ASSESSMENT OF ECONOMIC COST OF HUMAN/ELEPHANT CONFLICT IN TSAVO CONSERVATION AREA, KENYA

By

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Submitted in partial fulfilment of the requirements for the degree of Master of Science in Animal/Human/Ecosystem Health in the Department of Veterinary Tropical Diseases in the Faculty of Veterinary Science, University Of Pretoria.

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DECLARATION

I, Jeremiah Poghon Kaitopok hereby declare that the dissertation which is handed in by me to the University of Pretoria for the degree Master of Science is my own work and has not been previously submitted by me for a degree at another university.

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Signed Date

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
Cap	Chapter
GIS	Geographical Information system
Kg	Kilogram
Kshs	Kenya Shillings
KWS	Kenya Wildlife Service
MIS	Management Information Systems
SD	Standard Deviation
USA	United States of America
USD	United States Dollar
Ver	Version
WWF	World Wide Fund for Nature

SUMMARY

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By

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The aim of this study was to investigate the economics of damage to crops and infrastructure, injuries and loss of life at the human-elephant interface within Tsavo Conservation Area between 2010 and 2013. Data was generated from the Kenya Wildlife Service occurrence data base. A total of 488 cases with complete data were extracted. Both descriptive and inferential statistics was used in data analysis. The study established that zones with a higher incidence of conflict were proximate to the park and near main water points. Crop damage was the most (83%) prominent reason for human-elephant conflict. Others were property destruction (8%), human injuries (5%) and human deaths (4%). Crop damage occurred more often during wet seasons than dry seasons. Correlation analyses showed that the size of land was significantly associated with the value of the crop destroyed, with mean land size being 0.7 (+/- 0.99) acres. This was equivalent to 984,254 kg of crop yields over four years with an average of 246 063.71 (+/- 21 288) kg/annum. The main crop destroyed was maize, planted as a single crop. The majority (76%) of those affected were small holders with less than 0.7acres and they practiced subsistence farming. Men were the only gender killed by elephants (n=21), although both sexes

were injured (n=24). In total, 40 incidents recorded damage to buildings and infrastructure. The value of crop damage, human injuries and deaths was Kenyan shillings 32,618,500 over the four year study period. It is recommended that the government should reduce human/elephant interaction in Tsavo Conservation Area by erecting an electric fence around the park, involving the community and compensating them for the entire cost of the loss incurred due to elephants from the Park.

CHAPTER 1. INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

Human/wildlife conflict is as old as the existence of man. It has become more prevalent over the last decade due to increased interaction between human populations and wildlife that coexist and compete for scarce natural resources (Elisa 2005; Tweheyo Hill & Abua 2005; Chaminuka et al. 2008). Human/wildlife conflict occurs in developed and developing countries alike. However, it is more pronounced in developing countries than in developed countries, because rural populations depend on livestock and crop husbandry for their livelihoods. Also, there is an increasing human population in areas with an abundance of wildlife and natural habitants (Elisa 2005; Chaminuka et al 2008).

Human/wildlife conflict is a major obstacle to wildlife conservation efforts (Gusset et al. 2009). The patterns of these conflicts in and around protected areas vary according to the different wildlife species and human activities. In developing countries, lions, cheetahs, leopards, snow leopards, wolves, tigers, buffalo, Brazilian tapirs, capybara, spotted hyenas, elephants, honey badgers and caracals, have been mentioned as wildlife species that negatively impact on communities living near to protected areas (Dickman 2010; Elisa 2005). They inflict livestock depredation, cause crop damage and destroy social infrastructures, as well as transmitting diseases to livestock (Gillingham & Phyllis 2003). Human/wildlife conflict has also been associated with competition for natural habitats and resources (Inskip & Zimmerman 2009; Chaminuka et al. 2008, Chaminuka et al. 2012a). Other factors contributing to human/wildlife conflict include climate change, illegal poaching and

hunting as well as human activities around protected areas (Kenya Wildlife Service 2011).

