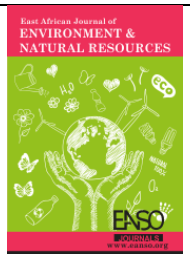

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Original Article

Potential Approaches and Techniques for Long-term Management of the Human-Elephant Conflict in Western Serengeti, Tanzania

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ABSTRACT

Human-elephant conflict is a ubiquitous feature between Ikorongo-Grumeti Game Reserves (IGGRs) management and the adjacent communities of Bunda and Serengeti Districts, in the Mara Region. This study aimed at analyzing the conflict and then coming up with potential techniques for effective mitigation of the conflict in the area. Data collection involved direct observations, key informant interviews and household surveys using questionnaires. The analysis was done using SPSS computer software. Results revealed and recommended several non-conventional mitigation measures namely the construction of trench (95.3%), electric fencing (92.7%), establishment of buffer zone management units (BZMUs) (92.7%) and geo-fencing system (92.3%). Also were wireless sensing networks (WSN) (85.3%), translocation of problem elephants (11.7%), and evacuation of people adjoining wildlife area boundaries (22%) as HEC prevention and mitigation measures with long-term impacts. Generally, no single solution was considered effective as different approaches must be integrated to address the problem proactively. Hence, it is recommended that community involvement in decision-making and policy formulation be emphasized to effectively implement proposed mitigation measures.

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INTRODUCTION

Human-elephant conflict (HEC) marks one of the greatest challenges of conservation in many countries around the world (Burn et al., 2011). In this case, both the Asian elephant (*Elephas maximus*) and the African elephant (*Loxodonta Africana*) have been the principal sources of the conflict in Asia and Africa, respectively through their consistent impact on the livelihoods of local populations (Hedges, & Gunaryadi, 2010; Nyhus, & Tilson, 2004; O'Connell-Rodwell et al., 2000; Sarke, & Røskaft, 2010; Sukumar, 1991). For example, in Indonesia, 12 elephants were reported to be poisoned to death by farm workers as they were trying to enter and feed on oil palm plantations (Nyhus, & Sumianto, 2000). In China, in the mountainous area of Simao, near Xishuang Banna Nature Reserve, property damage and crop raiding by Asian elephants have been reported to be done by a group of about 19 to 24 elephants (Distefano, 2005; Chen *et al*., 2016). Moreover, in African countries such as Uganda, Cameroon, Zimbabwe and Namibia, African elephants are seen to be the most aggressive animals once they enter into communal lands as they attack a large area and raid crops (Aliénor et al., 2018; O'Connell-Rodwell et al., 2000; Naughton et al., 1999).

In particular, HEC affects humans socio-economically and culturally as people spend much of their time in crop fields guarding their farms from raiding elephants while threatening the survival of elephants through revenge (AfESG, 2007; Archie, & Chiyo, 2012; Fungo, 2011; Jadhav, & Barua, 2012; Kumar et al., 2011).

Human-Elephant Interaction Problems in Tanzania

The Tanzanian wildlife policy of 1998 introduced a Community Based Natural Resource Management (CBNRM) approach that was revised in 2007. Section 3.2.1 (c) of the policy states that "*Village communities living adjacent to protected areas, wetlands or in wildlife corridors will be encouraged to establish Wildlife Management Areas (WMAs) to secure habitat for wildlife and halt wetlands degradation*" to promote the management of wildlife resources outside the core protected areas by establishing Wildlife Management Areas (WMAs). The approach aids in enforcing wildlife law and facilitates the application of various techniques for protecting wildlife resources such as elephants against illegal uses (URT, 1998). WMAs aid in the mitigation and prevention of conflicts between humans and wildlife as the approach enables the local communities to have authority and a participation platform for managing wildlife on their land (Wilfred, 2010). Part VIII of Tanzania's Wildlife Conservation Act of 2009 describes the management of human-wildlife conflict by suggesting many approaches including problem animal control (PAC) and consolation for the loss of life, crops or injury caused by wild animals (URT, 2009).

According to Perea (2009), elephants consume approximately 150 kg of food daily, making crop raiding by elephants a major problem for local communities around protected areas (Bitala, 2004). The absence of an effective buffer zone between protected areas and human settlements or farmlands in Ikorongo-Grumeti Game Reserves favours the perpetuation of the conflict (Fridolin, 2014; Kideghesho, 2006; Nelson, 2012). In the 2003/04

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season, about 323ha (732 tons) of crops were damaged by elephants while about four people were reportedly killed, also by elephants and both events occurred in Serengeti District (Walpole *et al*., 2004). Mwakatobe, Nyahongo, Ntalwila and Røskaft. (2014) found that in the 9 surveyed villages around Serengeti National Park, and Ikorongo and Grumeti Game Reserves, the mean estimated cost of crops damaged per household by raiding elephants in 2014, were about USD 31.49 (closest villages), USD 14.06 (medium distanced villages) and USD 12.1 (far away villages).

