of PAs leading to blockage and/or loss of wildlife migratory corridors has mainly been due to encroachment through various anthropogenic activities including an expansion of human settlements and farming which also involves livestock grazing (Graham *et al.,* 2009). This have been reported as among the critical threats to wildlife survival in different PAs in Tanzania.

Establishing and effective management of wildlife conservation corridors to link PAs networks was recently recommended to facilitate wildlife movements and reduce HECs (Mbane *et al.,* 2019). In 2013, two wildlife migratory corridors were formerly established for conservation in Tanzania namely, Kitendeni wildlife corridor in the Enduimet Wildlife Management Area connecting Kilimanjaro with the Amboseli National Parks in Tanzania and Kenya respectively and Umemarua wildlife corridor connecting Ruaha National Park and Mpanga-Kipengere Game Reserve (Mbane *et al.,* 2019). However, Kitendeni wildlife corridor in Enduimet Wildlife Management Area (EWMA) is still under threat due to the rapid increase in the human population which is not only blocking the corridor and elephants' movements but also has resulted in an amplified HECs (Jones *et al.,* 2012).

Henceforth, to address this gap of knowledge, we tangled nine (9) villages members forming Enduimet WMA namely; Lerangwa, Kitendeni, Irkaswa, Endonyomali, Tingatinga, Lerangwa, Sinya, endonyimali and Olmolong) to address to our objectivies on; (i) examine the trend of human elephant conflicts hotspots areas and elephant season home range (ii) to assess the impact of HECs on crop (iii) Review the approaches used for HECs mitigation assessing local communities' perceptions towards mitigating HECs and; (v) Rise elephant's conservation awareness among local communities.

2.0 MATERIALS AND METHODS

2.1 Description of the study area

The study was conducted in nine (9) villages that forms Enduimet Wildlife Management Area (EWMA). The EWMA is a wilderness area that covers 752 km^2 (Minwary, 2009), within the Longido District, in the Arusha Region (figure 1). The area is bordered by Kilimanjaro National Park (KINAPA) to the South-east, Tanzania-Kenya political boundary to the North and Ngasurai plains open area to the West (Sayuni B Mariki *et al.,* 2015) and joining the Kilimanjaro-Amboseli ecosystems and functioning as an important wet season dispersal area and feeding ground for Amboseli and Kilimanjaro wildlife. The EWMA was established in 2003 under the Tanzania wildlife policy of 1998 and comprises nine villages (Dekker, 2018) mainly distributed along the productive slopes of Mt. Kilimanjaro. As many as 1600 elephants monitored by the Amboseli Trust for Elephants (ATE), spend 30% part, or most of the year in EWMA (Kikoti, 2009), EWMA represents an important wet season sanctuary for elephants (*Loxodonta africana*) and other species including wildebeest (*Connochaetes taurinus*), lions (*Panthera leo*), zebras (*Equus quagga*) and African buffalos (*Syncerus caffer*) few to mention (Okello *et al.,* 2016). The average annual rainfall of EWMA ranges between 300mm and 600mm, daily average temperatures between 30°C to 35°C and it covers an elevation ranging between 1,230m -1,600m (Trench *et al.,* 2009). The long rainy season lasts from March to May, while the short rains season lasts from August to October (Mbane *et al.,* 2019), and cropping has become common during these months amongst the agro-pastoralists (Mbane *et al.,* 2019). Farmers practice small scale farming and plant crops that mature fast and are droughts tolerant such as maize and beans.

The vegetation in EWMA is primarily comprised of mixed Acacia woodlands, including *vachellia commiphora* brushland, *vachellia tortilis* savannah and *Sporobulus* short grass plains, typical of semi-arid East African savannah (Mbane *et al*., 2019) (Figure 2). The EWMA comprises the Kitendeni widlife corridor, which connects the Kilimanjaro and Amboseli national parks in Tanzania and Kenya respectively (Sayuni B Mariki *et al.,* 2015) and serves as a major transboundary migratory corridor for many wildlife species, including the African elephant (Muruthi & Frohardt, 1999). This remains the only formally protected wildlife corridor that links the West Kilimanjaro ecosystem to other ecosystems, after the blockage of other corridors that link Lake Natron Game Controlled Area (GCA) and Arusha and Mkomazi National Parks (Noe, 2003). The EWMA contains arable and fertile lands with high agricultural potential and a number of human settlements, in particular the villages of Tingatinga, Elerai, Lerang'wa, Kamwanga, Irkaswa and Olmolog which has intensified recently(Noe, 2003).The corridor is, however, under threat following the expansion of human activities in the area and the changes in land use over the years (Kija *et al.*, 2020). The human population in EWMA is about 57,103 people, having increased by 30% between 1988 and 2017 (Dekker, 2018). Although traditionally the resident Maasai are nomadic pastoralists, agriculture and tourism-related activities are becoming an important source of income (Songorwa, 2004).

