DETERMINANTS OF HUMAN – ELEPHANT CONFLICTS IN SHIMBA HILLS ECOSYSTEM, KENYA

BY

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DECLARATION

Declaration by the Candidate

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DEDICATION

To God Almighty who has always guided me throughout my entire life. To my beloved mum Mary Buresia Wanyingi. I'm grateful for your love, care, encouragement and every effort you gave to me. I am also grateful to my husband, Dr. Johnstone K. Kimanzi, for the financial and emotional support he gave. God bless you.

ABSTRACT

Human-elephant conflict (HEC) is a key example of the growing competition between people and wildlife for space and resources in Kenya. To effectively implement mitigation measures, understanding of the underlying factors that determine HEC is required. This study, carried out between November 2012 and February 2013 in Shimba Hills (SH) Ecosystem, mapped the elephant conflict prone areas and assessed the effectiveness of the mitigation measures. The study used questionnaires, group discussions and available Shimba Hills National Reserve (SHNR) conflict records to generate information on the nature and type of HEC, and conflict locations (presence data). GIS-based stepwise logistic regression was used to analyze the relationship between conflict areas and the selected habitat factors including distance to roads, fenced and unfenced areas, water and settlements; as well as relationship between conflict areas and slope, elevation and land cover types. Binary logistic regression was used to show presence data of conflict sites and absence data (non-conflict sites). Random points were generated in the study area to represent absence data. Results showed that elephants (94.3%) were the most notorious animals that caused conflict in form of crop damage (91.5%), usually occurring at night (91.5%) in SH ecosystem. The distances to water (β= -0.0012, P=0.000), fence (β= -0.0006, P=0.000), roads (β=0.0005, P=0.016) and settlements (β=0.0002, P=0.037) were significant determinants of HEC. Areas near water and fence, and away from roads and settlements were most prone to conflicts. The four significant variables were used to generate elephant conflict prone area map. Such a map is of practical and strategic use to wildlife managers in SHNR. The study recommends community awareness programs to be implemented to educate and involve the community on early detection of HEC and the mitigation measure required.

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LIST OF ACRONYMS

DEM	Digital Elevation Model
FGDs	Focused Group Discussions
GIS	Geographic Information System
GPS	Geographical Positioning System
HEC	Human elephant conflicts
KFS	Kenya Forest Service
KWS	Kenya Wildlife Service
SH	Shimba Hills
SHNR	Shimba Hills National Reserve
VIF	Variance Inflation Factor
HWC	Human-Wildlife Conflict

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CHAPTER ONE

INTRODUCTION

1.1 Background

The Human Elephant Conflict (HEC) has been a persistent problem in many regions of the world Africa. The competition for resources increasingly brings conflicts wherever humans and wildlife coexist. The ongoing pressure on natural habitats increases the risk of conflicts across African protected areas. Hoare & Du Toit (1999) report that eighty percent of the African elephant's range extended outside protected areas which were surrounded by agricultural activities. According to Riley *et al.* (2003), human-elephant interaction becomes a conflict when people experience, perceive and interpret them as producing negative impact. Whereas the conditions for HEC may be unique to each specific area, the key driver of such conflict is competition for space and resources (Balmford *et al., 2001).*

The Shimba hills (SH) ecosystem in coastal Kenya is a site of great concern due to its high biological richness and status as an indigenous homeland of the sable antelopes (*Hippotragus niger roosevelti)*. It is a prime example of a location where well-intended management and conservation initiatives have led to even greater conservation dilemmas. Like other protected areas in Africa, the limited size of Shimba Hills National Reserve (SHNR) and the Mwaluganje Elephant Sanctuary (MES) cannot adequately sustain the rapidly growing resident elephant population. The extensive browsing behavior of elephants is destroying the existing ecosystem and severely affecting endemic plant species such as the Cyanometra trees (Kiiru, 1995; Kahumbu, 2002). Additionally, elephants have learned to search for food outside the Reserve boundary leading to severe conflict with farmers living near the boundary (Kahumbu, 2002; Woodroffe *et al.*, 2005). The present situation illustrates the immense challenge of reconciling global biodiversity goals with local residents' needs and concerns for economic development and safety. SHNR is a typical example of how HEC and subsequent mitigation strategies employed by park managers and conservationists have continued to experience emerging concerns.

In SH ecosystem, the elephant problem has been there since the 1980's (Rose, 1984) and by 1994, elephants were considered a major threat to local communities (Thouless *et al*., 2008). The government together with relevant conservation agencies introduced diverse mitigation measures including the erection of an electric fence and translocation of problem animals.

The erection of the electric fence in the 1990s' greatly reduced the conflicts by 33% between 1995 and 2001 (Thouless *et al*., 2008). Although the erection of electric fence curbed the conflicts for a while, lack of proper maintenance of the fence made the conflicts to reoccur as the elephants would break the fences and enter into farms. Translocation involved moving of the problem elephants to Tsavo East National Park. The translocation process was costly and some elephants were reported to return to their former ranges.

In spite of the foregoing challenges, electric fence and translocation methods have proved effective elsewhere in Africa's protected area (Kasiki, 1998). However, the haphazard way in which the management of SHNR implemented these mitigation measures in SH ecosystem, possibly due to lack of understanding of the underlying causes and potential areas where the conflicts occurred could have contributed to their ineffectiveness within SH ecosystem. This therefore necessitated conducting the current study to determine the key factors that lead to HEC in SH ecosystem.

1.2 Problem Statement

Several mitigation measures have been applied to solve Human-elephant conflicts in SH ecosystems. In SHNR, high technological mitigation measures such as the electric fence and translocation have been tried, yet the problem still persists. Effective management strategies require a complete understanding of the problem, its locality-specific causes and past attempts to solve it. Since elephant conflict has been associated with habitat factors, this study sheds light on key factors that determine human elephant conflicts in SH ecosystem.

1.3 Research Objectives

1.3.1 Main objective

The main objective of this study was to investigate the biophysical factors that contribute to human elephant conflicts in SH ecosystem.

1.3.1 Specific Objectives

i. To identify the types of human wildlife conflicts in SH ecosystem.
ii. To determine the biophysical characteristics of elephant conflicts sites in the SH ecosystem.
iii. To determine the relationship between the frequency of conflicts with water, roads, fence, no-fence, elevation, slope, settlements and land-cover.

iv. To map out conflict prone areas.

v. To compare the perceived effectiveness of traditional and modern mitigation measures of HEC in the SH ecosystem.

1.4 Research Questions

This study was designed to answer the following research questions:

i. What are the main types of human wildlife conflicts in SH ecosystem?

ii. What are the key determinants of human elephant conflicts in SH ecosystem?

iii. What are the characteristic features of human elephant conflicts in SH ecosystem?

iv. What is the relationship between human-elephant conflicts and selected habitat factors among them roads, water, settlements and fences?

v. What are the differences in the effectiveness of traditional and modern mitigation measures?

1.6 Justification of the study

SH ecosystem was chosen for this study because it was the first protected area in Kenya to be completely surrounded by electric fence, and this has caused an artificial concentration of elephants into a small area leading to persistent human- elephant conflicts. The SH ecosystem also has a total of 1,396 plant species that are endemic to Shimba Hills National Reserve and the forest habitat holds more than half of Kenya's rare tree species (Luke, 2005).These attributes make SH ecosystem an important ecosystem for conservation.

The elephant is considered a keystone species that opens up forests and woodlands for other animals and plants and acts as a dispersal agent for plants (Haynes, 2011, Dougall and Sheldrick, 1964). The elephants can drastically modify the habitat for itself as well as influence the survival of other species (Desai and Baskaran, 1996). The African Elephant has developed an adaptive behavior to the prevailing circumstances of the area it inhabits. This is manifested in the way in which it continues to thrive even in small confined areas like Shimba hills.

The only studies examining relationships between elephants and conflict areas in SH ecosystem were those of Jivetti (2004), Reuling (2007) and Dyson (2012). Jivetti (2004) attributed HEC to land use conflicts and recommended that there was need for more consistent efforts in applying current policy and a unified land use policy throughout the country. Reuling (2007) integrated land cover and local vulnerability to determine what socio-ecological factors influenced local perceptions of elephant threat around SH. Among the factors Reuling identified were the cultivation of cassava and coconut and ethnicity of the communities surrounding SH ecosystem. Dyson (2012) on the other hand, considered the dependence of the local community on SHNR for their livelihood. The denial or control of utilization of resources in SHNR is possibly the reason why the community had a negative perception toward the Reserve. Dyson (2012) recommended that prevention measures should be taken to minimize HEC.

1.7 Conceptual Paradigm

Figure 1.1 is the conceptual diagram showing all the probable factors that would contribute to HEC in SHNR. Using the areas that have conflicts and those that have no conflict, the logistic regression would be used determine the key factors that contribute to HEC, hence map the conflict probable areas to assist in managing conflicts.

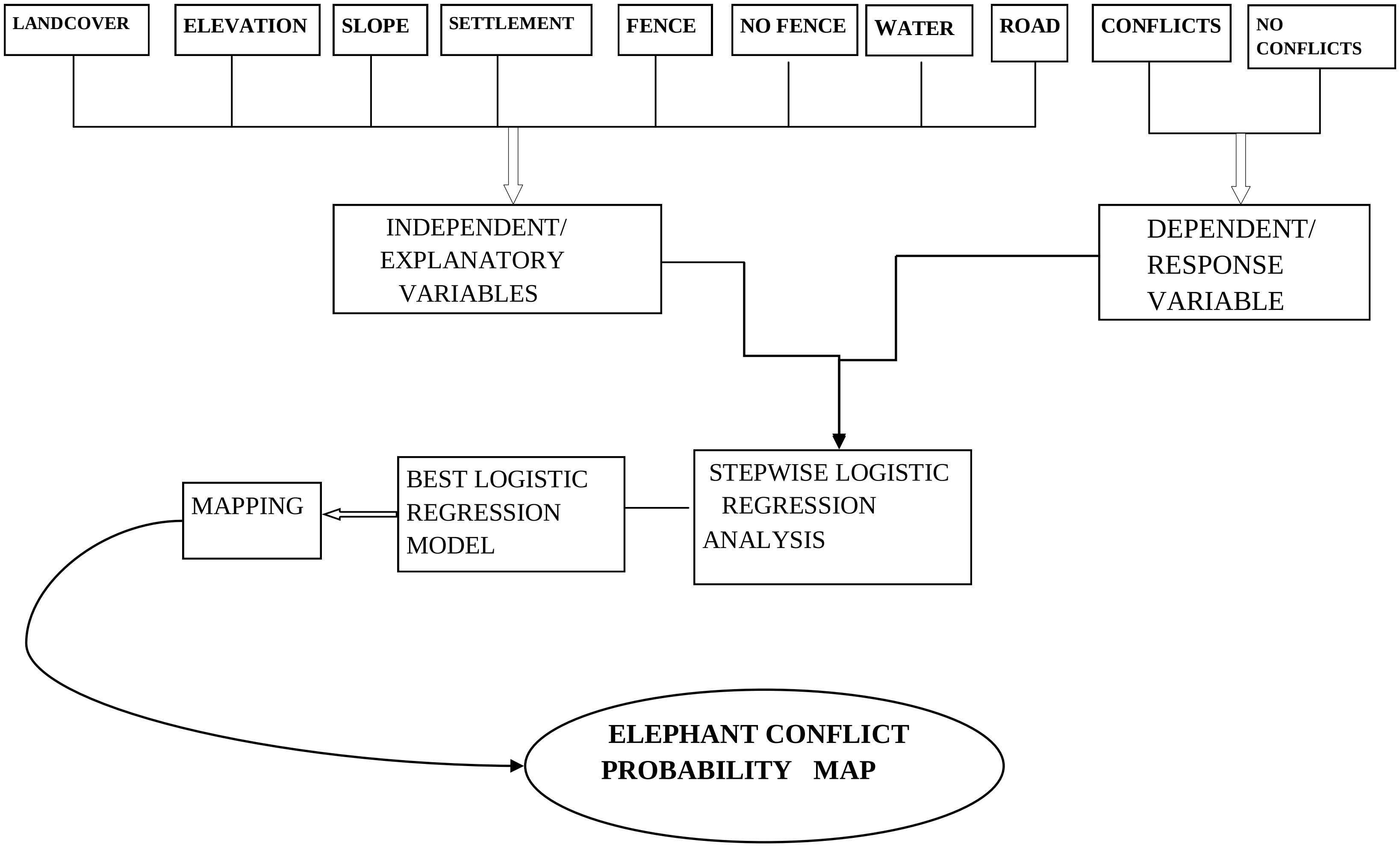

Figure 1.1: The conceptual model of developing an elephant conflict probability map

CHAPTER TWO

LITERATURE REVIEW

2.1 Human- Wildlife interactions

Human-wildlife interaction occurs when human beings come in contact with wildlife either intentionally or unintentionally. These contacts may either be positive or negative, ranging from people enjoying feeding and watching birds, to wildlife foraging, to potential life threatening events like injury of either animal/ human which leads to conflict. Anon (2005) defined conflict as any interaction between humans and wildlife that results in negative impacts on the social, economic or cultural life of human beings and on the conservation of wildlife populations, or on the environment. It occurs when growing human populations overlap with established wildlife territories, creating reduction of resources or life to some people and/or wild animals (Woodroffe *et al.*, 2005).The demand for space and resources due to growing human population leads to displacement of natural wildlife territory.