In Africa, livestock depredation, crop damage, human and livestock injuries or deaths, impact negatively on livelihoods (Dickman, 2010; Kissui, 2008; Chaminuka et al, 2012b). In developing countries, human/wildlife conflict can have short and long term effects on livelihoods based on the extent of crop or livestock production. Governments obtain revenues from wildlife through tourism, often at the expense of socio economic losses incurred by affected communities. In response, local communities retaliate by killing or persecuting the wildlife species involved in the conflict. Neglect of the affected local communities by government authorities can reinforce negative attitudes, thus escalating the conflict (Wiladji & Tchamba, 2003).

Crop damage in Africa is often associated with elephants that extend their feeding sites to human settlements. Crop damage has been reported in Zimbabwe, Uganda, Cameroon, Ghana, Tanzania, Mozambique, South Africa and Kenya (Elisa, 2005; Osborn & Parker, 2003). Apart from elephants, other wildlife species responsible for crop damage include birds, rodents, primates, antelope, buffalo, hippopotamus and bush pigs (Gillingham & Phyllis, 2003; Elisa, 2005: Chaminuka et al, 2012b).These, it should be noted, are predominantly herbivores.

In contrast, livestock depredation is caused mainly by large carnivores. Leopards, lions, cheetahs, spotted hyenas, tigers, wild dogs, bears, wolves and civet cats have been associated with livestock depredation (Johnson et al, 2009; Sangay & Vernes, 2008). In African countries such as Kenya, Zimbabwe, Cameroon, South Africa and Mozambique, livestock depredation has been widely documented. Livestock that are

vulnerable to depredation in African countries include cattle, goats, sheep and donkeys (Chaminuka et al, 2008; Lamarque et al. 2009).

In other countries such as Bhutan, India and Brazil large carnivores have been associated with human/carnivore conflicts that always lead to retaliatory attacks from the communities. The loss of livestock depends on the seasons and the time of the day. In Bhutan and Pakistan the loss is usually incurred during the summer seasons. (Johnson et al, 2009; Chaminuka et al, 2008; Gusset et al, 2009; Kissui, 2008).

Transmission of diseases from wildlife to livestock is also common where wildlife escapes from parks and protected areas and interacts with livestock (Kissui, 2008). Sources of human/wildlife conflict like depredation, damage, crop destruction and disease transmission as well as competition for resources such as land and water, have significant socio economic costs for rural communities that interact directly or indirectly with wildlife in Africa (Linkie et al, 2006; Chaminuka et al, 2012b; Kissui, 2008).

The increase in wildlife numbers and concurrent increase in human population has led to increased human-wildlife conflict in Kenya (Kenya Wildlife Service, 2008). It has become an important challenge to conservation, especially in the Tsavo-Amboseli area where wildlife ranges outside parks within local communities. This has been attributed to the desire for direct household benefits and alternatives to the unpredictable and declining pastoral lifestyle, which is encouraging agricultural expansion among pastoral communities leading to wildlife displacement (Okello et al, 2010). Human/wildlife conflict results in deaths of livestock and people, destruction of crops, interference with learning and disruption by pastoralists tending herds. Wildlife has also been implicated in disease transmission to livestock Reduction in wildlife

related conflict can provide long term incentives for partnerships in conservation (Kock, 2005; Mburu & Birner, 2007).

Many previous studies have focused on the economic losses local communities incur in human/wildlife conflict. This has led to proposals and designs of several control measures (Elisa, 2005; Gusset et al, 2009; Kissui, 2008; Chaminuka et al, 2012b; Linkie et al, 2006). However, the conflict continues to occur. This is because the measures do not take into account the losses resulting from human/wildlife interactions by the local communities nor ensure that balance is reached. Although there is adequate documentation on the reported losses to local communities, there are few studies that have focused on economic cost analyses of both losses and compensation derived from human wildlife interactions (Chaminuka et al, 2012b; Wildaji & Tchamba, 2003; Jack, 2009). This study sought to assess the economic cost of the human/wildlife interactions to households living around Tsavo Conservation Area, by estimating the actual costs of the crop damage, human injuries, human deaths and property destruction associated with elephants.