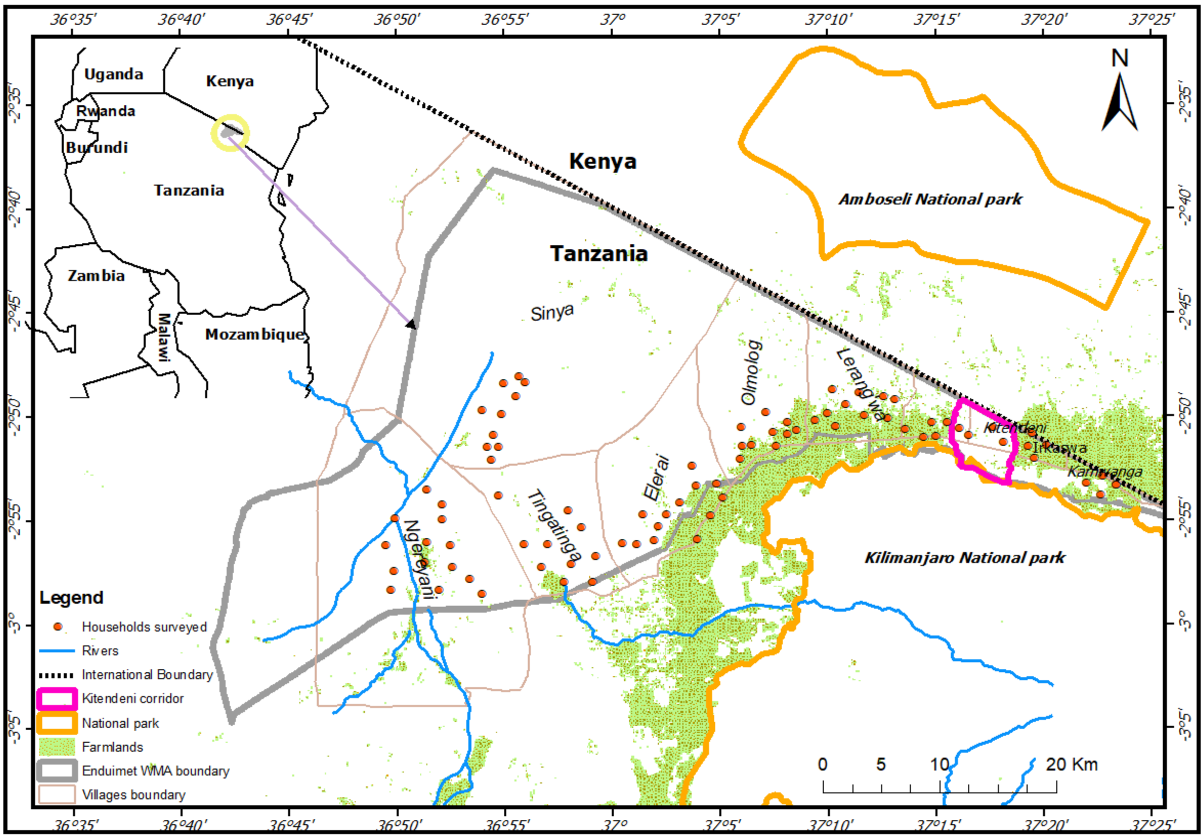

Figure 1: *Map of the study area showing the location of Enduimet Wildlife Management Area*

Figure 2: *Vegetation cover savannah in the Enduimet Wildlife Management Area.*

2.2 Data collection
In order to address the objectives intended for this study, we employed the following approaches.

Firstly, Literature review; Different reports, books and journals on HECs, management techniques and mitigation measures both printed and electronic materials were reviewed to get enough insights on the subject matter before commencement of the field activities. Secondly, the study used purposive sampling; targeting 96 members from each village for 10 villages forming EWMA were selected and included in the project, in total, we had 960 participants from all villages, with the current human population in EWMA being about 37,000 people, having increased by 30% between 1988-2017. All the participants were given a questionnaire regarding HECs on the frequency of elephant visits in villages, the incidence of crop-raiding, property damaged, crops frequently raided, a season in which crops are raided, and what management techniques applied by farmers to mitigate and control elephants from raiding crops. Thirdly, Training; To conduct training relating to the education on the HEC issues, several educational resource materials focusing on the elephants' educational resource materials were established in the form of banners, posters, stickers, placards, booklets, education kits and HECs mitigation banners, education materials both in (print out and electronic media) to share the information about elephants' ecology, behavior and importance for the EWMA landscape in general. Additionally, in Implementing elephant conservation awareness & outreach activities: this project, used 5 days to conduct conservation education and HECs mitigation awareness programs.