Human-wildlife conflict (HWC) occurs when the needs and behavior of wildlife impact negatively on the goals of humans or when the goals of humans negatively impact on the needs of wildlife. These conflicts may result when wildlife damage crops, injure or kill domestic animals and threaten or kill people. The HWC escalates when local people feel that the needs or values of wildlife are given priority over their own needs, or when local institutions and people are inadequately empowered to deal with the conflict. If protected area authorities fail to address the needs of the local people or to work with them to address such conflict adequately, the conflict intensifies, becoming not only conflict between local communities and the wildlife but national HWC.

Traditionally, it was widely believed that, it was the larger herbivores including elephant (*Loxodonta africana*), buffalo (*Syncerus caffer*) and hippopotamus (*Hippopotamus amphibius*), and large carnivores such as lion (*Panthera leo*), leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), spotted hyena (*Crocuta crocuta*), wild dog (*Lycaon pictus*) and crocodile (*Crocodylus sp*.) that were responsible for most of the HWC (Anon, 2005; Parker *et al*., 2007). However, small animals can also be responsible for high levels of human–wildlife conflicts. In Africa, some small mammals are a source of conflict, although generally, they play important ecological roles such as soil aeration, seed dispersal, provision of food for large animals, indication of the status of environmental health and formation of linkages in the food chain (Aschwanden, 2005).

Competition between wild species occurs when habitats become degraded, especially by elephants. Elephants can even jeopardize the survival of sympatric wildlife species. In Waza National Park in Cameroon, the destruction of *Acacia seyal* by elephants near the ponds where they gather at the end of the dry season endangers the survival of the giraffes that feed on this tree. Muriuki (2003) found that HWC were prevalent in all parts of Kenya, but were more pronounced in agricultural areas where the affected farmers reported the conflicts. In Shimba Hills, concerns have been raised on the growing number of elephant population that has a negative impact on the indigenous trees of SHNR. For SH ecosystem, HWC has involved wildlife such as the elephants (*Loxodonta africana*), buffalo (*Syncerus caffer*)), baboons (*Papio* *anubis*), monkeys (*Colobus polykomos*), wildpigs (*Sus scrofa*), crocodiles (*Crocodylus niloticus*) and Lions (*Panthera leo*).

2.2 Ecology of African elephant

The African elephant (*Loxodonta*) is within the Order Proboscidae, Family elephantidae and Genus *Loxodonta* (Shoshani, 2005). The two recognized subspecies of African elephant are the forest elephant (*Loxodonta africana cyclotis*) and the savanna elephant (*Loxodonta africana africana)*. Savanna elephant is larger than the forest elephant, has sparser body hair, more triangular ears that are larger and thick, curved tusks as opposed to the straighter, narrower downward pointing tusks of the forest elephant (Lausen and Beckoff, 1978). *L.a. africana* inhabits the Eastern and Southern Africa, while *L.a. cyclotis* occurs predominantly in the Congo Basin of Central Africa (Blanc *et al.,* 2007). A genetic study done on the subspecies of African elephant found that the two, are infact distinct species namely, L. *africana* and L. *cyclotis* (Comstock *et al.,* 2002*)*.The World Conservation Union (IUCN) however, recognizes *L. africana* as a single species (AfESG, 2004).

East Africa accounts for about 90 thousand elephants out of a population of 0.5 million individuals in Africa (IUCN, 2013). Kenya currently has over 35 thousand elephants, with the largest population of 11 thousands in the Tsavo ecosystem (Litoro et al., 2012).). Shimba Hills houses an elephant population of nearly 700 animals, a level that is unsustainable due to the small size of the Reserve, increasing number of elephants and increasing degradation of elephant habitat (Kiiru, 1995; Kahumbu, 2002; Litoro, 2003). The fence-confined and rapidly growing elephant population has reduced the endemic plant species and greatly stressed the fragile ecosystem within the biologically diverse Reserve (Kahumbu, 2002).The population of elephants in SHNR has ranged from 270 to 658 with an average of 400 (Litoro, 2003). Table 2.2 and figure 2.1 highlight the status of elephant population in SH ecosystem between 1992 and 2012.

Table 2.1: Elephant population status between 1992 and 2012 in SH ecosystem

Year of Count	**Elephant Population**	**Data Type*/Quality***	**Data Source**
1992	300	DC[3]	Litoro et al.,2012
1997	464	AT[1]	Litoro et al.,2012
1999	658	IR[1]	Litoro et al., 2012
2002	649	DC[2]	Litoro et al., 2012
2012	274	AT[1]	KWS,2012

***Data type: AT -** Aerial Total, **DC** – Dung Count, **IR** – Individual Recognition

***Data Quality**: ($^{1-3}$; (^{1} being highest))

Source, Conservation & Management Strategies for Elephants in Kenya, 2012

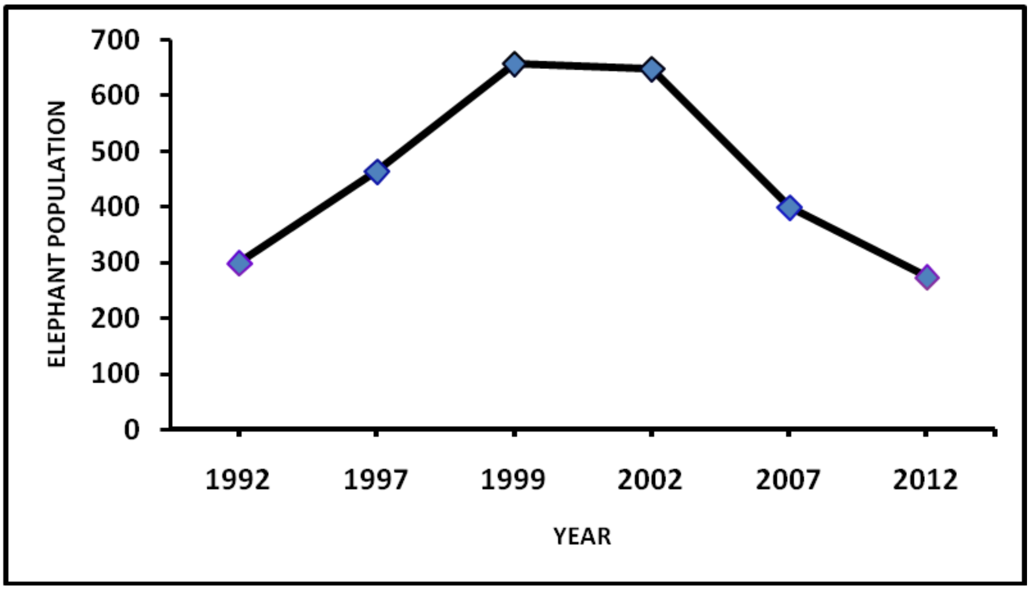

Figure 2. 1: Elephant population status between 1992 and 2012 in SH ecosystem

In the past, Shimba elephants were free to migrate out of the Reserve to other protected areas nearby, particularly from the West into Tsavo East National Park and south into Mkomazi Game Reserve in Tanzania, but intense poaching in Kenya and Tanzania in the 1970s and 1980s caused the elephants to seek refuge within SHNR (Litoroh, 2002). The erection of the electric fence and poaching threat curbed their movement. The creation of the Mwaluganje Elephant Sanctuary eased their movement between Shimba hills and Mwaluganje forest.

Although the East, central and Southern African elephant populations have shown a stable population growth over the years (Junker, 2008), elephant numbers have been threatened by various factors including poaching, habitat loss and HEC. Poaching for ivory is the main issue affecting the elephant population in many protected areas in Africa (Blanc *et al.*, 2007; Thouless *et al.*, 2008). Ivory is a marketable commodity that has been worked and traded for thousands of years (Conrad, 2003).Throughout much of the twentieth century, hunting of elephant for ivory has continued to reduce their populations. Elephants were hit particularly hard in the 1970's when an estimated 100 thousand individuals were killed per year and up to 80 percent of herds were lost (Doughlas-Hamilton, 1979).The sharp decline in elephant numbers in Africa caused an international outcry which led to ban of ivory trade (Stephenson, 2007).Through the anti-poaching efforts and implementation of laws protecting elephants, their population has had a recovery in numbers in many parts of Africa (Blanc *et al.*, 2003). African countries with elephants continue to invest massive financial resources and personnel to protect the species (Thouless *et al.,* 2008).

Habitat loss, in form of deterioration and fragmentation of natural habitats attributed to the climatic changes and various human activities (Laurence *et al.*, 2010), has over the years negatively impacted on the elephants. The elephant habitats are declining in extent and quality as expansion of human populations continue to convert land for agriculture, settlement and development activities (Thouless, 1999). Africa has many of the world's poorest nations, with majority of the population still reliant on agriculture as a primary source of food and revenue (UNDP, 2005). Almost three quarters of Kwale County (825,700ha) can be regarded as suitable for agricultural production (Oosten,1989).While a majority of communities in Kwale are engaged in farming activities and livestock keeping, natural resources such as forests, rivers, and indigenous plants have provided food, fuel and medicine for the community. Increase in human population utilizing these resources has led to depletion of crucial habitats leading to fragmentation.

The gradual increase in elephant density results in expansion of their home ranges. Home range provides a measure of elephant spatial use in relation to various biotic and abiotic factors. Elephant home range is larger in dry season than in wet season. Kahumbu (2008), found that elephants in SH used a small portion of the available range of 262 km^2, the home range size was affected by the exclusion of elephant from some areas in the Reserve. Kahumbu also observed that the cow and the bull elephants used their range independent of one another. This behavior makes the elephants to colonize new areas outside the Reserves, which normally bring them into contact with humans. The onset and increase in conflicts is as a result of the interaction between elephants and humans (Sukumar, 1990).

2.3 Human elephant conflicts

Humans and elephants often compete for land, food, and water. Human-elephant interaction in elephant ranges depicts increasing levels of human activities near PAs although the outcome of this interaction impacts negatively to the local people (Omondi *et al.,* 2002) The conflict occurs almost everywhere when elephants come into contact with humans, regardless of whether the elephants are protected or not (Hoare, 2000). Parker *et al.* (2007), broadly defined HEC as "any human-elephant interaction which results in negative effects on human social, economic or cultural life, on elephant conservation or on the environment". Conflict arises from a range of direct and indirect negative interactions between humans and wildlife. These can culminate in potential harm to all involved, and lead to negative human attitudes, with a decrease in human appreciation of wildlife and potentially severe detrimental effects for conservation (Nyhus *et al.*, 2000). Conflict generally arises from economic losses to agriculture, including loss of cattle through predation and destruction of crops. In arid areas it often occurs over access to water and competition for resources.

Gradual increase in human population in Africa has increased demand for land for development of dry-land crop agriculture and infrastructure. On the other hand, high populations of large herbivores have aroused concerns in East Africa through their migration in search for forage and water. Agricultural activities around wildlife habitats are prone to raids by herbivores such as elephants which destroy most of the crops causing conflicts (Hoare, 1999). Changes in crop farming practices by local communities linked to maize, bananas, cashew nuts, pumpkins, sugarcane, carrots and onions, the preferred food crops by elephants, and the pattern of crop depredation parallels the crop-growing season (Hoare, 1999; Kiiru, 1995a).

In the early 20th century, elephants in the SH ecosystem were believed to have ranged widely in Kwale County and across to Tsavo (60km North) and Mkomazi (40km South) (Thouless *et al*., 2008). They were gradually eliminated from the rest of the County through poaching and controlled shooting and some were confined in the Reserve. However, despite the confinement in the Reserve, the elephant destroyed the defenses and moved outside the protected areas leading to their contact with humans thereby causing conflicts. SH ecosystem has experienced serious elephant conflicts since the 1980's. From 1980 to 1994, 18 people in the area were recorded to have been injured by elephants, and about 2171 cases of conflicts involving crop raids, human death and property destruction had been reported (Thouless *et al*., 2008). Elephants disrupted the social lives of people. For instance, children could not go to school for fear of running into elephants, and properties were being destroyed by elephants in areas around the Reserve. With the persistent conflicts, there was need to strike a balance between human welfare and elephant conservation thus requiring the identification and application of mitigation strategies (IUCN, 2006).

2.4 Factors influencing human elephant conflict

The varying availability of food, water and shelter due to changes in weather are the key determinants of the distribution of elephants (Harris *et al.*, 2008; Ngene, 2010). Much has been done on the determinants of distribution of elephants (Foley, 2002; Ntumi *et al*., 2005; Harris *et al*.,2008;Van Aarde *et al*., 2008; Mukeka, 2011) and these may be of value in determining the overlap in distribution and the consequent likelihood of HEC. Overlap in spatial use by people and elephant leads to interactions between them. These interactions may be associated with the spatial variables such as human density, extent of land transformation, agricultural practices, the density of roads, proximity to protected areas and distance to permanent rivers (Hoare and du Toit, 1999; Parker and Osborn, 2001; Sitati *et al*., 2003).

High human population leads to greater demand for land to settle. Elephants are constantly losing range to expansion of human settlement. Lack of land-use and sustainable development planning will only lead to an untenable increase in HEC, with a predictable negative outcome for the elephant (Lindeque, 1995). The human population around Shimba Hills grew from 75,557 in 1979 to 151,748 in 2009 (KNBS, 2009). The increasing human population raises the demand for the basic resources such as fuel and timber, usually acquired through illegal collection from the Reserve. Conversion of potential wildlife habitats to commercial and residential settlements blocks previous pathways that wildlife used. This consequently leads to increased conflicts as humans and wildlife compete for resources and human pressure is exerted on wildlife ranges. This situation is compounded by the introduction of land use activities that are incompatible with wildlife conservation.