All these cause dissatisfactions and in the long run, have inculcated hatred of wildlife and in many cases a revenging behaviour (Chang'a *et al.,* 2016). With the ongoing wildlife conservation efforts, recent spatial observation trends have shown that the elephant population in Ikorongo-Grumeti Game Reserves has increased from 355 in 2003 to 1320 elephants in 2014, fueling the existing human-elephant conflicts (Goodman, 2014; Nelson, 2012; WWF, 2014b).

Despite the rise in human-elephant conflict, there is little information that is known on the current efforts towards introducing new approaches to be applied in addressing the problem. This is because most traditional techniques such as chilli essence (Malugu, 2011), guarding farms (Walpole *et al*., 2004), scaring elephants using noise and pungent materials (Pittiglio et al., 2014), planting alternative crops and buffer crops around fields (Hoare, 2012), and benefit sharing (Gross et al., 2016) have shown short-term impacts still leaving a wide security gap to be filled. On that note, research was done to identify and recommend novel approaches and techniques for managing HEC in western Serengeti, Tanzania. This chapter presents novel approaches that can be applied to help mitigate HEC in the study area and in areas with comparable situations.

METHODOLOGY

The Study Area

Ikorongo-Grumeti Game Reserves (IGGRs) and the surrounding villages lie between latitudes 1º30' and 2º45' S and longitudes 33º00' and 35º30' E. The Ikorongo Game Reserve itself covers 563 km^2 while the Grumeti Game Reserve covers 416 km^2 (Fig. 2) (Kideghesho, 2006; Kideghesho, & Mtoni, 2008).

The area experiences two rain seasons occurring in March to May (long rains) and November to January (short rains). It is characterized by an average annual rainfall approximated to range between 500 mm and 1200 mm, declining towards the park boundary and increasing towards Lake Victoria, and an annual temperature range of between 21°C and 27°C (Goodman, 2014). The vegetation cover of an area is a highland savannah with thorn tree woodlands and plains ranging from approximately 900 to 1500 meters above sea level. The area is an integral part of the Serengeti-Mara ecosystem, known as the home of the Great Migration as it protects the path of the annual wildebeest migration (Kideghesho, 2006).

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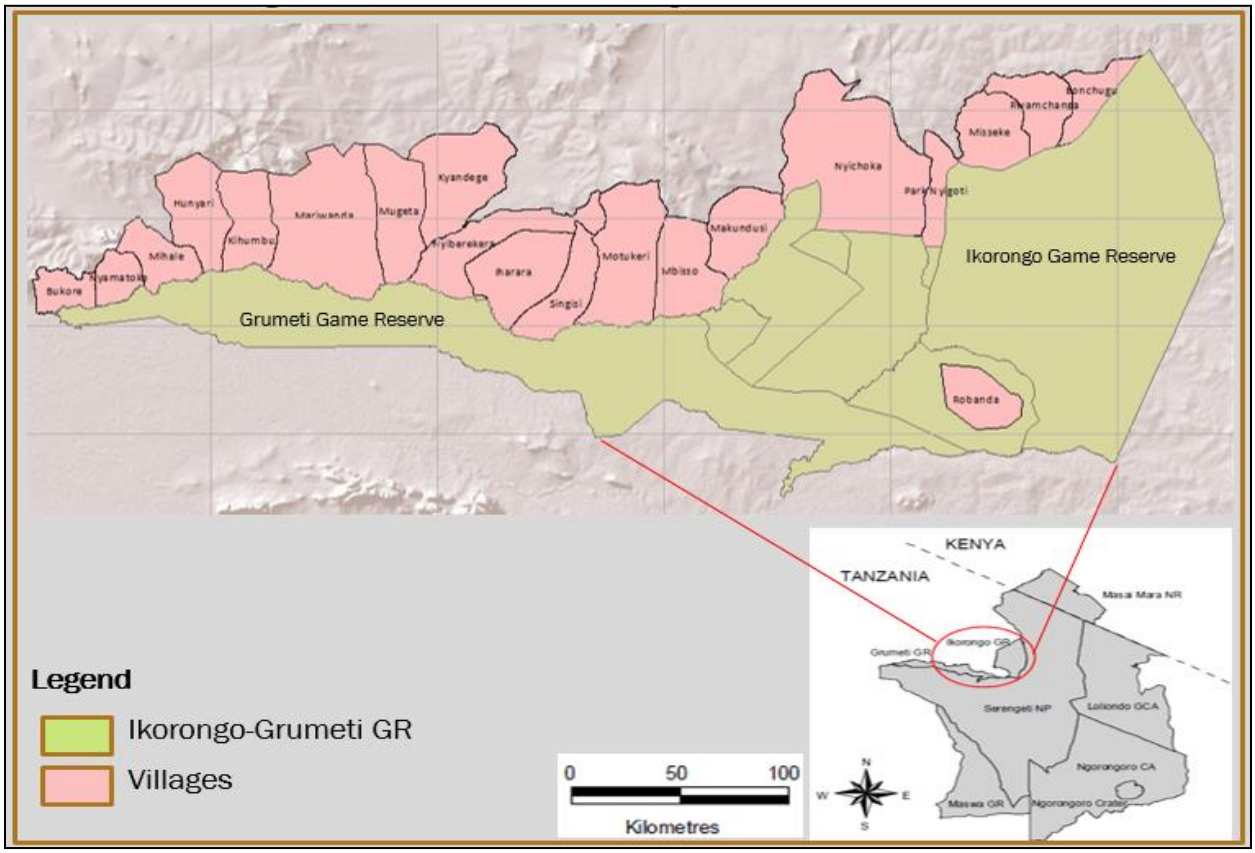
Figure 1: Map of Serengeti Ecosystem, with the Study Area Cycled in Red