2.3 Data analysis

Data were analysed by using SPSS statistical package (version 22; IBM). We used descriptive statistics in summarizing the data collected in forms of figures and tables. For the crop-raiding patterns a chi-square goodness-of-fit test was used to investigate differences in type of cultivated crops and elephant crop raids across villages and seasons. Furthermore, Mann-Whitney U-tests were used to assess differences between average wet and dry season home ranges, and sex differences in home range between seasons.

2.4 Ethics consideration

We thank the Tanzania Wildlife Research Institute (TAWIRI) and Tanzania Commission for Science and Technology (COSTECH) for granting the research permit to conduct this study. We also thank DED at Longido Districts, Enduimet Wildlife Management Area (EWMA) and VEOs of Kitendeni, Tingatinga and Elerai, Irkaswa and Sinya, for allowing household surveys to be conducted in their communities and granting us the research permit and access to conduct the field work to carry out this assessment survey.

3.0 RESULTS AND DISCUSSION

3.1 Mapping Human-Elephant conflicts hotspots areas and trend in Enduimet Wildlife Management area

The total number of 823 HECs incidents were recorded between 2016 and 2022 across the nine (9) villages forming the EWMA in which 796 (96.7%) incidents had crop damages while 27 (3%) incidents with no crop damages). Most of the crop raiding events (98.7%, *N*=812) took place during the night and raiding elephant groups ranged in size from 1 to 60 (median 4), with 70% of groups being greater than 10 elephants. The most affected village in Enduimet WMA during the entire study period was Tingatinga (68.4%, *N*=563), followed by Ngereyani (13.6%, *N*=112), Lerang'wa (7.8%, *N*=64), and Kitendeni (6.3%, *N*=52), while Elerai, Irkaswa, Kamwanga and Ol'molog experienced the lowest number of HECs events (1.2% *N*=10, 1.6% *N*=13, 0.2% *N*=2, and 0.9% *N*=7, respectively). Furthermore, we found that Tingatinga and Ngereyani are statistically significant hotspots of HECs occurrences (Figure 3).