The distance from the roads has been documented to influence the poaching impact on elephant numbers (Mukeka, 2011). Nearness to permanent rivers and protected area boundaries has been shown to influence the distribution patterns of elephants in Tsavo National Park (Mukeka, 2011). Kyale (2006) found that poaching was rampant near streams and permanent water sources due to higher elephant concentrations in these areas. Ngene *et al.,* (2009) observed that elephants were found near roads because the poaching threat was less here than in vegetated areas where poachers enjoyed more cover.

2.5 Regression Models

Regression methods have become an integral component of any data analysis concerned with describing the relationship between a response variable and one or more explanatory variable. Analysis involving two or more independent variables and a dependent variable employs the multiple regression. Multiple regression is useful in understanding the functional relationships between the dependent and independent variables, to try to see what might be causing the variation in the dependent variable. Modeling offers a powerful tool in understanding species- habitat relationships. Regression models vary depending on the type of response variable used. The response variable with presence and absence data uses the binomial logistic regression, while count variable uses Poisson regression.

Since the Poisson regression uses large amount of count data of the response variable, many studies have not been able to obtain the required minimum number for analysis, and this makes the method unpopular for use in regression analysis. Over the last decade, the logistic regression model has become the standard method of analysis for the situation where the outcome variable is binary. As McCullagh & Nelder (2000) stated, logistic regression is one of the simplest ways of estimating a resource selection probability function. Taking a census of the used and unused units in a population of resource unit, one estimates a logistic function for the probability of use as a function of variables that are measured on the unit. What distinguishes a logistic regression (LR) from the linear regression model is that the outcome variable in LR is binary or dichotomous, such as used or unused units, occupied or non-occupied units, success or failure etc. This difference between logistic and linear regression is reflected both in the choice of parametric model and in the assumptions. Once this difference is accounted for, the methods employed in an analysis using LR follow the same general principles used in linear regression (Hosmer & Lemeshow, 1989). The LR coefficients are used to estimate odd ratios for each of the independent variables in the model (McCullagh & Nelder, 2000).

Logistic regression has been used extensively in probability of events such as disease prediction, habitat determination and causality cases. Breslow & Day (1980) discussed how the LR model gives a simplified, quantitative description of the main pictures of the relationship between the several risk factors and the probability of disease development. It also enables one to predict even for categories in which scant information is available. Ramsey *et al.*, (1993) also used this tool for investigating habitat association. In demonstrating causality, the analysis shows that an independent variable causes a change in a dependent variable (Zar, 1984). Sitati *&* Walpole (2006) used LR to explore a range of factors that influenced the susceptibility of certain farms to attacks than others. The LR has also been extensively used in environmental and ecological studies such as habitat suitability models and prediction of deforestation (Van Gills & Loza, 2006). Manyenye (2008) used LR to predict and map risk areas for zebra poaching in Tarangire National Park, Tanzania. There are several reasons why people choose the logistic distribution for analyzing a dichotomous outcome variable. These are:

- From mathematical point of view, it is an extremely flexible and easily used function. Analysis of data from retrospective studies via logistic regression may proceed in the same way and using the same computer program as prospective studies.
- Method lends itself to biologically meaningful interpretations.

Like all the statistical analysis, LR assumptions include;

1. Logistic regression does not assume a linear relationship between the dependent and independent variables.
2. The dependent variable must be a dichotomy (2 categories).
3. The independent variables need not be interval, nor normally distributed, nor linearly related, nor of equal variance within each group.
4. The categories (groups) must be mutually exclusive and exhaustive; a case can only be in one group and every case must be a member of one of the groups.

The variables chosen for this study met the above assumptions and thus sufficient for a logistic regression analysis.

2.6 Measures to mitigate human elephant conflicts

Mitigation measures attempt to reduce the level of impact of conflict and lessen the problem. Amid the continuing conflicts between humans and elephants, various mitigation measures have been adopted in different areas and their effectiveness ascertained in a spatial and time context. Parker *et al.*, (2007) classified mitigation measures either as traditional methods, conventional approaches or experimental methods. Traditional methods are indigenous knowledge based and have been devised by rural communities living alongside elephants. Conventional methods are used by wildlife managers while the experimental method uses the acoustic, olfactory and barrier techniques. The traditional methods usually, involve inexpensive and low-technology innovations implemented by farmers at the local level (Parker *et al.*, 2007) while the modern methods are expensive and use high-technology, requiring advanced technical know-how (Sitati and Walpole, 2006).

Traditional methods deter or scare animals from entering the farms. Such deterrents are usually composed of low-tech materials that are widely available in rural locations. Rural farmers may use a range of noisemakers, such as beating drums and tins, 'cracking' whips, yelling and whistling to chase elephants away. Farmers may also use catapults, or throw rocks, burning sticks and occasionally spears at crop-raiding elephants. This usually involves getting close to the animals, and therefore the level of danger is high. Fires may be lit on the boundaries of fields or burning sticks may be carried by the farmers. Plastic and rubber may also be burnt to create a noxious smoke, and fires may be left burning all night even if the farmers are not present in the fields.

The problem with the foregoing deterrents is that they tend to become ineffective over time. Usually a community will rely upon just a few methods, and these will be used repeatedly with little variation. Because of this, elephants may habituate to them, and may eventually ignore them altogether.

Conventional methods used by KWS include elephant shooting, electric fence and removal techniques. Removal techniques involve killing elephant in the problem area or translocation of the elephants. Translocation is the removal of a problem animal by tranquilizing and transporting it to a new location where they are released, using specially designed vehicles (Rout *et al.,* 2007*).* Translocation of animals has been undertaken in Kenya and South Africa, among other countries. Translocation may appeal more to conservation organizations because it has a number of advantages, including saving elephants from being killed, replenishing populations that have been diminished by poaching, and taking obvious action that satisfies local communities who are normally confronted with conflicts.

Although translocation is considered a humane management alternative to killing problem elephants the cost is extremely high and the operation involves specialist equipment and skills (Nelson *et al*., 2003). Identification of the problem animal is difficult, especially if it involves migratory elephants, while capture and transportation of elephants is stressful. (Tchamba, 1995).

Several mitigation measures including traditional methods, killing problem elephants, electric fence and translocation have been implemented in SHNR. In the 1980s, thirteen problem elephants were killed (Thouless *et al*., 2008). However, a more viable long term solution to the conflict was needed, if elephants were to be conserved in an area with high human population. In 1992, electric fencing was adopted as a long term solution to the elephant menace, and was completed in 1998. Funding for the fencing project was provided by various donors, including KWS, Eden Trust (UK), the European Union, and the World Bank (Litoro, 2003).

After the erection of the electric fence, the farms that had been abandoned due to elephant dangers were cultivated, and HEC reduced by 33% between 1995 and 2001(Jivetti, 2004). Human deaths and injury were also reduced by 70%, while fewer elephants were killed by KWS rangers. The fencing of the Mwaluganje Elephant Sanctuary also reduced HEC. It is now a source of tourism revenue for the local people whose farms were continually being raided by elephants (Jivetti, 2004). The fence requires regular maintenance to function properly, but lack of trained technicians has threatened the efficiency of the electric fence (Litoro, 2003).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The study was carried out in SH ecosystem which comprises of Shimba Hills National Reserve (192 km^2), Mwaluganje Elephant Sanctuary (MES) (36 km^2), Mkongani North (11 km^2) and Mkongani West (14 km^2) Forest Reserves, making up a total area of 253 km^2 , and surrounding neighboring locations. It is situated in Kwale County within the Coast Province in Kenya. The ecosystem is a remnant coastal rainforest located 35 kilometers south of Mombasa, Kenya between longitudes 4^{o}05'-4^{o}21'S and latitudes of 39^{o}15'-39^{o}30'E (Figure 3.1).. It is composed of a low range of hills which rise to just over 400 m above sea level. The SHNR and MES are jointly managed by the Kenya Wildlife Service (KWS), Kenya Forest Department (KFD), and the Mwaluganje Elephant Sanctuary Committee (Conservation International, 2007).

The area experiences a humid semi-equatorial climate of an average monthly temperature ranging from 24^{o}C to 28^{o}C and an average annual precipitation of 1200mm. SHNR is ideally located in the wettest portion of Kwale County and the hills are a primary water source for the area. The average annual precipitation ranges between 500 and 1,500 mm (Shimba Support Group, 2007). The highest yearly precipitation occurs from March-June when the long rains take place and later in the year during the short rains of October and November.

3.1.1 Flora and Fauna

The vegetation in and around SHNR creates an intricate montage of open grasslands, bush-lands, woodlands and forests. The mosaic of high-canopy forest, grass, deciduous forest and thicket provides ideal habitat for a diverse range of species (Kiiru, 1996). The remnant humid tropical ecosystem contains endemic, threatened, and endangered flora. Being one of the richest areas of plant endemism in Kenya, SH ecosystem has a total of 1,396 plant species that are endemic to Shimba Hills and that the forest habitat holds more than half of Kenya's rare tree species.

Some of the world's endangered fauna of prime biological importance include the Sable antelope (*Hippotragus niger harris*) and Cyanometra trees that are destroyed by elephants also occur here. Other fauna in SHNR include; baboon (*Papio anubis*), buffalo (*Syncerus caffer*), colobus (*Colobus guereza*), elephant (*Loxodonta africana*), waterbuck (*Kobus ellipsiprymnus*), impala (*Aepyceros melampus*), duiker (*Cephalophus monticla*), hartebeest (*Alcelaphus buselaphus*) and bushbuck (*Tragelaphus scriptus*).

3.1.2 Geology and soil

The area is composed of sedimentary rocks from the Duruma Sandstone series. The soil composition of the area is classified as Shimba Grit and Mazeras Sandstone from the Upper Triassic Age (200 million years ago) (Shimba Support Group, 2007). The soil in Kwale has very poor fertility due to excessive leaching, high sand content and low organic content.

3.1.3 Landuse and socio-economic activities

Small-scale agriculture is the most significant source of income in Kwale County, although 92% of the County is categorized as having low agricultural potential (Kahumbu 2002).The crops grown here are mainly cassava, maize, sweet potato and pigeon peas and tree crops such as cashew nut and coconut. The Digo and Duruma, two of the nine subtribes of the Mijikenda group compose the largest populations in Kwale County (Kenyaweb, 2001). Other livelihood activities in the area include charcoal production and small businesses.

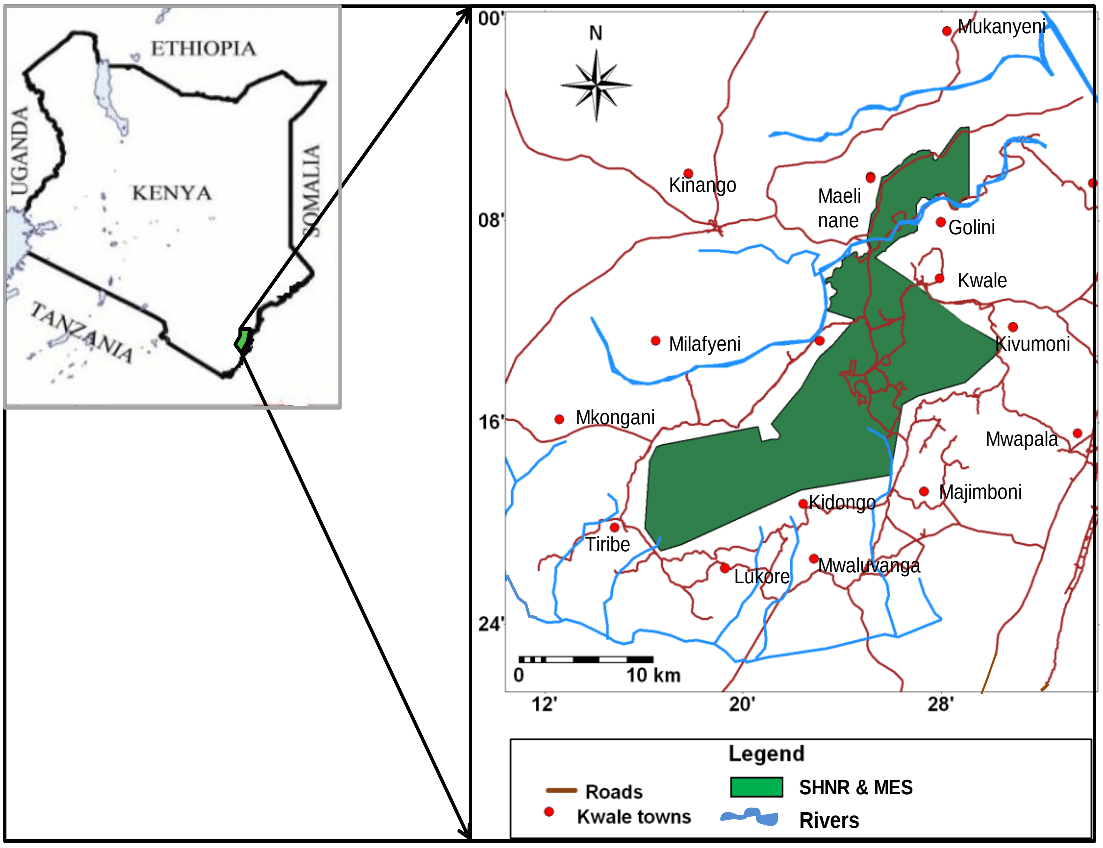

Figure 3.1: Location of the study area. (Source: Author, 2013)

3.2 Materials

Data used in this research was acquired from different sources as summarized in Table 3.1.