Source*: Singita Grumeti Fund (SGF, 2000)*

Ethnic Groups

The reserves are bordered by diverse ethnic groups which are approximately more than 20 tribes in the area. The major ones include Ikoma, Taturu, Ikizu, Nata, Isenye, Zanaki, Sukuma, Kurya, Zizaki, Ngoreme and Jita, mostly undertake agro-pastoralism to sustain their living. Crops cultivated are maize, cassava, millet and sorghum as food crops, and cotton as a cash crop. Livestock include goats, donkeys, cattle and sheep (Galvin et al., 2008; Kideghesho, 2006).

Research Design and Sampling Procedure

Research Design

Primary data was collected using a cross-sectional research design, which was adopted because it is more flexible and less costly (Babie, 1990; Bailey, 1994).

Sampling Procedures

Sampling Unit

The target population for the study involved communities bordering the two-game Reserves. The sampling frame was the village registry books containing a list of households that served as sampling units.

Sampling Methods and Sample Size

Six villages were purposely selected from villages adjacent to the game reserves based on the nearest distance from the protected area boundary and several human-elephant conflict incidents were reported. The villages selected were *Nyamatoke, Hunyari, Iharara, Makundusi, Nyichoka and Bonchugu*. A simple random sampling method was used to select 50 households from the village registry book of each sampled village to keep the

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sample size above 30 households. Bailey (1994) found that a sample size of 30 from one observation unit is considered adequate to which statistical analysis can be applied.

A total representative sample of 300 households from the target population of 3004 households was obtained, of which 55.7% were female and 44.3% were male. Age distribution of respondents from all six villages varied from 18 to ≥66 years with the majority being in the active age group of 18-35 years. Most of the surveyed households depended on crop farming (43.7%) and mixed farming (38.7%) as their prime source of income, whereas 53.7% had an approximate annual income of less than TZS. 800 000/=. Those with an annual income ranging from TZS 800, 000/= to 1 600 000/= were 27.7%, followed by those having an approximate annual income of TZS. 1 600 001/= to 2 000 000/= and above TZS. 2 000 000/= who comprised of 9.7% and 9.0%, respectively. Moreover, twelve (12) key informants who were District Game Officers (DGOs), SGF staff, Village Executive Officers (VEOs) and elderly villagers both men and women were purposively chosen based on their political position, experience and authority.

Research Instruments

A questionnaire entailed questions, which are either close-ended or open-ended. The questionnaires were divided into five parts. Part A covered particulars of respondents, part B covered respondents' land use and property rights, part C covered information on the human-elephant conflict, part D covered HEC prevention and mitigation measures, and part E covered respondents' willingness to contribute to the new approaches and techniques.

Pre-testing

Pre-testing was carried out before embarking on the study to ensure that the questionnaires were working properly (Polit et al., 2001). According to Machoka (2017), a pilot test comprises 10 percent of the total targeted population. Therefore, pilot testing for this study was carried out and comprised 30 households (five households from each of the six villages, but such households were not included in the actual study sample). A pilot study was used to improve and modify the data collection tools to make them relevant and reliable (Van Teijlingen et al., 2011). Following pre-testing, some changes were made in the questionnaires to minimize the chances and vagueness of some questions before being administered to the respondents. The amended questionnaires were then used for data collection during the final survey.

Validity of the Instrument

The validity test was done using the content validity test to test the tool for accuracy and adequate coverage of the topic under study. To improve content validity, the researcher sought out an expert's judgment and help from the other researchers to assess whether the questions were perfectly formulated and represented the topic under study. Following the expert's judgment, the items that were less adequate and inaccurate in regard to the topic under study were removed while some were changed.