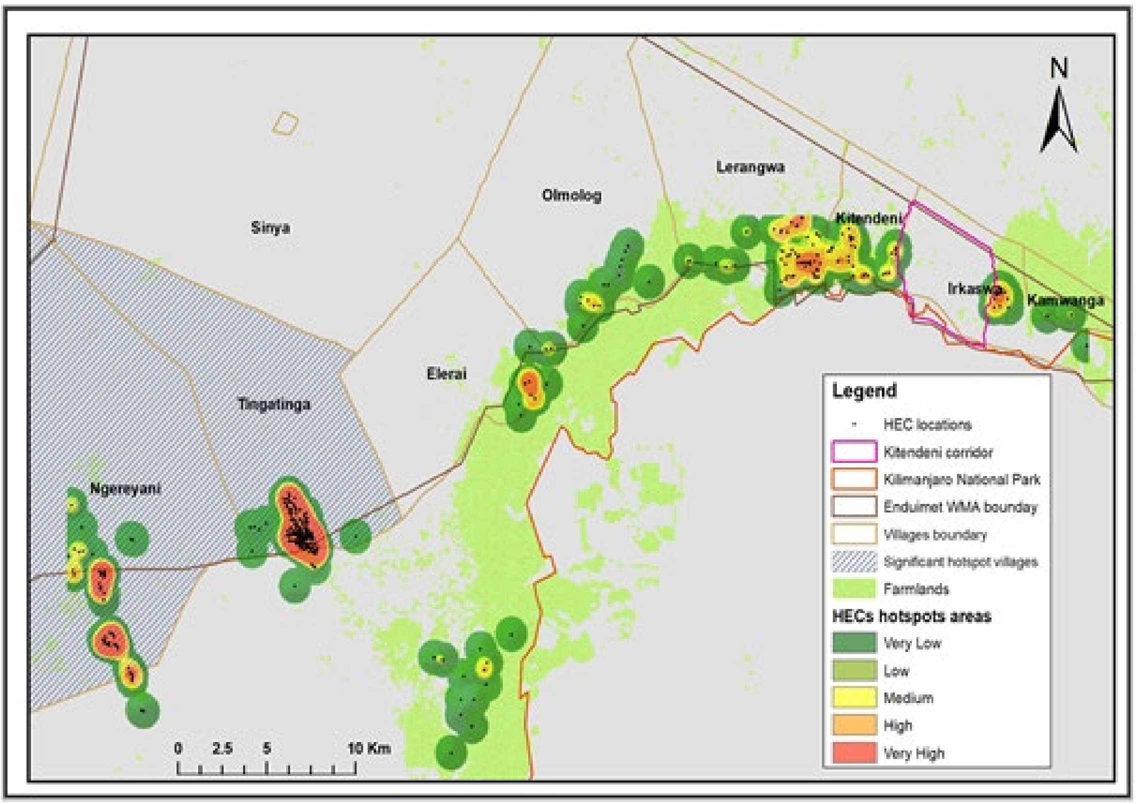

Figure 3**:** Human elephants conflicts hotspots areas in the Enduimet Wildlife Management Area.

3.2 Influence of distance from the PAs to the occurrence of HECs

We also found that elephant crop raid incidences occurred to farmland cultivated closer to park boundary, Thus the nearer the farmland from the park boundary the higher the elephant crop raid incidences, results revealed a negative significant relationship between farmland distance from the park boundary and HECs occurrence (β =-1.15; p =0.005). the elephant raids occurred most often in farmland located up at the edge of the park boundary (80% of incidents), concentrating on areas bordering the Park and up to 20 km, and on agricultural areas within Kitendeni wildlife corridor. A small number of raids (2%) occurred (21-40 km) from the PA boundary especially in the villages of Lerangwa, Kitendeni and Irkaswa where the corridors connecting Amboseli and Kilimanjaro national parks lie on, while in Tingatinga and Ngereyani the areas at higher risk of HECs as farms located within 11 km from bushland and forest where elephant reside and also corridor connecting Kilimanjaro and Arusha National Parks, implying that anthropogenic activities destroyed elephant habitat and blocked elephant migratory corridor, Our results coincide with those of previous studies who found that croplands with higher PA frontage could expect higher chances of crop raiding (Hoare, 2000; Janaki Lenin, 2011) (figure 4).