Table 3. 1: Data sources

Data	**Source**
Digital Land cover map	Reuling, 2007
DEM 90M	United States Geological Survey(USGS, 2012)
Printed topographic map 1:50,000	Survey of Kenya
Rainfall data	KWS research department
2009 population census	Ministry of Agriculture, Kwale
Conflicts data	Primary data from the field by the researcher
No conflicts data	Generated by researcher using Ilwis 3.3
Settlement	Ministry of Youth Enterprise, Kwale
Road	Ministry of roads, Kwale

3.3 Data Collection

Data on types of HWC and mitigation measures to capture objectives one and five was collected using a structured questionnaire.

To obtain data on names of conflict sites in the study area, as well as complement the information provided in the questionnaire, Focused Group Discussions (FGDs) were used. Biophysical factors including land cover, elevation, slope, settlement, water, road, fence and no-fence were collected using secondary data method and pre-processed using GIS techniques, hence achieving objective two, three and four.

3.3.1 Types of Human-Wildlife conflicts and mitigation measures

3.3.1.1 Questionnaire

Questionnaires were distributed to respondents based on (1) an area's long documented history of HEC and (2) villages located within the range of 0 to 10 km from the Reserve boundary. There were 11 locations located within this range and they were purposely selected on the bases of (1) and (2) above. The 11 locations were stratified into blocks of four regions: North West comprising of Mbuguni and Ngomeni locations; South West that included Mkongani, Mwaluphamba and Mwaluvanga; South East comprising of Lukore, Majimboni, and Magawani; and the North East comprising of Tsimba, Tiwi and Golini (Figure 3.2). The South East and North East regions were characterized by high populations and several nearby social facilities that together contributed to the settlements being clumped together. The North West and South West regions comprised majorly of rural areas whose populations were small and scattered. Respondents comprised the general community in the proximity of the Reserve and the staff of KWS and KFS. These two groups of the respondents were targeted because they were deemed to have a treasure in the wealth of knowledge on the type and nature of elephant conflicts occurring around them. The questionnaire was pre-tested among some group of a population in the town centre which was not included in the main sample group, and the necessary corrections were done in the questionnaire.

The questionnaires administered comprised of two sections, A and B. Section A gathered data on the demographic details of the respondents and the resources obtained from the Reserve, while section B was made up of structured questions to collect information on status of HWC, times and seasons of elephant attacks , and traditional and new mitigation measures used (Appendix 1). For the regions selected, the population sample was chosen using the following the formula by Kothari (2004):

$$n_i = n.N_i\,\sigma_i / N_1\sigma_1 + N_2\,\sigma_2 + N_3\sigma_3 + N_3\sigma_3 + \ldots. + N_k\sigma_k$$

$$\text{for } i = 1,\ 2, \ldots. k$$

where ;

σ_1, σ_2, .. and σ_k denote standard deviations of the *k* strata

N_1, N_2,… N_k denote the sizes of *k* strata

N_1, n_2,…n_k denote sample size

Questionnaires were administered using systematic random sampling by skipping one or two households depending on the village settlement pattern. A total of 106 questionnaires were administered.

Figure 3.2: Map showing the administrative location boundaries of Kwale County and the stratified regions. Source, Reuling, 2007

3.3.1.2 Focus Group Discussions

Focus Group Discussions (FGDs) were used to obtain the conflict sites in the study area as well as to complement the information generated from the questionnaires. FGDs used pre-defined questions to gather information on human-wildlife conflicts around SH-Ecosystem, the elephant problem and to locate conflict areas on a baseline map derived from the topographic reference map of the area (appendix 2). Using these conflict areas the actual coordinates of conflict locations were recorded using a handheld Global Positioning System (GPS). Through FGDs a consensus view of a group on what can be done to reduce the elephant problem was sought. Selection of participants was based on those who had good knowledge of the area who were elderly members of the society. The discussions were done by combining respondents from two neighboring locations into one forum. These comprised of Mbuguni-Ngomeni locations, Mkongani-Lukore locations, Mwaluphamba-Mwaluvanga locations, Majimboni-Magawani locations, and Golini-Tsimba-Tiwi locations. The number of participants per discussion group was 10 members. Among them were officials that were appointed by the community to report on human-wildlife conflict, elderly men and women. Five sessions of group discussions were done. Data collected were collated and integrated in the discussion chapter in a narrative form in line with suggestions by Shemweta and Kidegesho, (2000).

3.3.2 Characteristics of elephant conflicts

Habitat characteristics that make elephants inhabit and live in a given environment include; elevation, slopes, water, fenced areas, no-fence areas, roads, settlements, land cover, and rainfall. Data for these variables were collected using GIS techniques coupled with secondary data. Figure 3.3 shows a baseline map from which the habitat factors were derived. Data for elevation was obtained from Digital Elevation Model (DEM), which was downloaded from the Shuttle Radar Topographic Mission website (USGS, 2012). Using ILWIS Academic software and the DEM, slope map was prepared in degrees and percentages. Data on water was derived from supplemented water points and rivers. Data on the supplemented water points were obtained by recording their coordinates using a handheld GPS while that the rivers were obtained by digitizing them from the scanned topographic map of SHNR.

Field observations showed that SHNR and MES boundaries are fenced with electric fence except in Lukore and Mwaluganje areas. Data on the fenced part of the Reserve boundaries were obtained by digitizing scanned topographic maps of Kwale and Msambweni Countys. The coordinates of the two no-fence areas were obtained by recording the two end points in the field using the handheld GPS to get no-fence variable.

The road network of Kwale and Msambweni Countys consisted of tarmacked and un-tarmacked roads which made up the major and minor roads. Both minor and major roads for this study were obtained from the Roads department at Kwale County as shapefiles. Data on settlements was obtained from Kwale Youth Development database that included commercial and residential buildings, and institutions.

The land cover map of Kwale County prepared by Reuling (2007) was scanned and digitized to obtain the required land cover types namely bush land, forest, woodland, agriculture and town. Rainfall data for the period January 2008 to December 2011 was obtained from KWS Kwale research records.

A total of 89 conflict locations were recorded in the SH-ecosystem using the handheld GPS to represent the presence points. Absence data when combined with presence data are used in regression based models to predict the relative likelihood of occurrence of conflicts (Pearce and Boyce, 2006). Therefore, an equal number of random points (89 absence points) were randomly generated using the ILWIS 3.3 to represent the absence data points.

Apart from the 89 conflict presence points recorded using the GPS, historical records of 1176 conflicts were obtained from SHNR records from January 2008 to December 2011. These were useful in relating the frequency of conflict with rainfall and the months of the year.

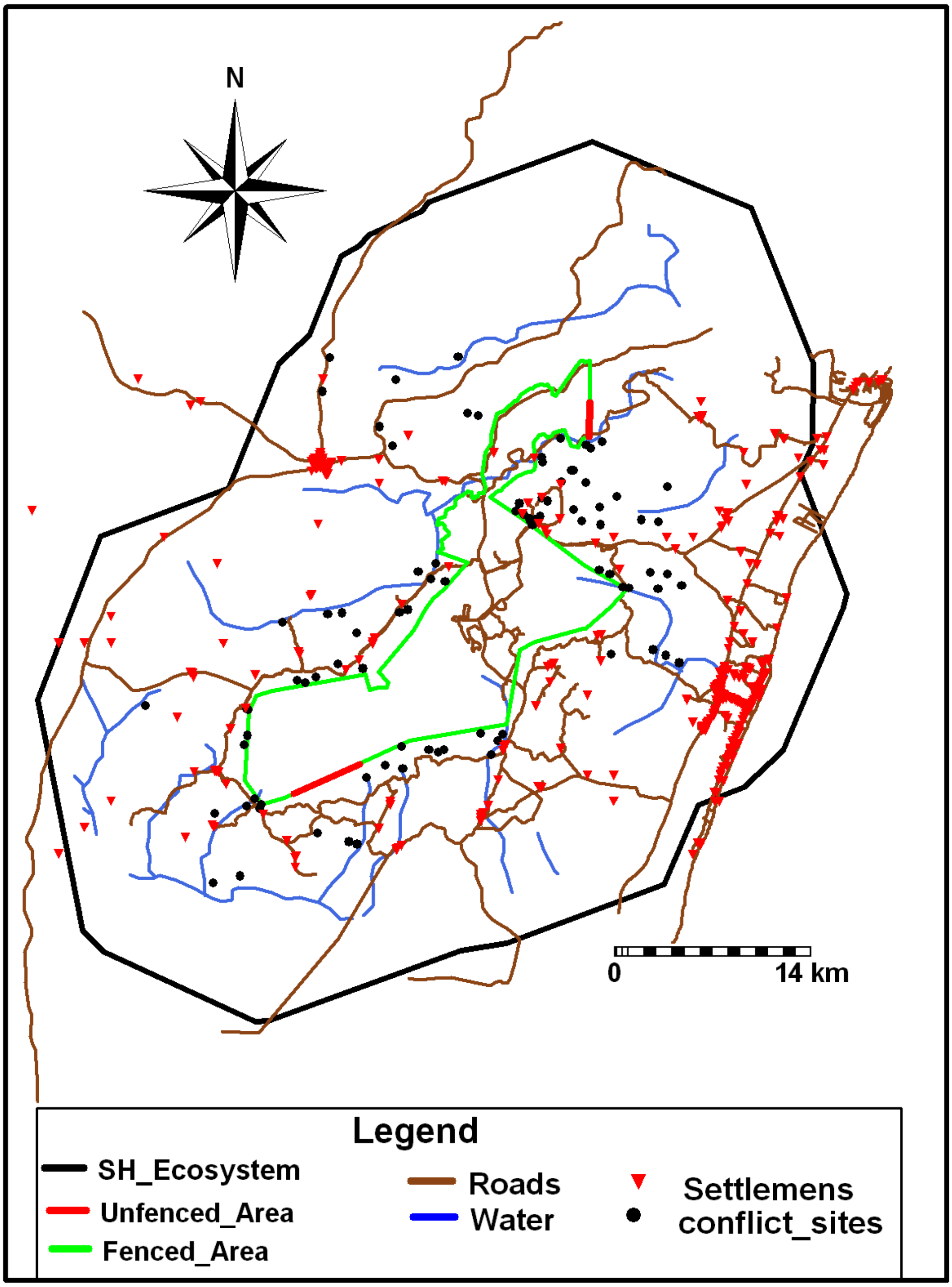

Figure3.3: Relationship between conflict and explanatory variables

3.4 Data Analysis

3.4.1 Analysis of types of HWC and comparison of Mitigation measure

The data collected from questionnaires on 106 respondents was entered and coded in excel spreadsheet and analyzed using the Statistical Package for Social Sciences (SPSS) version16. Descriptive statistics using percentages and frequencies were used to analyze data on demographics, resources obtained from the Reserve, animals involved in conflicts and types of conflicts. Chi-square goodness of fit test was used to analyze the dependency of the local community on resource utilization from SHNR. Bar graphs and pie charts are used to present information on mitigation measures.

3.4.2 Analysis of characteristics of conflict sites

The eight explanatory variables of elevation, slope, land cover, settlement, water, road, fence and no fence were analyzed in GIS using the ILWIS software. Distance calculation was done for settlements, roads, water, fence and no-fence; they were then cross-analyzed with the response variables. The rest of the variables among them land cover, slope and elevation were directly cross-analyzed with the response variable (appendix 7). The variables were imported to SPSS for logistic regression analysis.

3.4.3 Analysis of relationship between elephant conflicts with selected variables

In order to relate independent variables with conflict locations (response variable) data were analyzed using stepwise logistic regression. As recommended by Menard (2010), preliminary analysis of the data was performed to check the assumptions of logistic regression with respect to the selected predictors of the study.

Multicollinearity, which is high correlation among predictors in logistic regression, affects the validity of the statistical tests of the regression coefficients by inflating their standard errors (Garson, 2010). If the variables considered are correlated, Variance Inflation Factor (VIF) test is done to predict which factor caused the multicollinearity problem. If none of the variables had VIF greater than 10 (Mernard, 2010), the variables were fit for the logistic regression analysis.

3.4.4 Mapping conflict areas

The final best model from stepwise logistic regression having the significant factors was used to prepare a conflict prone areas map in ILWIS package using the following logistic regression equation (Sokol and Rohlf, 1995):

$$\mathbf{P\ (X) = Exp\ (\beta_0 + \beta_1 X_1 + \beta_n X_n)\ /\ 1 + Exp\ (\beta_0 + \beta_1 X_1 + \beta_n X_n)}$$

Where **P(X)** = probability of occurrence

Exp= Exponention of the variables

$\boldsymbol{\beta_0}$ =Constant

$\boldsymbol{\beta_1}$ **=** Regression coefficient of variable 1(or 1st factor)

$\boldsymbol{\beta_n}$ **=** Regression coefficient of variable n(4th factor)

$\mathbf{X_1}$ **=** Raster map of variable 1**.**

$\mathbf{X_n}$ **=** Raster map of variable n

CHAPTER FOUR

RESULTS

4.1 Characteristics of Respondents

4.1.1 Demographic information

Results showed that slightly more men (56.6%, n=106) than women (43.4%,) were interviewed. Majority of the respondents (81.1%, n=86) had lived in the study area for more than 10 years. Respondents aged between 36 to 55 years were the highest (49.1%) followed by those aged 18-35 (32.1%). Less than half of the respondents interviewed (40.6%) had secondary education while only 25.5% had no formal education (Table 4.1).