Reliability of the Instrument

The researcher employed the internal consistency reliability test to measure how consistently participants responded to a set of items. The researcher aimed to determine the coefficient of internal consistency using Cronbach's alpha (sometimes called coefficient alpha) whose value varies between 0.00 (indicating no reliability) and +1.0 (indicating perfect reliability). Cronbach's alpha was used to measure the reliability of tested items. A coefficient of 0.89 was obtained, which according to Nitko, & Brookhart (2011), a correlation of ≥ 0.80 is determined to be necessary to establish internal consistency reliability.

Article DOI: https://doi.org/10.37284/eajenr.8.1.2630

DATA COLLECTION PROCEDURES

Primary Data Collection

Data were collected using various techniques, namely direct observations, key informant interviews and household surveys using questionnaires.

Direct Observation

The researcher visited Ikorongo-Grumeti Game Reserves and their bordering villages observing different anthropogenic activities taking place within surrounding communities through a transect walk. Moreover, the researcher used direct observation to obtain information on the new approaches and techniques conceived to have long-term impacts on human-elephant conflict prevention and mitigation.

Key Informant Interviews

The researcher used face-to-face interviews as a technique of key informant interviews involving asking questions and receiving responses from the respondents. This technique was favoured as it provided information from knowledgeable people and offered an opportunity to explore unanticipated ideas in a free exchange of ideas (Brookes, 2007). Key informants were DGOs, SGF staff, Village Executive Officers (VEOs) and old people who had first-hand background information and knowledge about the status and trends of human-elephant conflict for the past eight years (2008-2015). They were also people with knowledge about the losers and gainers in the human-elephant conflict, and new potential approaches and techniques with seemingly long-term impacts that could be applied to prevent and mitigate HEC in the area.

Household Survey

In this study, questionnaires with both closed and open-ended questions were administered to the respondents from selected households of each sampled village (Kothari, 2004). Questionnaires were used to seek information on factors that lead to HEC in the area, and barriers towards the applied mitigation measures based on local knowledge people have, and how can be addressed. Moreover, they were used to obtain information on the new measures with supposedly long-term impacts on the prevention and mitigation of HEC in the area. A respondent had an opportunity to score out of 100 each of the proposed techniques based on their opinion regarding the performance of each in combatting the problem.

Secondary Data Collection

Secondary data were obtained from different sources including books, journals, research papers, pamphlets, web-based literature, and relevant reports from Singita Grumeti Fund, Bunda and Serengeti District Game Offices and Village Government Offices (VGOs). Secondary data provided information that was complementary to the primary data. Secondary sources provided up to eight (8) years period information on the status and trend of human-elephant conflict incidences, some people affected, many elephants suffering from the conflict and information on applied measures to prevent elephants from damaging crops, infrastructure and killing and/or injuring human beings and domestic animals.

Data Analysis

Qualitative data obtained from the survey were analyzed using content analysis. Content analysis involved summarizing by breaking down the recorded dialogue into the smallest meaningful units of information and opinions of respondents over the study topic (Kajembe, 1994). On the other hand, quantitative data were verified, compiled, summarized, coded, and descriptively analyzed in the Statistical Package for Social Science (SPSS, version 12.3).

Ethical Considerations

Ethical considerations are crucial for any research. The research ethics by the Research and Publications Committee of the Sokoine University

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of Agriculture (SUA) were observed to make sure that ethical guidelines for carrying out the research and ethical values are not dishonoured (Matovelo *et al*., 2010). The respondents were guaranteed discretion regarding the information to be provided and concealment of the source of data as the questionnaire did not call for the revelation of identity. To enable independence in the study, measures were taken to make sure that the individual bias of the researcher did not interfere with the research process and that all parties were given fair consideration. In reporting the findings, the researcher accurately represented the data collected and it was used only for this study.

RESULTS AND DISCUSSION

Conflict Analysis and Conflict Management Strategy

Human-elephant conflict mitigation cannot be solved by the Wildlife Division alone. It requires multidisciplinary collaboration, ranging from Ministries responsible for managing natural resources and social welfare to local communities living in the conflict zones. Designing a conflict analysis tool to gather the conflicting parties and discuss each party's interests and issues influencing the conflict is necessary to reach a consensus.

The researcher, therefore, adopted conflict analysis and strategy design tools to describe the nature of HEC and measures to resolve the conflict between local communities, IGGRs and Ikona Wildlife Management Area (WMA) authorities (Table 1).