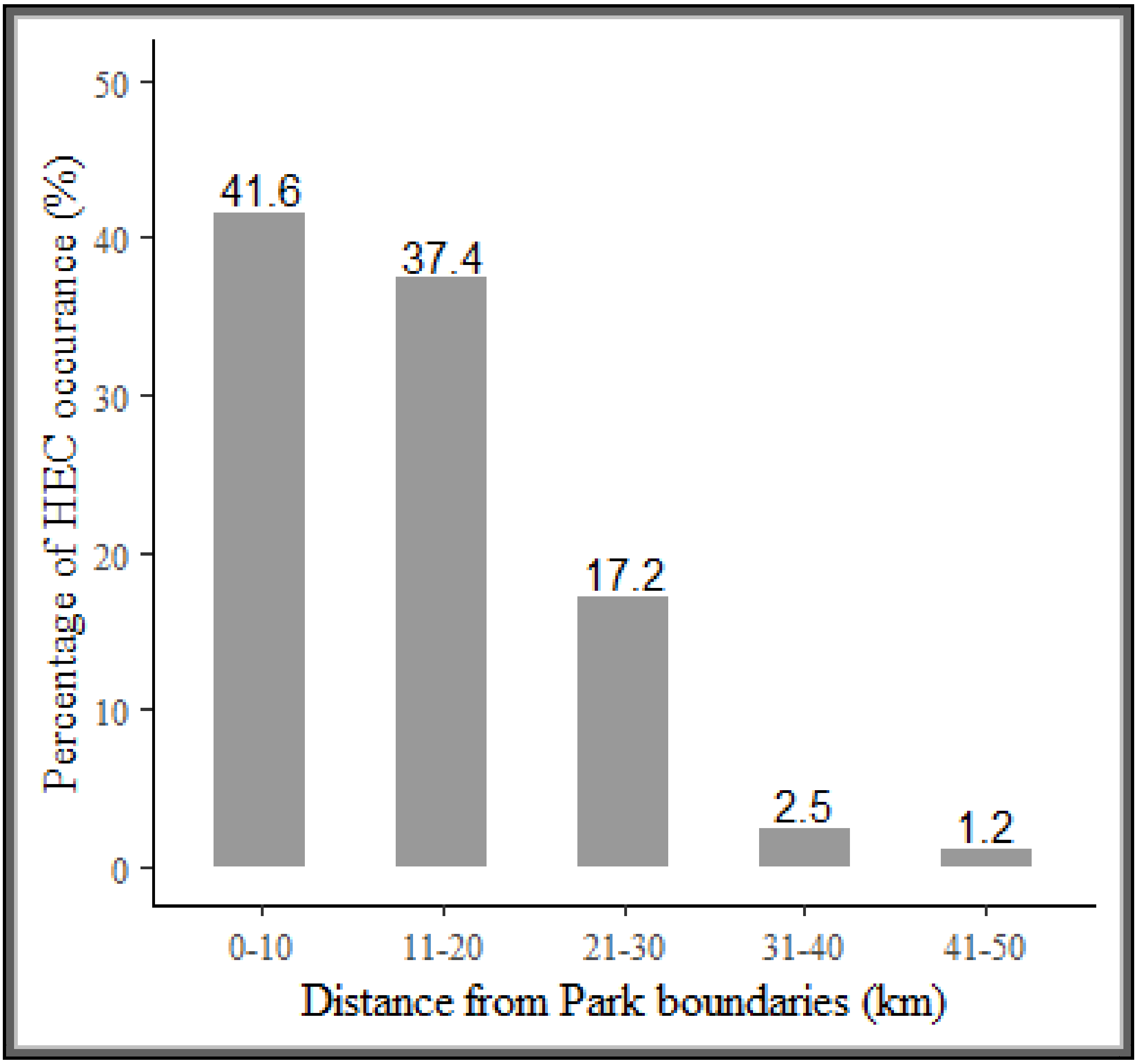

Figure 4: Influence of distance from park boundaries (km) on HECs occurrence in the Enduimet Wildlife management area.

3.3 Elephants home ranges and influences on HECs

The home ranges analysis revealed that the annual and seasonal 100% MCP ranges for collared elephants varied greatly for females (552 km^2 to 1,278 km2) and bulls (1,023 km^2 to1,618km^2) (Table 1), Also, results shown that an average 100% MCP home range for bull was (*X*=820 km^2) and (*X*=941 km^2) in wet and dry season respectively indicating non-significant difference in bull home ranges between season (*U*=71, *P*=0.707). Correspondingly, female elephant average home ranges were recorded as wet (*X*=789 km^2) and dry season (*X*=691 km^2), Similarly, no significant difference between female elephant home ranges across seasons (U=6, P=0.332). Generally, Results revealed that there were no statistical differences between bulls and females for their wet season range (U=127, P=0.511) or dry season range (*U*=92, *P*=0.217).

Moreover, results shown much variation in 95% fixed kernel density estimation (KDE) home range sizes between bulls and females by season and between years (Table

2). The average wet season range for bulls (913 km²) was 157 km larger than for females (756 km²) across all the four years (U=3, P=0.206).

The variations of the elephant home range have influenced the occurrences of Human-elephant conflicts as the most important areas that had suitable habitats for elephants have been converted into farmland, settlements due to rapid increase of human population and shift of the Maasai community from nomadic pastoralism to agropastoral (figure 5) (Chiyo et al., 2005; Trench et al., 2009).