Table 4. 1: Demographic information on the respondents

Variable	Name	Frequency (n=106)	Percentage
Gender	Male	60	56.6
	Female	46	43.4
Age	18- 35 years	34	32.1
	36- 55 years	52	49.1
	56 - >65 years	20	18.9
Stay duration	< 1- 5 years	16	15.1
	6- 10 years	4	3.8
	>10 years OR Born here.	86	81.1
Education	No Formal education	27	25.5
	Primary	32	30.2
	Secondary	43	40.6
	University	4	3.8

4.1.2 Livelihood activities undertaken by the local communities

Most of the communities around SH ecosystem depend on crop farming (36.8%) and mixed farming 34.9%. Traders comprised of 19.8% while very few respondents practiced livestock keeping (4.7%) (Table 4.2).

Table 4. 2: Livelihood activities of the local communities in SH ecosystem

Livelihood Activity	**Frequency (n=106)**	**Percent**
Crop Farming	39	36.8
Livestock Keeping	5	4.7
Crop Farming & Livestock keeping (mixed)	37	34.9
Trade	21	19.8

4.1.3 Utilization of natural resources in SHNR by the local community

Natural resources found in SHNR that are used by the local communities include firewood, water, medicinal plants, charcoal, timber products and wild fruits (Table 4.3). Distance from community houses to the Reserve did not hinder the communities from obtaining the resources (χ^2=0.583, df=7, P=0.11). The proportion of respondents who utilized various resources from the Park differed significantly (χ^2=71.467, df=7, P=0.001) (Table 4.3). Firewood and water (54.7% and 31.1% respectively) were fetched more frequently than wood products (charcoal= 17.9 %) and timber (13.2 %).

Table 4. 3: Natural Resources communities obtain from SHNR

Resources	**Frequency* (n=106)**	**Percent***
Firewood	58	54.7
Charcoal	19	17.9
Grass	14	13.2
Water	33	31.1
Timber products	14	13.2
Wild fruits	8	7.5

*Multiple response given

4.2 Types of human wildlife conflicts experienced in SHNR and surrounding

4.2.1 Animals causing conflicts

Animals that cause conflicts ranged from birds to elephants. The proportion of respondents who experienced conflicts differed significantly (χ^2=194.772, df=5, P=0.001) in respect to the type of animal involved in causing conflicts. Results showed that elephants caused conflicts more (94.3%) relative to monkeys (53.8%) and bush pigs (34%) (Table 4.4).

Table 4.4: Wild animals from SHNR that are involved in conflict

Animal	Frequency * (n=106)	Percentage*
Elephant	100	94.3
Monkey	57	53.8
Rodent	21	19.8
Bird	20	18.9
Bush pig	36	34
Leopard	10	9.4

*Multiple responses given

4.2.2 Types of Conflicts experienced

Conflicts caused by elephants ranged from destruction of food stores to human death (Table 4.5). Chi-square goodness of fit test results showed that there were significant differences in the types of conflicts (χ^2=132.978, df=3, P=0.001). Crop damage was the major type of conflict (91.5%) experienced in SH ecosystem followed by human threat (76.4%).

Table 4.5: Types of conflicts experienced

Forms of conflict	Frequency* (n=106)	Percent*
Crop damage	97	91.5
Disease Transmission	29	27.4
Human threat	81	76.4
Damage infrastructure	37	34.9

*Multiple responses given

4.2.3 Time when conflict occurred

Majority of the respondents (91.5%) indicated that elephant conflicts occurred at night. 3.8% conflicts occurred during the day and 5.7% reported that they occurred all times. Respondents further indicated that conflicts occurring at night were majorly caused by elephants, while bush pigs and monkeys attacked during the day and at all times respectively (Table 4.6)

Table 4.6: Time when conflicts occurred

Time of Day	Frequency (n=106)	Percentage
During the Day	4	3.8
At Night	97	91.5
All the Time	6	5.7

4.2.4 Time of the year when conflicts in SH ecosystem occur

Between January 2008 to December 2011 there were 1176 HEC reported in SH ecosystem. The highest number of incidents were recorded in July, with a mean of 42.25 incidents per month whereas the lowest recorded incidents were in January with 20 incidents per month (Table 4.7). Human threat was highest in the months of March, May and July, whereas crop raiding had the highest peak in the month of July (Figure 4.5).

Table 4.7: Mean ±SE monthly number of HEC incidents in SH

Months	Jan	Feb	Mar*	Apr*	May*	Jun*	Jul	Aug	Sep	Oct*	Nov*	Dec
Mean conflict No.	20	22.67	31	26.25	36.25	26.5	42.25	25	22.25	23	22.75	21
Conflict season rate	Low	High	High	Low	High	Low	High	Low	Low	High	Low	low

*Shaded region are the rainny months of the year.The rate of conflict was determined by comparing the present month with the previous month.

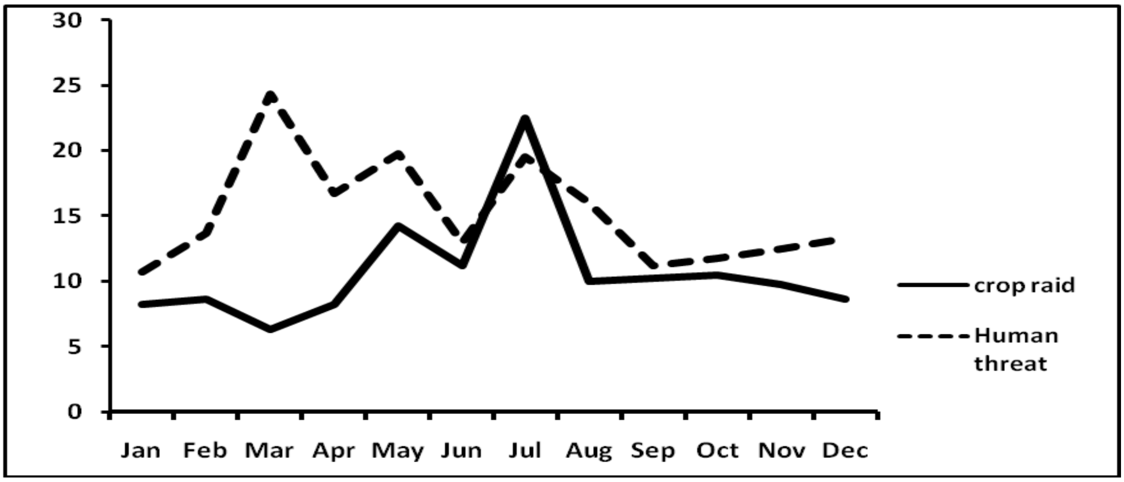

Figure 4. 1: Mean monthly HEC incidents of crop raiding and human threat

4.3 Characteristics of conflict sites in SH ecosystem

All the conflict sites recorded in the field in relation to distance from settlement, water and road were within the range of 0 to 7 km. The distances to land cover and no-fenced area had similarly for 7-10km (22 conflicts) as well as greater than 10 km (28 conflicts) (Table 4.8).

Table 4.8: Distance calculation of characteristic features of conflict sites

Distance	settlement	Fenced	no-fenced area	Water	Land cover	Road
0-7km	89	85	39	89	33	89
7-10km	0	4	22	0	22	0
>10km	0	0	28	0	28	0

4.4 Relationship between conflict sites and selected variables

4.4.1 Screened variables

Spearman's rank correlation performed for the explanatory variables showed that two coefficients of correlations with values > 0.5 that is, between fenced and unfenced and between roads and settlements were correlated (Appendix 6). This indicated that multi-collinearity existed which would have caused a problem in the regression analysis. Only the variables which showed collinearity were further analyzed using Variance Inflation Factor (VIF).VIF was done to predict which factor caused multicollinearity problem as listed in Table 4. Since none of the variables had VIF of >10 (Mernard, 2010), all the variables were fit for the logistic regression analysis.

Table 4. 9: Variance Inflation Factor (VIF) of the selected variables

Variable	VIF
Roads	1.573
Settlement	1.355
Fence	2.016
No-fence	1.559
Water	1.078

4.4.2 Selection of variables for logistic regression model

In the logistic regression model, seventy five non-conflict sites were predicted out of 89 sample points. Despite this only 71 conflict sites were correctly predicted out of 89 points (Table 4.10).The overall accuracy of the full mode was 81.1 %; this meant that the model explained 29.5 % more than the null model (50.6% for null model, table 4.11).

Table 4. 10: Null Model Classification Table

Observed		**Predicted**		
		Conflict		**Percentage Correct**
		Absence	Present	
Conflicts	Absence	89	0	100.0
	Present	89	0	.0
Overall Percentage				**50.6**

Table 4. 11: Full Model Classification Table

Observed		**Predicted**		
		Conflict		**Percentage Correct**
		Absence	Present	
Conflict	Absence	75	16	82.4
	Present	18	71	79.8
Overall Percentage				**81.1**

4.4.3 Model fitness

The final model with the four significant variables had a Nagelkerke R^2 = 65.3%, which indicates that the four predictor variables explain over 65% of the probability of conflict occurrence. The model was also tested using the Hosmer and Lemeshow (H-L) test whereby if the H-L goodness of fit test statistic is greater than 0.05 it implies that the model is fit (Hosmer and Lemeshow, 2000). According to this analysis, H-L was 0.376 implying that there were no difference between the observed and the model predicted values.

4.5 Mapping of conflict prone areas

Figure 4.8 shows the probability of occurrence of elephant conflicts around SH ecosystem. This map is a result of multiplying the coefficients of roads, fence, settlement and water with the raster map of the variable (Table 4.11) using the formula in chapter 3 section 3.2. The map of the probability of conflict occurrence was divided into 4 classes: low (0 -0.4); medium (0.4 - 0.7); high (0.7 - 0.9) and very high (0.9 – 1.0) probability. Most of the SH ecosystem had a very high probability of having conflicts (44.6%) followed by high class (30.6%) and medium class (17.2%). The low class (7.6%) represented areas in towns or shopping centers.

The conflict prone area map was overlaid on the conflict locations map for validation. Out of the 89 identified HEC locations, 56 occurred in the very high and high conflict zones, twenty two in the medium conflict zone and eleven in the low conflict zones.

Table 4. 12: Significant variables in the logistic regression process

FACTOR	B	Wald	df	Sig.	Exp(B)
Roads	.0005	5.790	1	.016	1.001
Settlement	.0002	4.343	1	.037	1.000
Fence	-.0006	33.910	1	.000	.999
Water	-.0012	31.556	1	.000	.999
Constant	4.241	36.984	1	.000	69.477