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Table 1: Conflict Analysis and Strategy Design

Conflicting Parties	Issues at Stake	Importance of Issues*	Interests	Options for Mitigating the Conflict	Willingness to Settle the Conflict	Next Steps
Local communities (farmers & Pastoralists)	-Crop damage -Threat to human life (killings & injuries) -Infrastructure damage -Livestock depredation (killings & injuries)	**VH** **L** **M** **VL**	– Protect crops from damage – Protect humans from deaths or injuries caused by elephants – Better access to decision-making – Maintenance of customary rights of occupancy – Access to pasturage and water sources	– Support financially the new mitigation measures (53.4%), provide manpower (35.3%) and be ready to be relocated (22%)	– Distrust of government and PAs management (bad experiences) – Would only continue a talk if the process is perceived as fair	– Conduct conflict resolution meetings at the village level to address the issues and strategies among villagers
Elephants (Represented by PAs management)	-Blockade of migratory routes -Loss of habitat (food, water & shelter) -Elephant killings & injuries	**VH** **H** **L**	– Prevent degradation of habitats (food, water & shelter) – Prevent elephant killings and injuries – Maintain an environment in which humans live in harmony with nature	– Provision of conservation education – Use of more effective mitigation measures	– Prefer to use Community Outreach Programs (COP) rather than force – Would use force when necessary	– Platforms to conduct conflict resolution meetings and forums to develop strategies to address the issues

Source: Adapted from Conflict Detection and Resolution (CDR)

***Key: VH**=Very high priority**, H**=High priority**, M**=Medium priority**, L**=Low priority**, VL**=Very low priority

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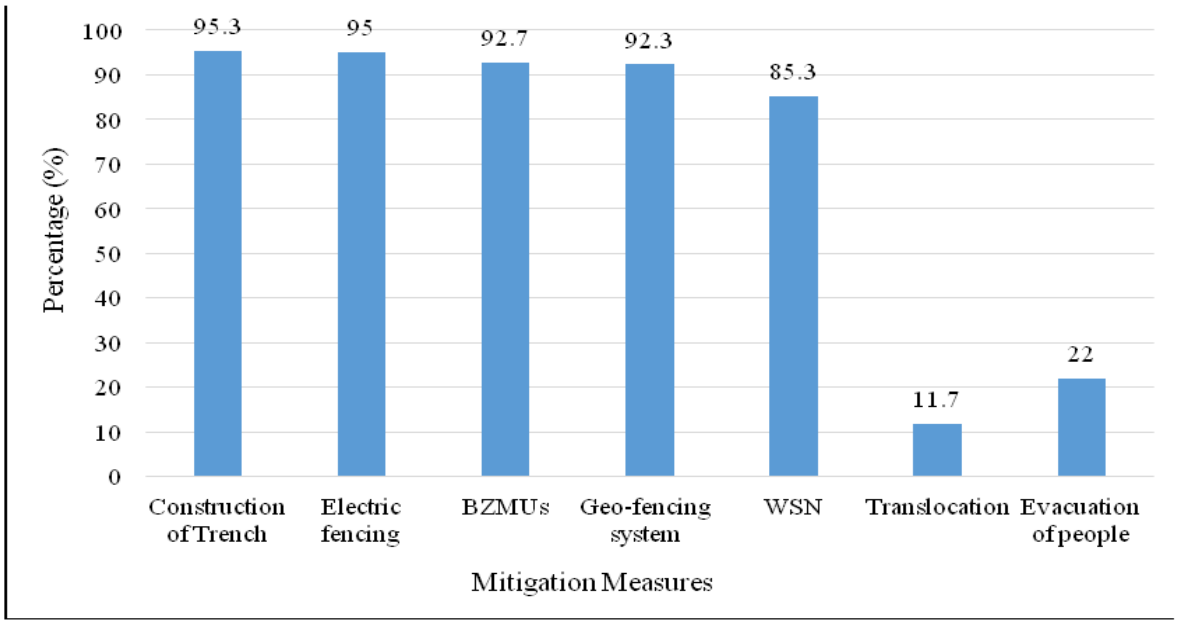
The results indicated that conflict resolutions through meetings and consolation payment for damage caused by elephants have been the most implemented approach, which leaves out most cases with the affected and deceased communities unhappy and unsatisfied. The approach is unsustainable and short-lived, therefore more relatively long-term and sustainable approaches must be sought to address the issues at stake. In this regard, a package of mitigation approaches and techniques for HEC that is cost-effective, easy to apply and friendly to the environment, but able to resolve the current widespread problem is paramount. Therefore, the following sections present discussions on relevant findings that facilitate the transformation of the current HEC using different approaches

Potential Unconventional Techniques for HEC Mitigation

As a result of the less effective HEC mitigation measures being applied for ages and the subsequent short-term impact, there has been an increased demand for more effective measures with long-term impact to prevent and mitigate the conflict. According to Dhanaraj, & Sangiah (2017) and Sheela *et al*. (2016), the application of advanced techniques in the management of HEC across the globe has shown positive impacts with long-term results. Household respondents suggested new seven potential measures in the order of priority concerning effectiveness in mitigating the conflict (Fig 2).