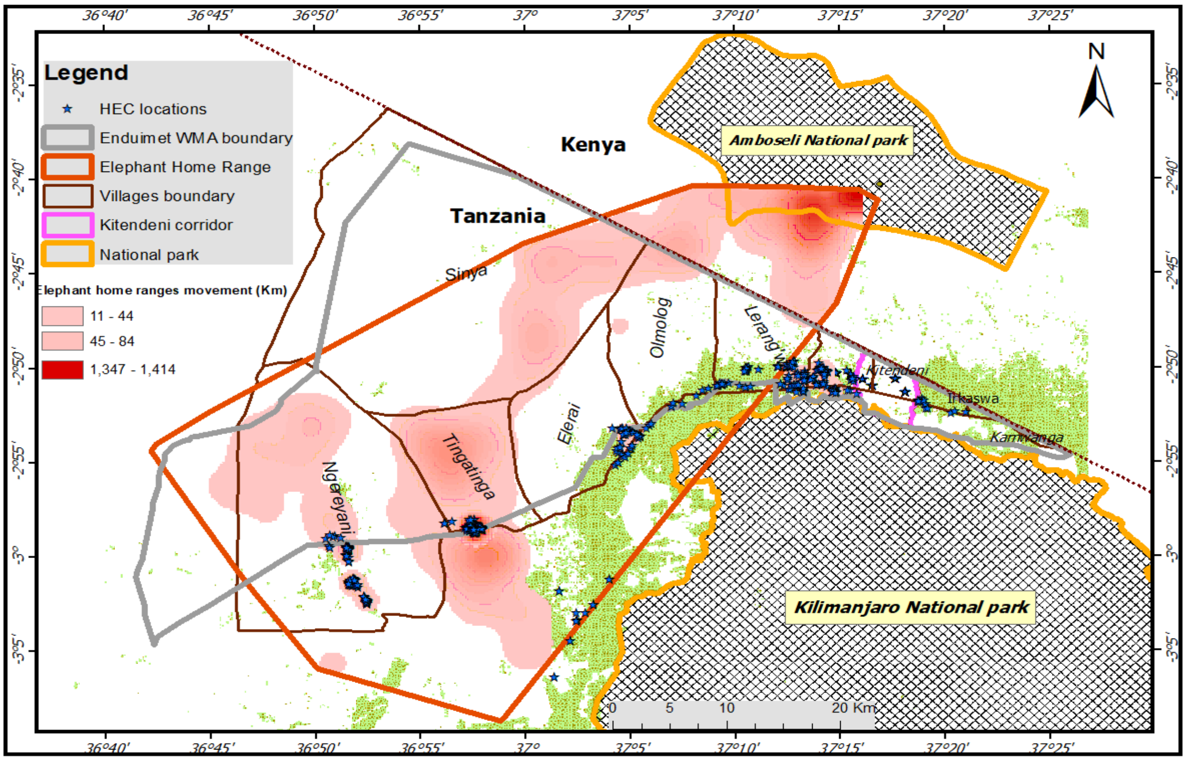

Figure 5: Home ranges for collared elephants in EWMA Tanzania, from 2016 to 2020, based on fixed Kernel density estimation (KDE)

Table 1. Annual and seasonal 100% maximum convex polygon (100% MCP) home range sizes (Km2) for Seven elephants monitored in Amboseli Kenya from 2016-2019.

		2016-2020		
Sex	**Collar ID**	**Annual**	**Wet**	**Dry**
Female	2010-1075	552	368	368
	2010-1-77	1,278	1,066	704
	2010-1073	819	816	169
	2010-1074	770	768	572
Mean ($\bar{x}$)		**996**	**756**	**644**
Bull	2010-1616	1,225	880	704
	2010-1613	1,167	972	913
	2010-1615	1,023	1,019	530
	2010-1620	1,618	781	1,393
Mean ($\bar{x}$)		**1,258**	**913**	**885**

Table 2. Seasonal 95% fixed kernel home range sizes (km2) by season and year for seven elephants monitored in Amboseli Kenya from 2016-2020.

		2016-2020	
Collar ID	***Sex***	***Wet***	***Dry***
2010-1075	Female	418	368
2010-177	Female	1,066	704
2010-1073	Female	816	169
2010-1074	Female	768	572
		756	**644**
2010-1616	Male	880	704
2010-1613	Male	972	913
2010-1615	Male	1,019	530
2010-1620	Male	781	1,393
		913	**885**

3.4 Extent of Impact of HEC on crop

Our results from household questionnaire survey revealed that six cultivated crops were most affected by elephant in farmlands around EWMA. Among these crops maize (*Zea mays*) was the most affected with approximately equal 51.5 ha (40.48%) of all cultivated crops followed by beans (*Phaseolus vulgaris*) 25.95 ha 30.36%, tomato (*Solanum lycopersicum)* 3.75 ha 23.69% and the least crops affected was wheat (*Triticum aestivum*) 0.29 ha about 0.11%)of the total crop raids affected (figure 6). Furthermore, the impact of elephant crop raids to various crop types differed significantly across villages ($\chi^2 = 740.37$, df = 5, $p < 0.001$) (Table 3).