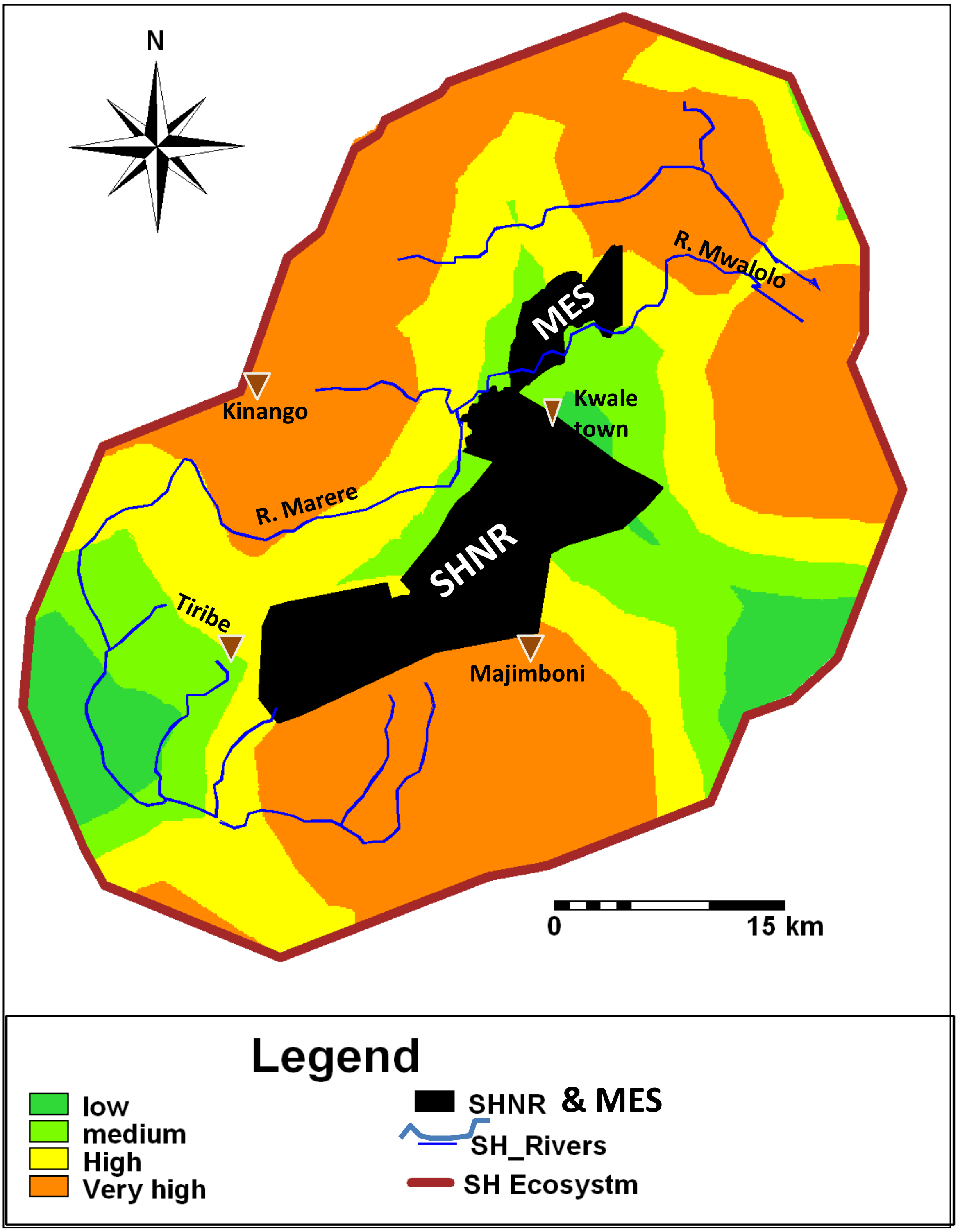

Figure 4.8: Conflict prone areas in SH ecosystem

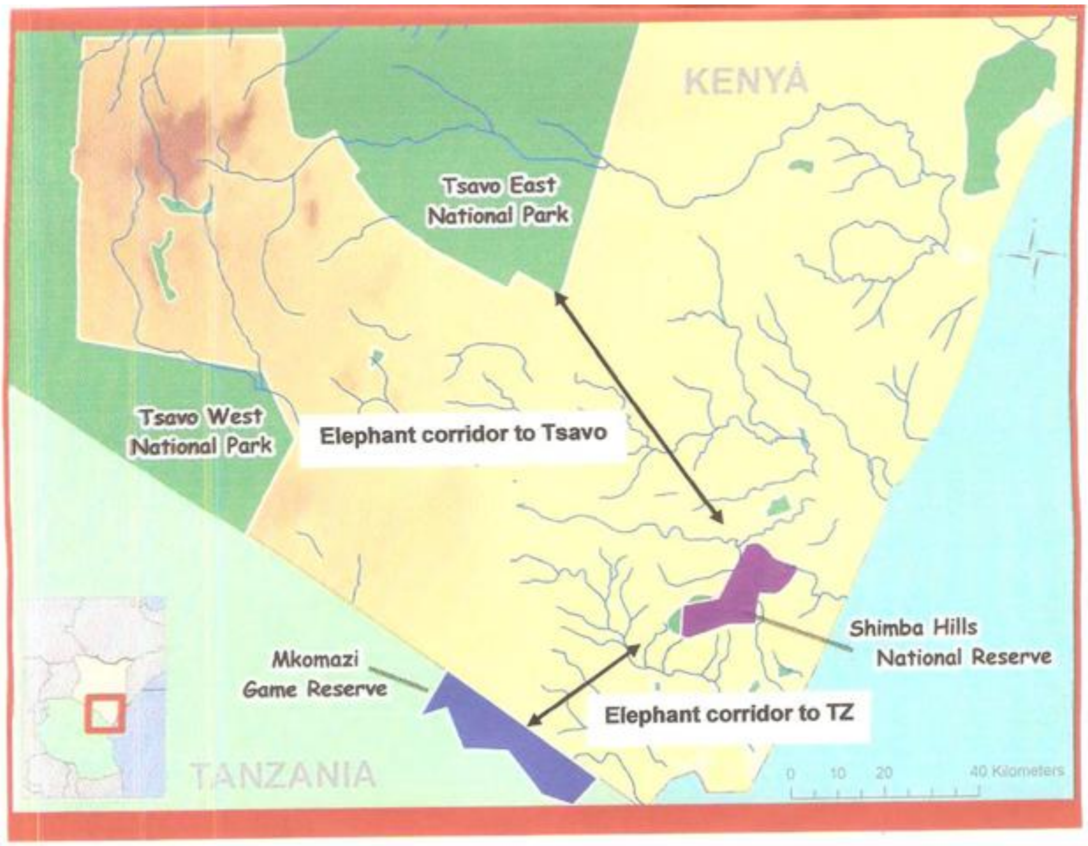

Figure 4. 2: Map showing ancient elephant migration corridors to Tsavo and Mkomazi protected areas. Source, Reuling, 2007

4.6 Human elephant conflict Mitigation measures

4.6.1 Traditional Methods

Local communities in SH ecosystem have been using various mitigation measures that are easily available and less costly to curb the conflict menace. Traditional mitigation methods used include noise,fires,chasing problem elephants, traps, killing and guarding of crops. Majority of the respondents prefered using noise inform of shouts for attention and help (34.6%, n=106) and setting up fires (30.2%, n=106) to keep away the animals, guarding and chasing problem elephants (Figure 4.1).It was noted that many villagers used a combination of measures to reduce the conflicts. A combination of methods used was based on the ease of the method. A combination of noise and fire (65.6%, n=106) were more effective than guarding and chasing (25%) (Figure 4.4 and figure 4.5).

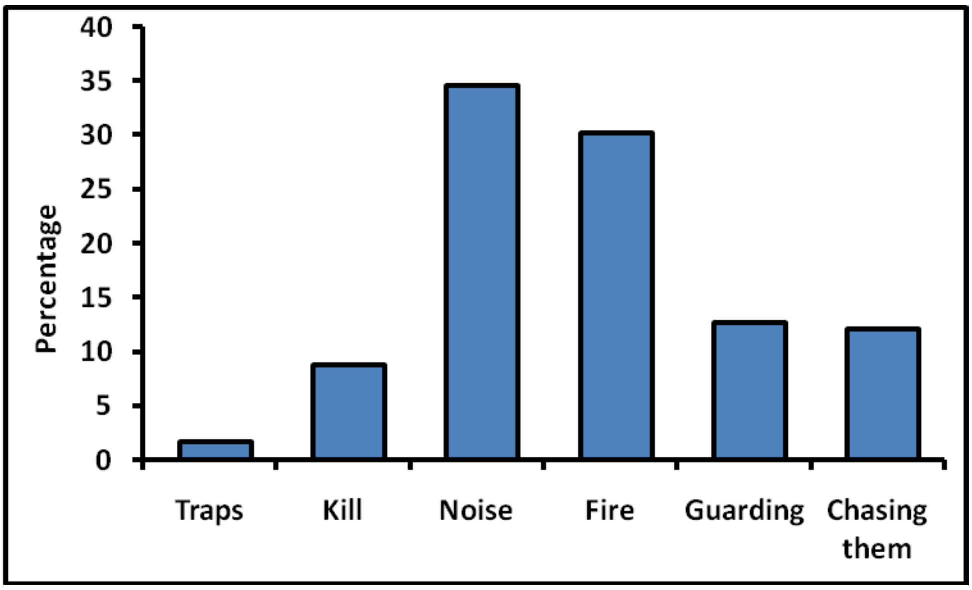

Figure 4. 3: Prevalence of use of the traditional mitigation measures

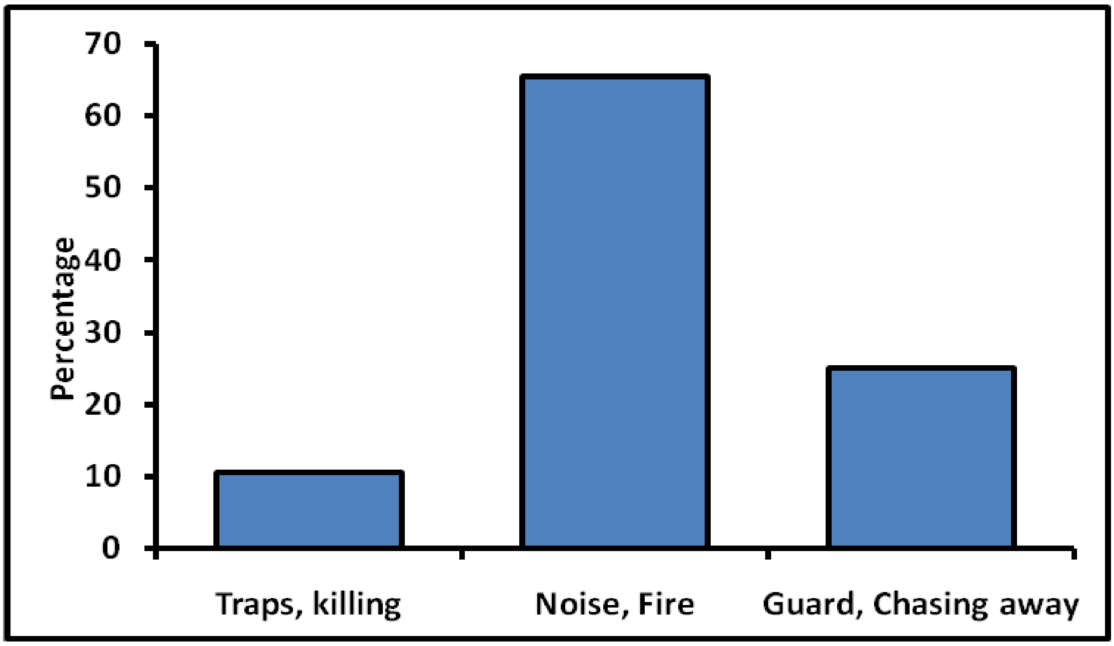

Figure 4.4: Respondents' views on traditional mitigation measures used

4.6.2 The conventional mitigation measures used

The conventional methods used by KWS management to reduce conflicts in SH ecosystem include the electric fence and rangers' patrols. Figure 4.8 shows that electric fence bordering the ecosystem was the most effective measure (70.8%, n=106) followed by regular ranger patrols (31.1%). Translocation of problem elephants (12.3%)(Figure 4.6).

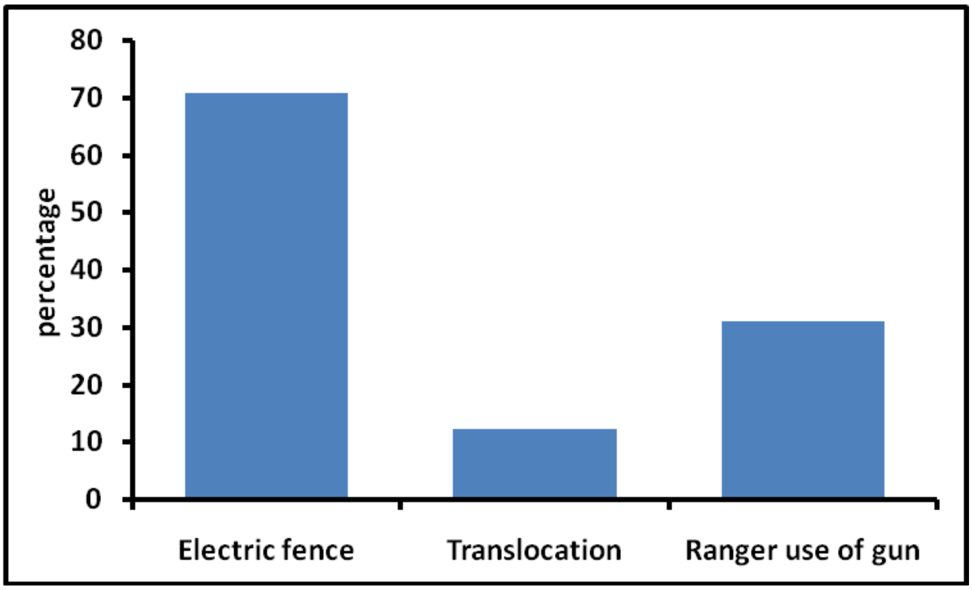

Figure 4.5: Conventional measures used to mitigate HEC

4.6.3 Comparison between traditional and conventional mitigation measures

Results of a comparison between traditional mitigation methods and conventional mitigation methods used by KWS in SH ecosystem revealed that a 65% (n=106) of the respondents preferred the conventional methods used by KWS than the traditional methods (11%).The rest (15%) reported that both traditional and conventional methods were equally effective in mitigating elephant menace (Figure 4.7).