Figure 2: Average Scores as a Reflection of Potential Effectiveness of the Proposed Unconventional HEC Mitigation Measures (BMZ = Buffer Zone Management Unit; WSN = Wireless Sensing Network)



Construction of Trench

A trench, about 20 ft wide and 8 ft deep may be excavated at the edge of the reserve (Fig. 3). It is a deterrent to non-jumping animals like elephants. The soil excavated from the trench is heaped on top of one side of the bank, making the trench appear deeper and limiting the problem animals from crossing from PAs into villages. The technique has been applied around the majority of national parks in India, Sri Lanka and Uganda (Babaasa et al., 2013; Fernando *et al*., 2008; Mackenzie, & Ainebyona, 2012).

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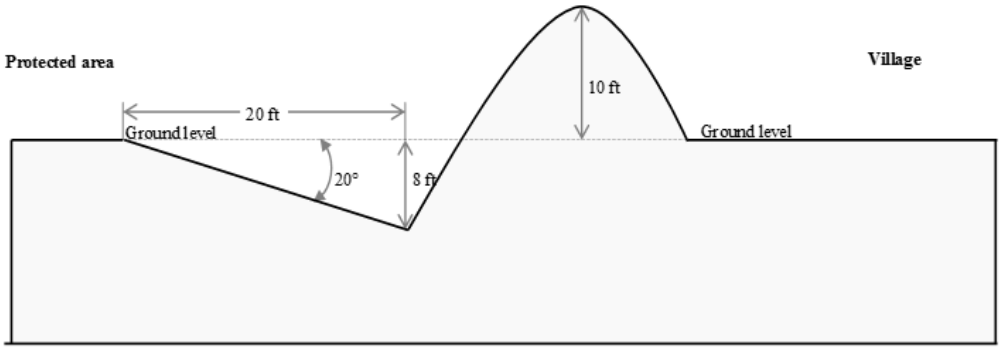
Figure 3: Schematic Diagram of the Proposed Trench Construction



According to the results, 95.3% of respondents were of the opinion that trench construction could be applied as an unconventional mitigation measure to the HEC. They further considered the technique to be effective as a physical barrier that will prevent elephants from moving out of the protected area boundary into village land.

Electric Fencing

Electric fences have been quite effective in preventing problem animals, particularly habitual raiding elephants in the majority of countries facing the HEC (Babaasa *et al*., 2013). The technique acts as the physical barrier preventing the elephants from invading farms in the village land bordering the protected areas. The majority of the respondents (95%) indicated that the erection of an electric fence (Plate 1) along the boundary between IGGRs and villages will have a positive impact on the conflict as it will restrict elephants' movement from PAs into farmlands located along the reserve's boundary.

Plate 1: An Electric Fence Limiting Elephant Crossing from PAs into Villages

(Source: RDB, 2014)

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Buffer Zone Management Units

Buffer Zone Management Units (BZMUs) comprise specialized personnel dedicated to rapid response upon elephant's invasion or when about to cross from PAs into village land. Therefore, the majority of the respondents (92.7%) suggested the delineation of a clear buffer zone between the IGGRs, Ikona WMA boundary, and its adjacent villages. Moreover, the establishment of the BZMUs should be in line with the establishment of permanent ranger posts along the buffer zone.

Geo-fencing System

Geo-fencing system was also among the unconventional mitigation measures identified during the study survey. The system involves a virtual fence line within a computer geographical information system (GIS) and programmed in geographical positioning system (GPS) positions into the tracking collar of crop-raiding elephants, which creates a Geo-fence around the particular animal. If the elephant strays outside of its known range or tries to enter a local village to raid crops, global system for mobile communication (GSM) elephant collars with installed subscriber identity module (SIM) cards send a text message to the control centre or BZMUs managers alerting them of the immediate problem, and the location of the elephant, enabling rangers, VGS and reserve staff to locate and drive back the elephant into the reserve boundaries. The majority of the respondents (92.3%) indicated that the technique will have an effective and long-term impact on the mitigation of HEC in the conflict zones of IGGRs.

Wireless Sensing Network

Results indicated that 85.6% of respondents considered wireless sensing networks (WSN) as another category of approaches and techniques for HEC mitigation measures. WSN-based systems are widely used for various purposes such as warning systems against different hazard scenarios (e.g. fire) and research on the detection of movement and distribution patterns of wild animals (Dhanaraj, & Sangiah, 2017). Such a WSN-based system can also be effective in generating an early warning against the presence of elephants near the village land and thus can prevent potential human-elephant conflict scenarios. The proposed technique uses very high frequency (VHF) transmitters embedded in the collar fitted on the elephant's body that are connected to track the location of the animal while approaching the restricted area.