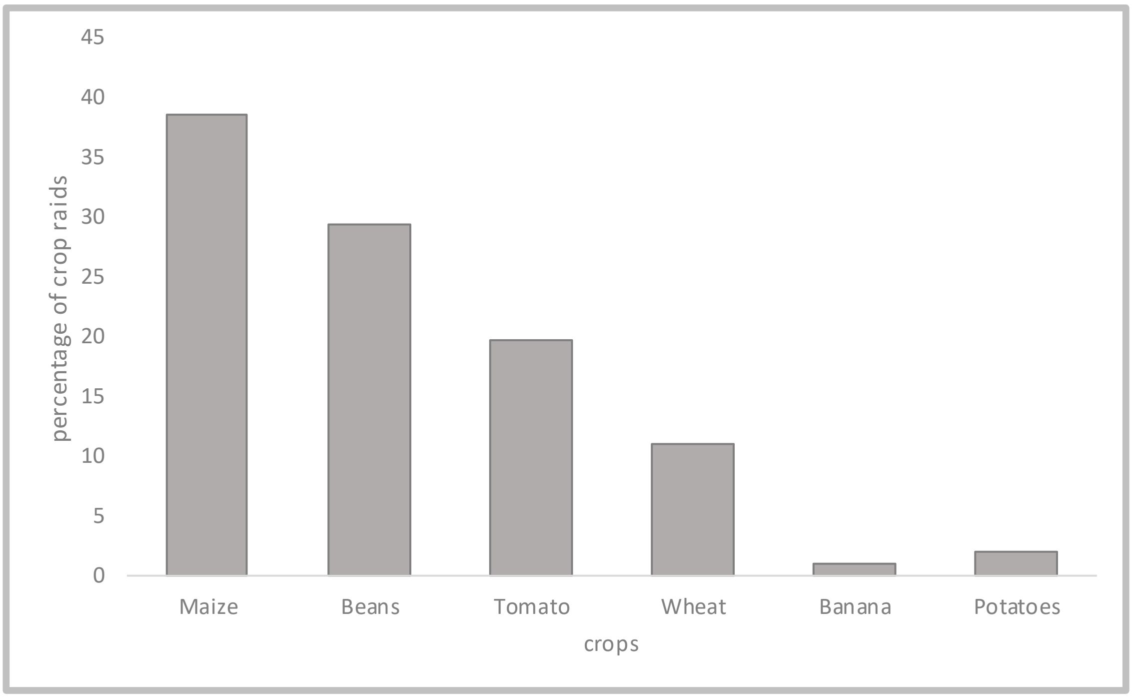

Figure 6: Extent of elephant crops raids in Enduimet Wildlife Management Area, Tanzania, from 2016 to 2020

Table 3: Chi-squared goodness-of-fit tests of the null hypothesis that the impact of elephant crops raids in total cultivated crop types differ across the villages using elephant crop raids report from 2016-2020 in Enduimet wildlife management area.

Percentage contribution of crop type to elephant crop raiding within villages (100%)												
Crop type	**Elerai (%)**	**Irkaswa (%)**	**Kamwanga (%)**	**Kitendeni (%)**	**Lerangwa (%)**	**Ngereyani (%)**	**O'Imolong (%)**	**Tingatinga (%)**	**Chi-square**			
									Total (N)	***%***	***χ^2***	***P-value***
Banana	0	0	0	0	4.7	12.5	0	0.5	20	2.38	63.02	<0.001
Beans	60	46.2	0	50.8	18.8	17	35.3	31.3	255	30.36	85.5	<0.001
Maize	40	53.8	0	25.4	75	42	64.7	36.9	340	40.48	90.3	<0.001
Potatoes	0	0	0	5.1	0	0	0	3.9	25	2.98	27.64	<0.003
Tomato	0	0	100	16.9	1.6	28.6	0	27.4	182	23.69	369.08	<0.001
Wheat	0	0	0	1.7	0	0	0	0	1	0.11	11.9	0.1039

3.5 Review of the potential approaches used for HEC mitigation in Enduimet Wildlife Management Area

In EWMA a multitude of traditional methods have been developed over the years to prevent crop raiding by elephants in conflict hotspots areas. The escalation of HECs in the past few years and technological advances have resulted in development of additional methods to address the problem.

Although, traditional methods are easy to use, have low costs and are more effective at low levels of HECs. With increasing conflict, more technical need to be used which carry higher costs. The various techniques employed in HECs mitigation in EWMA range from chasing elephants by noise making, making fire, use of torches, burning of chill bricks, chill burning, guarding, use of dogs to scare elephant etc. No one method is a 'standalone' universal solution for human conflict mitigation. Each technique has its advantages and disadvantages. Methods maybe used in differing permutations to increase their effectiveness since farming practices, traditions of people, habitat characteristics and resource availability may vary widely across the range of elephants.