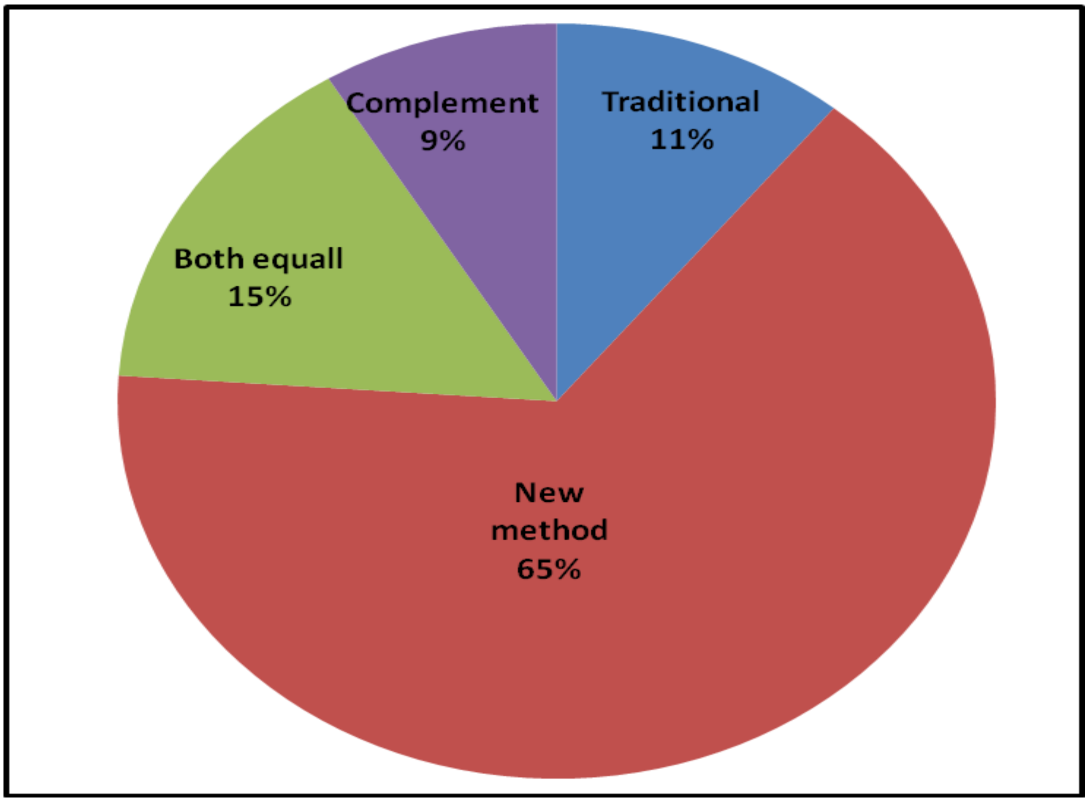

Figure 4.6: Respondents views on the effectiveness of traditional and conventional mitigation measures.

CHAPTER FIVE

DISCUSSION

5.1 Types and causes of human wildlife conflicts in Shimba hills ecosystem

Results showed that crop raiding and threats to human life were the most common types of conflicts experienced in SH ecosystem. Crop raiding occurred in the months of May and July following a seasonal pattern corresponding to maturing of crops like maize and beans which are planted twice a year in the region. The peak of crop raiding occurred two months before harvesting time (in July). This may be due to two reasons. First, just like many regions in Kenya, maize harvesting in Kwale was done when the crop had dried on the field. At this stage the corn cob becomes difficult to chew which increases handling time. Additionally palatability may decrease compared to two months before harvesting when the liquid content of crops is still higher. Osborn and Parker (2001) found a similar trend in crop raiding in Zimbabwe which occurred in the month of March, which was two months to the harvest.

Threat to humans was mainly experienced during the months of February, early March and July. Generally, Kwale County experiences water shortage in the months of January, February and early March shortly before the beginning of the rainy season, when the local communities usually travel long distances to obtain water from the waterholes provided at the Reserve boundary by the KWS. It is during such times that conflicts occur as humans come into contact with elephants. Many farmers guard their farms against elephant intrusion in the month of July and the mere presence of the elephants threatens the farmers, especially at night.

Among the conflict animals reported, elephants and bush pigs were the most notorious around SH ecosystem. The high population of elephants, ranging from 400 to 700 (Litoro, 2003) would explain their significant impact. Elephants have the tendency to search for food outside the protected areas leading to increased incidences of crop raiding and threats to human. As reported by Smith and Kasiki (2000), high elephant numbers had the capacity to inflict catastrophic damage during one visit to a farm. During the interviews, respondents confirmed that communities living around Shimba hills had a religious belief that forbids them from consuming bush pig meat. When found in the farm land, bush pigs were just chased away and not killed. This has led to the gradual increase in bush pig population in the Reserve.

5.2 Characteristic of conflict sites

Results revealed that distance from water sources, roads, settlements and the fence showed a significant relationship with conflict sites. These results are not surprising because elephants are known to move short distances from day to day, keep close to water, select the highest vegetation cover, and avoid people (Harris *et al*., 2008).

Elephants require drinking water every one or two days (Douglas-Hamilton, 1973). Harris *et al*. (2008),reports that the presence of water was the best predictor of elephant presence and if it is close enough to water an elephant seeks areas with high vegetation cover. Rivers and streams in SHNR originate outside the Reserve and during the dry season most of the seasonal rivers in the Reserve dry up forcing elephants to search for water from permanent rivers like Marere and Mwalolo located outside the Reserve. SH ecosystem has riverine and bush land vegetation cover near Rivers Marere and Mwalolo. More conflicts occurred within half a kilometer to about three kilometers away from water sources. Similar observations of elephants being found close to water points are documented about in Tsavo East National Park (Leuthold and Sale, 1973), Serengeti National Park in Tanzania (McNaughton, 1990) and Maputo Elephant Reserve in Mozambique (Boer *et al.*, 2000).

A majority of people living around the SHNR are small-scale farmers growing cassava, maize, sweet potatoes, pigeon peas, and tree crops such as cashew nut and coconut. The western side of the ecosystem comprising of Mbuguni and Ngomeni, Mkongani, Mwaluphamba and Mwaluvanga locations are drier than the Eastern side. Farmers in the western region are more vulnerable to crop failure and so live near water sources where they grow their crops. Such crops are easily attacked by elephants in their search for water.

Whereas people use roads to move from one area to another, elephants generally prefer areas away from the disturbing effects of roads such as road kills and poaching (Mukeka, 2010). Elephants in SH ecosystem are driven away from the farms by the rangers using vehicles. Lack of or inaccessible roads makes it difficult to access remote conflict sites especially at night, making the farms away from the road susceptible to frequent attacks. Sitati *et al*. (2003) found that farms that had been raided were frequently far away from accessible roads, while Barnes *et al*. (1991) found that elephants avoided zones within 7 km of roads because of human disturbance and poaching threat.

Most attacks were reported away from human settlements. Animals respond to human presence in a similar manner in which they respond to risk of predation. The behavioral changes of elephants to proximity of human settlement include reduced foraging, increased agitation and reduced resting. The SH ecosystem comprises of rural and urban settlements. The rural area has a scattered, low population with large farms located away from houses. The urban areas are characterized by clumped settlements, high population and small farms around houses. A study done by Harris *et al*. (2008), found that wherever settlements were found, female elephants stayed 5 km or more away .The female Shimba elephant occurred in groups together with the young. Local communities that had experienced attacks stated that they were attacked in the months of July while guarding their crops or in March while fetching water and/or firewood at the forest edge. Elephants that managed to go near settlements were the few habitual individuals most probably the bulls.

5.3 Conflict prone area mapping

From the conflict prone map (Figure 4.6), the highest conflicts are predicted to occur in far away and isolated settlements such as agricultural lands for Lukore and Tiwi locations, or range lands for Kulalu and Galana ranches in Mbuguni and Ngomeni locations.

According to this study, only the South East region (Lukore, Majimboni and Magawani locations) out of the four regions analyzed experienced conflicts near the fence line. Proximity to protected areas is a risk factor that has been found to shape vulnerability to attack differently based on the study location. This study's results are similar to those of other studies which revealed greater conflicts near protected areas such as Bia Conservation Area (Sam *et al.,* 2005), Kakum Conservation Area in Ghana, (Barnes *et al*., 2005), and Kibale Forest National Park in Uganda (Naughton-Treves 1998). The other three regions; North East (Tsimba, Tiwi and Golini), North

West (Mbuguni and Ngomeni), and South West (Mkongani, Mwalumphamba and Mwaluvanga) experienced lower levels of human elephant conflicts along the fence. Three reasons may explain these findings. First, there was greater KWS involvement in elephant control along the Reserve boundary than further away. Secondly, farmers along the Reserve border spent more time and effort defending their crops than those residing at a greater distance. Lastly, probably farmers had abandoned their farms near the fence line making them prone to unguarded attack by elephants.

According to the respondents engaged in farming, too much time and expense were required to travel to the KWS main office in Kwale town to report attacks whereas no tangible benefits accrued from reporting the damage. A study by Smith and Kasiki (2000) in Taita Taveta, Kenya, found significantly lower levels of human elephant conflict in areas bordering national parks.

The highest probability of conflict in the North West and South West regions were in areas further away from the fence boundary. This is probably because of the presence of the problem elephants that were translocated to Tsavo East and West National Parks. The behavior of the translocated elephants from Shimba hills to Tsavo East (Pinter-Wolloman *et al*., 2009) showed that the initially translocated elephants to Tsavo national parks were homing back to Shimba hills and some to Malindi (Figure 4.3). Pinter-Wolloman *et al.* (2009) found out that some elephants homed back immediately after release, while others waited until the onset of rains before homing.

5.4 Comparison between mitigation measures

Farmers in the sampled Kwale villages reported using a combination of methods to mitigate elephant crop raids. Among these were lighting fires overnight, beating of drums and shouting loudly. These methods are cheaper, non-lethal and easier to implement. Making overnight fires required enough firewood, while beating of drums or tins was done when elephants were seen on the farms. Effectiveness of shouts were reported to be dependent on their intensity and frequency, and for an individual farmer the shouts were ineffective as the elephants became used to them. Due to the short term effectiveness of the traditional measures, majority of the farmer preferred to rely on the solar powered electric fence bordering the Reserve. The electric fence was adopted in the 1990s'(Litoro, 2003), as a long term solution to elephant menace, and it greatly reduced the conflicts by 33% between 1995-2001 (Kamula, 2003). The challenges of high maintenance cost, theft of poles and low voltage power has however. made the electric fence to become less effective as a standalone mitigation measure.

Mitigation measures used by KWS include patrols by rangers, electric fence and translocation. These measures were initially effective but after sometime, elephants became used to them and devised ways of overcoming them. Community involvement in managing the conflicts by early reporting of conflict cases and change of villagers' perception of the Shimba hills Reserve was encouraged by the KWS management. This was evident when the community and KWS were actively involved in trench digging in Lukore areas during the data collection period for this study (Appendix 3).

There were three main suggestions on mitigation measures that were put forward. Firstly, the communities felt that there was need to form committees in each village that would be responsible for reporting incidences and assisting in formal compensation process. Secondly, though many communities were dependent on agriculture for their livelihood, growing of alternative non palatable crops were encouraged by the KWS management, the latter had informed the community that the Local Authority was willing to supply the pepper seed and market the pepper when ready. This idea did not seem novel to many locals especially women who relied on food crops grown to feed their families. Thirdly, since many communities had their farms located far away from their houses, they were advised to build their house near the Reserve fence, as this would deter elephant attack on the crops.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

According to the results it can be concluded that;

- Elephants were the most notorious animals that caused conflicts. Crop damage and threat to humans were common forms of conflict.

- Characteristic features found in conflict sites included water source, location of roads, fence and no-fenced areas, elevation, slope, settlement areas, and landcover.

- Potential prone areas for elephant conflicts are those far from settlements and roads, areas near water points and on the South Eastern side, areas near the electric fence.

- Four variables namely distance from the road, distance from the fence, distance to settlements and distance to water were significant predictors of potential conflict areas.

- The local communities used both the traditional and conventional mitigation measures to control elephant attacks. Despite this, a combination of the two categories of mitigation measures was considered a more effective control strategy.

6.2 Recommendations

It is evident that HEC is a persistent problem to communities living around SH ecosystem. Therefore the study recommends the following:

6.2.1 Recommendations from the study

i) Fence maintenance

The conversion of solar power to electric power, or increasing the voltage of the solar power, fence repair, and establishing provisions for continued fence maintenance should be foremost on the conservation agenda, along with the replacement of the wooden poles with concrete posts.

ii) Alternative economic activities

Since majority of the farmers in the study area are dependent on rain fed agriculture, whose output (crops) are prone to attacks,it is recommended that alternative crops such as chilli plant should be planted. This is consistent with the proposal of KWS management although most of the farmers did not support it.Other options include bee keeping and cultivation of medicinal plants. A study on a bee keeping project established in Northern Kenya found that beehive fences improved crop production and enhanced rural livelihoods through honey sales (King *et al.*, 2011). Since many communities in Kwale County still depend on medicinal plants from SHNR, the cultivation of these plants should be encouraged and farmers supported to do it to support their livelihood.

Community conservation initiatives

Although some communities living around Shimba hills participate in reporting conflict cases, an effective land-use policy near elephant habitats should be one of the most important actions that can be taken to mitigate HEC. Elephants' ability to coexist with humans is probably based more on the spatial arrangement of cultivated fields and human settlements than the actual amount of elephant habitat that has been converted.

6.3.2 Management Recommendations

i) Dual management strategy

HEC requires a dual strategy involving managing problem elephants and 'public relations' associated with their presence. Wildlife authorities need to review the existing awareness and education programmes, as well as efficient compensation measures to ensure good public relations with the local communities. There are strong indications that officially centralized approaches to problem elephant management are less likely to succeed than those ones where some decision making is devolved to a local level.

ii) Habitat enrichment and manipulation

This study has identified factors such as fence, water, settlements and roads that contribute to where conflicts will occur. Using this information, artificial waterways and salt licks should be established within forested areas of SHNR and elephant-food crops can be planted within forests to lure elephants away from plantations/ farms. Some lure crops that have been used include bananas (*Musa* spp.) and sugarcanes (*Saccharum* spp.).

iii) Creation of buffer /corridor zones

In locations like Lukore, where conflicts are predicted to occur near the fenced boundary, buffer zone should be created by planting a stretch of unpalatable crops between the Reserve fence and the crops protected, to enhance their security.

Elephants typically require large areas to roam, especially if they need to migrate to seasonal feeding sites. SHNR has a history of elephants migrating to Tsavo National Park, and over time the corridor adjoining the two protected areas has been blocked.