The VHF transmitters attached to the problem elephant emit pulsed radio signals, which when the animal is within the range, the signals are detected by the receivers erected on poles or towers. The signals taped by receivers are sent to a gateway node having a signal processing unit to filter specific signals of a particular frequency. Signals from the gateway node will be received by a central processing unit (CPU) (Ramkumar et al., 2014; Sheela *et al*., 2016). This processing unit will look for a pattern match of the incoming signal with a reference signal to detect and confirm the presence of an elephant within range. Once the CPU confirms the presence of an elephant, it will generate warnings and send the information to the nearby human-wildlife conflict management unit (HWCMU) office with specific location codes through GPS (Fig. 4).

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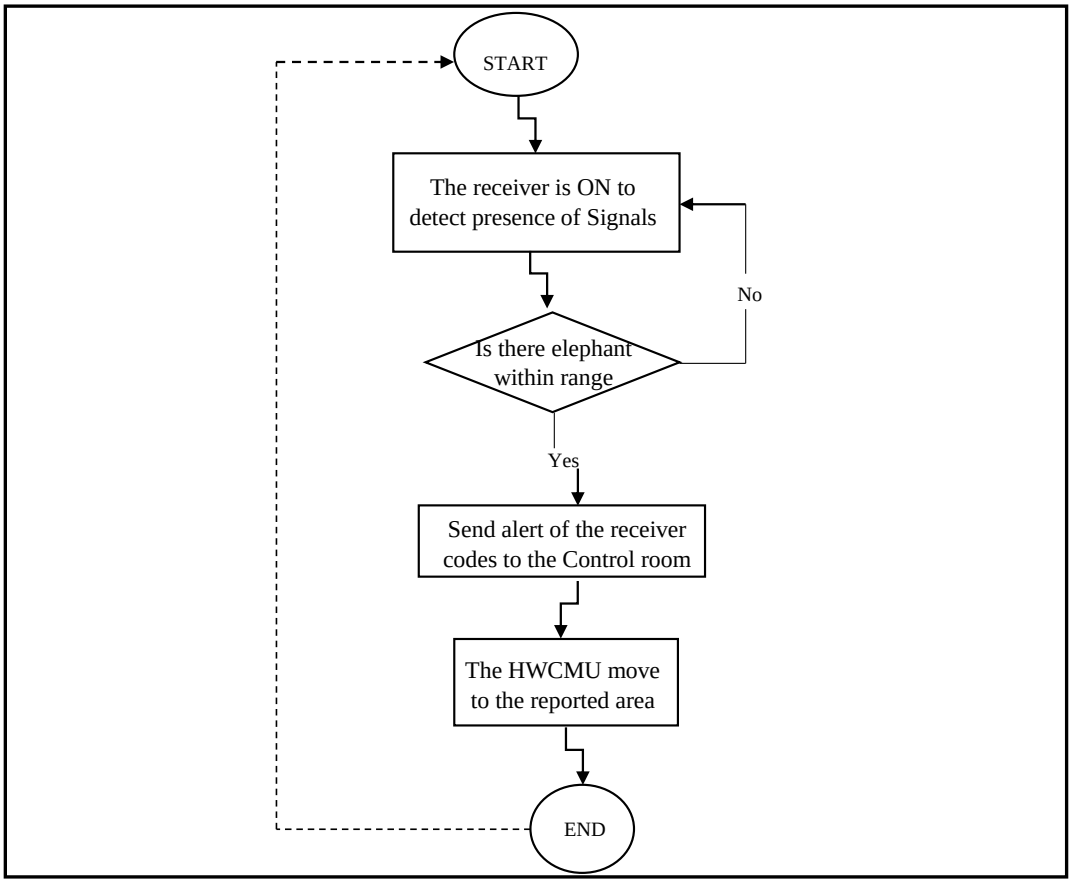
Figure 4: Schematic Diagram of the Proposed Integrated WSN for Elephants' Detection



(Modified from Ramkumar *et al., 2014*)

Translocation of Problem Elephants

Translocation is the removal of a problem animal by tranquillising and transporting it to a new location where they are released, using specially designed vehicles and specialists' expertise. With this approach, the least number of respondents, about 12% considered the approach to be potentially helpful in the reduction of problem elephants, hence minimising incursions and raiding pressure on crop fields. Translocation of animals has been undertaken in Kenya (Litoroh et al., 2001; Njumbi *et al*., 1996) and South Africa (Garai, & Carr, 2001), among other countries. Translocation may appeal more to conservation organizations because it has several advantages, including saving elephants from being killed, stabilizing the elephant population within the habitat carrying capacity, and taking such obvious action that satisfies local communities who are normally confronted with the conflict (Nelson et al., 2003). Before translocations can be undertaken, preliminary studies of the social structure of the elephants need to be conducted, so as to avoid disruptions that can affect family and other elephants.