Based on the Focus group discussion (FGDs) held in nine (9) villages forming EWMA; centred on the occurrence and impacts of HECs in the villages around EWMA and the mitigation approaches used, the respondents mentioned that local community have been trying to mitigate the HECs through different non-lethal conflict mitigation methods include noise making, making fire, use of torches, burning of chill bricks, chill burning, guarding, use of dogs to scare elephant etc. Unfortunately, almost of the measures that are being used have not been successful to achieve the goal. For instance, elephants nowadays don't get scared by loud noises either by shouting, drum beating, such as vuvuzela etc. Elephant are also intelligent and highly adaptable animals they also learn to overcome many of the methods used for mitigating HECs, and methods that were initially successful may lose their effectiveness over time. This also applies to other tactics because elephants get used to them with time. In general, the methods have lost their effectiveness, people just choose to use whichever is available because their performance does not differ significantly.

Expressive quotations from the FGDs held in one of the Village in EWMA on HECs mitigation approaches.

In one of the FGDs held in village the respondents expressed "*Although the community have been trained on diverse methods to alleviate the elephant conflicts, almost all of the methods have lost their efficacy. Desperately, most of human -elephants' conflicts do occur as a result of applying these methods e.g., drum beating, use of torches, throwing stones, using dogs to chase elephants to get angry and more destructive because of the noises caused etc." Even if, the community have also been receiving support from the Government and wildlife management agencies and other stakeholders working on wildlife sector on mitigate HECs such as* patrols, provision of education through NGOs, outreach programs *in all nine conducted FGDs, respondents explained that the government effort to mitigate HECs is still very minimal. The Districts Game Officers (DGOs) office or KDU offices is very far from the villages and have limited budget and insufficient human resources to act on every reported HECs case on time".*

3.6 Suggestions to increase the efficiency of the wildlife authorities to mitigate HECs

During the FGDs respondents were also asked to suggest the best suitable ways to increase the efficiency and mitigate HECs, the respondents suggested that the government should recruit more Game Officers and station them in the villages which are HECs hotspots. Also, the DGO office should have enough resources both human and equipment and constructing fences around PAs to stop elephant from coming them farmlands.

Expressive quotations from the focus groups.

"If the government really want to help the villagers to get rid of HECs, it should consider employing more DGOs, building fences around protected areas to stop elephant from coming to the villages. Also, The Government should consider having centres in those areas which are HECs hotspots areas as the population of elephants has increased, the government should consider cropping the elephants to have a manageable elephant population size. The cropping of elephants should be done in the village land to some of the elephants that occasionally come to the village. When other elephants see their fellows been killed, they will fear coming back to the village and it can take years for them to come back, and thus giving villagers space from HECs."

3.7. Awareness and knowledge of elephant conservation

Field staff of the EWMA is mainly composed of the rangers who protect the protected area, in addition to protecting the park, they are responsible for gathering of extensive information on illegal activities, including elephants crop raids. With this project rangers were trained and required to help monitor key threats to the EWMA especially those targeting elephants even after the completion of this project. The training managed to train 50 individuals from all nine villages forming the EWMA. Through an intensive 5 days lectures and practical sessions that were done in the field, rangers increased their knowledge and skills on protection of the elephant as well as manipulation of field tools such as (GPS, Binoculars, cameras).

About 27 posters on elephant conservation were published and distributed to the participants of massive conservation awareness session. The conservation awareness session. Similarly, 21 calendars were published with the message of elephant conservation and distributed during the session. Additionally, 29 conservation education sessions were conducted among community members 892 participants of targeted 960. The aim of conservation education sessions was to involve local community for the conservation of elephant in EWMA by minimizing HECs.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

The study has shown that the encroachment into elephant habitats have resulted in spatially and temporally predictable increases in HEC in EWMA. The forest areas suitable for elephant had been converted into agricultural land and settlements which has increased the competition between elephants and humans for scanty resources such as water and forage. As the majority of farms in EWMA were located close to the protected area, which likely stimulated crop foraging and escalated HEC situations.

4.2 Recommendations

The study proposal the following to mitigate HECs adjacent to protected areas as indicated by the results .

i. This study has shown that the majority of farms in EWMA were located close to the protected areas, which likely stimulated crop foraging and escalated conflict situations. Hence, the recommend that buffer zones, wildlife corridors and wildlife dispersal areas for elephants should be taken into consideration and given a high priority for protection. This will help avoid or minimize the conflicts that might arise between local communities and elephants, as correctly managed buffer zones outside PAs may be as important as wildlife reserves for the long-term viability of wide-ranging species.

ii. Collaring of elephants should be continued for a more in-depth understanding of elephant movement patterns and the use of certain migratory routes when moving through human-inhabited areas. Collars datasets locations can act as an early warning system before conflicts arise. Also, the assessment, of whether other wildlife species are using the corridor might be of interest in the future.

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