To mitigate this,linking separate protected areas with intact forested corridors which are themselves afforded some protection from conversion is required. The establishment of corridors is also very important for maintaining gene flow between different populations.

6.3.3 Recommendations for further research

- Mapping of suitable elephant habitats in the Reserve and its surrounding is recommended as an area of future research interest. Result from such a study will expound on understanding of elephant seasonal occupancy.

- Research on the behavior of problem elephants in Shimba Hills should be done as findings from the study will enhance a better understanding of the causes of conflict.

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APPENDICES

AppendixI1: Questionnaire

Title: Determinants of human-elephant conflicts in shimba hills ecosystem, Kenya

Date………………
Questionnaire No:……….

SECTION A: BACKGROUND INFORMATION CODES 9=No response	
Q1.Sex	Respondent's gender 1=Male 2= Female
Q2.Age in years	Respondent Age group 1=18-25 yrs, 2=26-35yrs, 3=36-35yrs, 4= 46-55yrs 5=>56 yrs
Q3.Vilage	Respondent's Village name ………………………
Q4.Education level	Education level of respondent 1= No schooling, 2= Primary education 3=Secondary education 4=Tertiary college/University
Q5.Length of residence	Duration of stay in village 1=<1yr, 2=1-5 yrs, 3=6-10yrs 4=More than 10 yrs
Q6.Livelihood activities	Livelihood activities of respondent 1=Crop farming 2= Livestock farming 3=Mixed(crop & Livestock) farming 4=Trade
Q7a.House distance from Reserve boundary	Distance of house from the Reserve boundary 1= along the fence 2= 1 or more houses between fence
Q7b.Farm distance from Reserve boundary	Distance of farm from the Reserve boundary 1=Along the fence 2=1 or more farms between the fence

Q8. Resources obtained from the Reserve	Resources community obtain from reserve 1=Firewood, 2= Charcoal, 3= Grass, 4= Water, 5= Timber products, 6= Wildfruits, 7= Medicinal plants
	8= Other……………………

SECTION B: HUMAN-WILDLIFE INTERACTION

Q9.Wildlife problems experienced	Do you experience wildlife problems? 1= yes 2= No
Q10. Problematic animals	Problem animals a)Elephant 1=yes , 2= No b)Monkey 1=yes , 2= No c)Rodents 1=yes , 2= No d) Birds 1=yes , 2= No e) Other……………………
Q11.Forms of conflicts faced	Types of conflict caused by elephant a)Crop damage 1=yes , 2= No b)Human threat 1=yes , 2= No c)Infrastructure 1=yes , 2= No d)Death1=yes , 2= No
Q12.Season when	During which season do elephants pose a theat a)Dry season 1=yes , 2= No b)Wet season1=yes , 2= No c) Both dry & wet season 1=yes , 2= No
Q13.Time of day when elephant attacks occur	What time do elephant attack occur? 1= During the day 2=At night 3=All the time
Q14.Conflict status/trend	What is the trend of conflict in SH 1= increasing 2= Decreasing 3= Remained same
Q15.Traditional methods to mitigate elephant	What local methods do you use to deter elephants 1=traps 2=Noise

conflict	3=Fires 4=Guarding 5=Chasing
Q16.Conventional method	Methods that KWS use are? 1=electric fence 2=Translocation 3=Ranger enforcement
Q17.Effectiveness	Comparison of traditional and new methods 1=Traditional 2=New method 3=Both equal 4=Complementary

Appendix II: Focus Group Discussion Questions

Introduction of the map

This is a map of Shimba Hills National Reserve (Explain the map: the area is bordered on the bottom (south east) by lukore and kubo location. On the either side of North east, majimboni and Tshimba locations,on the North west side it has the Kinango location on the South West region the Mwaluphamba location.(Topographic map off shimba ecosystem)

I would like to ask you some questions about this area.

a) Land use

1. I would like to ask you about changes in land use in this area currently compared to the past. For the past 10 years ,did the following types of land cover rapidly increase, increase some, stay the same, decrease some, or rapidly decrease?

Feature	Rapidly increased	Increased some	Stayed the same	Decreased some	Rapidly decreased
Land under cultivation.					
Land covered by forest.					
Buildings.					
Roads					

b) Elephant conflict history

1. Are elephants a problem in your village? (If yes) Thinking back as far as you can remember, when did wild elephants first begin to be a problem in this village?
2. How often have you seen elephants? (Every year/every few years/every month,etc.)

3. When you first saw elephants near your village, how many were they? Did you see individual elephants or groups of elephants? How many elephants are there these days? Do they come alone or in groups?

Appendix III: Community involvement in Trench digging

Source: Author, 2013

Appendix IV: A FGDs in Lukore location

Source: Author, 2013

Appendix V: Guarding sites near the electric fence

Source: Author, 2013

Appendix VI: Spearmans' correlation results

		Unfenced	Roads	Settlement	Elevation	slope	Fence	Water
Unfenced	Correlation Coefficient	1.000	.248(**)	.018	.009	-.207(**)	**.536(**)**	.105
	Sig.	.	.000	.404	.451	.003	.000	.080
Roads	Correlation Coefficient		1.000	**.554(**)**	-.135(*)	-.268(**)	.488(**)	.231(**)
	Sig.		.	.000	.036	.000	.000	.001
Settlement	Correlation Coefficient			1.000	-.298(**)	-.259(**)	.433(**)	.146(*)
	Sig.			.	.000	.000	.000	.026
Elevation	Correlation Coefficient				1.000	.137(*)	-.355(**)	.075
	Sig.				.	.034	.000	.158
Slope	Correlation Coefficient					1.000	-.260(**)	-.072
	Sig.					.	.000	.169
Fence	Correlation Coefficient						1.000	.218(**)
	Sig.						.	.002
Water	Correlation Coefficient							1.000
	Sig.					.		.

*****Means significant correlation

Appendix VII: Characteristics of conflict site analysis

Absenceje	nofence	supplimen	rivers	roads	settlement	forested	Elevation	slope	Fence	Waters
0	18742.4	15954.6	1858.6	127.8	110.4	1800.5	252	4.94	9333.5	1858.6
0	15890.7	13521	2085.1	203.3	1289.4	2340.6	258	3.28	6899.9	2085.1
0	15896.5	12295.5	511.1	1393.9	714.4	1469.4	234	8.36	5674.4	511.1
0	18341.7	14043.7	2212.8	3194.4	1823.7	0	186	4.76	9803.9	2212.8
0	16605.1	10541.5	1864.4	4146.9	2683.3	464.6	208	5.15	3949.4	1864.4
0	14113.4	12231.6	2863.3	4861.3	2787.8	1039.6	247	3.29	6789.6	2863.3
0	17598.2	11000.4	3972.7	3717.1	2340.6	3281.5	225	3.44	10169.8	3972.7
0	13503.6	6905.7	1277.8	3211.8	2869.2	4919.4	234	1.8	6075.2	1277.8
0	15832.6	9136	2782	3240.9	4024.9	10146.6	234	1.62	8392.6	2782
0	14049.6	8868.8	2247.7	1492.7	2381.3	13672	215	2.18	8810.7	2247.7
0	10222.1	3595.2	2015.4	1614.6	1330	7759.5	195	2.59	2764.6	2015.4
0	9095.3	3850.7	2880.8	1684.3	1515.9	11639.2	204	4.35	3792.6	2880.8
0	16674.8	11494	29	673.7	3403.5	17784.1	164	4.7	11436	29
0	9095.3	5262	1806.3	2898.2	1341.6	14595.5	196	1.16	4414.1	1806.3
0	12388.5	10622.8	1614.6	3060.8	2096.7	18910.8	158	4.35	8537.8	1614.6
0	12591.7	12103.9	1521.7	1109.3	2938.8	23179.7	162	3.33	9641.3	1521.7
0	9345.1	11000.4	1858.6	2183.8	865.4	22076.2	141	3.09	6394.6	1858.6
0	10303.4	14554.8	975.7	5628	4193.4	25630.7	58	3.78	8514.5	975.7
0	9002.4	14229.6	1684.3	3827.5	4123.7	24608.5	58	0.97	7579.4	1684.3
0	4303.7	9345.1	2875	1016.4	1905	19909.8	106	3.29	2793.6	2875
0	6057.7	12922.8	1208.1	87.1	1527.5	20769.4	139	5.53	6110	1208.1
0	8863	15728.1	638.9	40.7	4094.6	22360.8	66	1.35	8915.3	638.9
0	9676.1	16494.7	2323.2	2398.7	3118.9	22511.8	92	4	9745.8	2323.2
0	7817.6	15536.4	1939.9	1457.8	1684.3	20525.5	117	9.63	7875.6	1939.9
0	5331.7	14171.5	1620.4	1097.7	3101.5	15954.6	129	4.43	3223.4	1620.4
0	8572.6	17412.4	2073.5	708.6	1521.7	19665.9	109	5.95	6446.9	2073.5
0	11627.6	20467.4	1057.1	871.2	3542.9	23278.5	102	8.98	9612.2	1057.1
0	13956.6	22645.4	1080.3	2369.7	4234	23429.5	105	5.31	9513.5	1080.3
0	12307.2	16657.3	3078.2	644.7	1364.9	17720.2	132	1.89	3804.2	3078.2
0	15960.4	17813.1	2451	1277.8	1051.2	19392.9	129	11.2	7027.7	2451
0	11894.8	14334.1	1028	644.7	1521.7	14723.3	168	12.41	1219.7	1028
0	17685.4	15100.8	1289.4	1010.6	1998	18504.3	117	6.32	6475.9	1289.4
0	16094	11714.7	4437.3	1068.7	1039.6	16564.4	137	6.46	3246.7	4437.3
0	13968.2	9699.4	2323.2	493.7	1574	11767	260	16.17	580.8	2323.2
0	15298.3	9711	5366.6	528.5	1126.8	14299.3	211	16.48	1393.9	5366.6
0	13457.1	12533.7	1887.6	511.1	127.8	13939.2	170	11.22	1823.7	1887.6
0	18998	14618.7	1330	2207	2979.5	18876	39	3.48	6150.7	1330
0	16291.4	21861.3	2538.1	2996.9	3490.6	22924.2	88	5.13	9008.2	2538.1
0	14247	13509.4	2509.1	1155.8	1719.2	14125.1	86	4.46	5540.8	2509.1
0	13747.5	9368.3	2207	220.7	2300	13625.6	82	4.88	1736.6	2207
0	12446.5	13817.2	3728.7	371.7	911.9	10930.7	117	13.22	8380.9	3728.7
0	9292.8	10210.5	2061.8	882.8	842.2	9170.8	58	9.22	5076.2	2061.8
0	9048.9	14438.7	435.6	127.8	1876	6882.5	46	7.13	9054.7	435.6
0	4216.6	8932.7	3368.6	3089.9	5029.7	2979.5	64	3.91	4222.4	3368.6
0	2718.1	5447.9	2317.4	2329	2613.6	3513.8	102	13.68	2276.7	2317.4
0	4721.9	3345.4	3699.7	842.2	1417.2	5842.8	254	7.43	3107.3	3345.4
0	7329.7	3426.7	2555.5	232.3	1272	8450.6	370	6.4	1126.8	2555.5
0	3165.4	4187.6	2253.5	1196.4	882.8	4286.3	179	28.62	2067.6	2253.5
0	5140.1	11604.4	2706.5	1341.6	2358	2845.9	11	3.44	5140.1	2706.5
0	5662.8	12655.6	1661.1	81.3	1916.6	2665.9	19	2.23	5691.8	1661.1
0	9943.3	16994.2	3775.2	2648.4	2421.9	3107.3	0	0.43	9292.8	3775.2
0	3839.1	11796	900.2	0	4216.6	302	56	5.96	3571.9	900.2
0	1568.2	9862	609.8	232.3	5970.6	0	69	2.49	1597.2	609.8
0	400.8	10030.4	1707.6	1330	5697.6	0	92	11.75	342.7	1707.6
0	2636.8	12336.2	2363.9	174.2	7835	191.7	134	1.96	638.9	2363.9
0	6656	16355.3	2276.7	1568.2	6807	1184.8	154	7.65	4570.9	2276.7
0	9670.3	18934.1	1091.9	1928.3	6551.4	0	23	1.63	8578.4	1091.9
0	6981.2	16680.6	1260.3	2236.1	7759.5	145.2	118	18.1	4251.5	1260.3
0	4286.3	13892.7	1550.7	1771.4	9333.5	0	108	11.83	1510.1	1550.7
0	4530.2	11906.4	2032.8	1057.1	7521.4	197.5	115	1.03	2195.4	2032.8
0	9856.2	19555.5	2480	1057.1	12144.5	1254.5	122	4.72	7126.4	2480
0	10686.7	20386.1	1707.6	2927.2	11255.9	0	118	20.44	7957	1707.6

Appendix VIII: Traditional Mitigation Measures

Each mitigation measure	Frequency	Percentage
Traps	3	1.64
Kill	16	8.79
Noise	63	34.61
Fire	55	30.21
Guarding	23	12.63
Chasing away	22	12.09

Appendix IX: Combined traditional mitigation measure

Combined mitigation measure	Frequency (n=182)	Percentage
Traps, Killing	19	10.56
Noise, Fire	118	65.56
Guarding, Chasing away	45	25

Appendix X: New mitigation measure

New mitigation measure	Frequency (n=106)	Percentage
Electric fence	75	70.75
Translocation	13	12.26
Ranger use of gun	33	31.13