Evacuation of People

In the study villages, about 22% of the respondents considered the evacuation of people as an alternative measure that will have a higher effectiveness and long-term solution to the conflicts compared to the translocation of the problem elephant by nearly 10%. This proposal is anchored on the observation that distance from PA to settlements demonstrates a significant relationship with the intensity of conflict. The observation is not surprising because, elephants are known to move distances from day to day, in search of suitable

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habitats where they can obtain basic needs such as food and water (Harris et al., 2008). This can be evidenced as the amount of crop damage varied in the study villages with the change in the average distance of the surveyed households and farms in each village (c.f. pg. 31). As the encroachment of PAs by settlements together with cultivated land seemed fueling the damage of crops and increase in threats to both human and domestic animals, relocation of people living near protected areas is inevitable. People should be evacuated in the areas, which are reported to be the conflict zones and those, which are very close (<0.5km) to the IGGRs and Ikona WMA boundary.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The local communities used traditional mitigation measures together with the efforts from HWCMUs and PAs authorities to control elephant attacks. Despite these efforts, several barriers needed to be addressed to make the mitigation measures more effective as elephants have shown very high adaptability to most of the applied deterrents. The barriers included the use of local tools as the primary means to chase the elephants, low income and education level and large distance between ranger posts and villages.

Most importantly, seven unconventional mitigation measures were identified and recommended as mitigation measures with expected long-term impact on the HEC between local communities and elephants of the IGGRs and Ikona WMA. The proposed measures were:- construction of trenches; use of electric fencing and establishment of buffer zone management units (BZMUs); geo-fencing system and use of wireless sensing network (WSN); translocation of problem elephants and evacuation of people near the protected area boundary. The implementation of these methods requires a long timeframe, heavy financial resources as well as political will.

It is essential that human-elephant conflict mitigation becomes an integral part of the national wildlife conservation policy. Furthermore, strengthening trans-border cooperation is needed to manage elephant populations across IGGRs, Serengeti National Park, Ikona WMA and other nearby PAs. Development of a rigorous decision-making framework will require the participation of various stakeholders such as government ministries responsible for the management of natural resources, social welfare and land-use planners, PAs management authorities, natural and social scientists and economists and local people from communities adjacent to PAs.

There is a need for a clear policy and strategic planning given that the current approach to dealing with conflict is largely ad hoc, and predisposed to failure because of inappropriate application of methods, limited involvement of local people, lack of effective monitoring of conflict and conflict mitigation measures, and inadequate understanding of elephant ecology in deploying mitigation strategies. In the absence of new and improved wildlife conservation approaches, HEC might heighten due to the elephants' demands for large home ranges and free-ranging. No single solution is effective, and different approaches need to be integrated to address the problem proactively.

Recommendations

With reference to the study findings the paper recommends the following:

Recommendations for local communities

The planting of palatable crops (maize, millet, among others) close to the reserve boundary by farmers has led to a hike in the incidence of elephant crop raids within the landscape. It is recommended that farmers be encouraged to engage in the cultivation of non-target crops like onions, chilli, peanuts and sesame which are mainly commercial crops (Ekanayaka et al., 2011). Beekeeping projects can also be another option where community

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members can harvest and sell honey and beeswax, whereas beehive fences can enhance crop production and protection (King *et al.*, 2011). Local people should be encouraged to improve village-based guarding efforts to detect and deter elephants prior to their entry into crop fields. This should be in line with the use of more sophisticated tools like long-range flashlight torches.

Recommendations for PAs management

Local people need to have conservation education and an understanding of scientifically proven drivers of the HEC, it is therefore recommended that the IGGRs and Ikona WMA emphasise conservation education among local people. To improve the sense of belonging in the conservation, community involvement in conservation activities in the study area should be a priority in the General Management Plan (GMP) of the IGRRs and Ikona WMA.

IGGRs and Ikona WMA management in collaboration with the government of the United Republic of Tanzania (URT) should consider implementing the HEC mitigation measures suggested in this study, for effective and long-term mitigation of HEC.

Policy Recommendations

The wildlife conservation sector should consider incorporating and putting into action the potential and alternative long-term mitigation measures such as erecting electric deterrents, which are non-lethal to reduce the conflict between people and wildlife as suggested in Section 3.3.12 of the Tanzania Wildlife Policy of 1998. It is recommended that the government should set up a trust fund to compensate a greater proportion of the elephant-caused damage. Shared policy changes would enhance people's perception towards and ownership of those elephants being conserved. It is further recommended that the government create a clear and well-defined buffer zone separating the IGGRs and the surrounding communities.

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