1.2 PROBLEM STATEMENT

Approximately 8% of Kenya's land mass is set aside for wildlife utilization as national parks and reserves. This portion accounts for only 30% of total wildlife populations with the remaining 70% being found outside the protected areas (Kenya Wildlife Service, 2008). In Kenya all wildlife is regarded as belonging to the state and is managed by Kenya Wildlife Service (KWS), a state body created in 1989 to replace the earlier wildlife department. The KWS manages all national parks, while reserves are managed by local authorities, although legally all wildlife including those in reserves and private ranches fall under KWS (Kenya Wildlife Conservation and

Management Act, 1989 – Cap, 376). Kenya has maintained a restrictive stance on consumptive wildlife utilisation and focused on promotion of all non-consumptive forms of utilisation such as photographic tourism (Okello et al, 2010).

Change in land use, agricultural expansion, encroachment on protected areas and land subdivision, has led to an increase in cases of human/wildlife conflict. According to the KWS (2008), a total of 7,034 human/wildlife conflict cases were reported in the year 2008 in Kenya compared with 4,327 cases in 2007: Tsavo West and Tsavo East National Parks accounted for about 1,600 of these. The rapid increase in human/wildlife conflict cases has raised concerns about its implications for local communities. A community and wildlife department was created within KWS to mitigate human-wildlife conflicts and involve communities in wildlife management. Elephants, buffaloes, hippos, baboons, leopards, hyenas and lions were most commonly incriminated in human/wildlife conflicts, in that order. In Kenya elephants are responsible for over 75-90% of incidents by large mammal pest species in each district (Hoare, 1999). Although KWS keeps data on human/wildlife conflicts, there is little published information on the economic implications of human/wildlife conflicts at household level across Africa (Mburu & Birner, 2007; Chaminuka, Groeneveld & Van lerland, 2014). Communities bordering Tsavo/Amboseli practise mixed livestock and crop production, with many shifting to agriculture, which gives better returns. This has led to an increase in human/elephant conflict that has affected many communities' attitudes to wildlife (Okello et al, 2010).

Human/wildlife conflict has been on the increase and wildlife damage represents a real and tangible threat to livelihoods in terms of personal injury, crop and livestock losses and property damage (Kenya Wildlife Service, 2011; Emerton, 2000; Graham et al, 2010). While the direct losses may appear to be low in monetary terms, or

represent only small amounts of the total use values of wildlife, the socioeconomic impacts may be highly significant for households where investments represent a high proportion of household resources or savings (Bengis, Kock & Fisher, 2002; Graham et al, 2010).

Although the Kenyan Government compensates for human deaths and injuries caused by wildlife, the amount paid is inadequate. It only covers the cost incurred and the loss of employment income due to incapacitating injuries. Worse, there is no compensation for crop damage and livestock deaths and this has led to retaliatory attacks on wildlife (Andanje & Ottichilo, 1999). This has created a tense relationship between wildlife management and communities and has social consequences that pose substantial risks to the park and its resources in the long term (Anthony, Scott & Antypas, 2010).

1.3 RESEARCH AIM AND OBJECTIVES

The aim of the study was to assess the socioeconomic cost of human/elephant conflict on local communities living around Tsavo conservation area in Kenya. The specific objectives were:

- To determine the geographical locations where elephants mainly interacted negatively with humans within Tsavo Conservation Area.
- To establish the extent and nature of adverse interaction caused by elephants in Tsavo Conservation area.
- To estimate the economic implications of the human/elephant conflict caused by elephants in Tsavo Conservation Area.

1.4 CONCEPTUAL FRAMEWORK

To assess the economic cost of the human/elephant conflict, several variables were identified to assist in data collection and analysis. The variables were classified into two categories namely independent and dependent variables. Among the independent variables were type of the incident, date and month when the conflict occurred, year when the incidents were recorded, areas where incidents occurred and size of the land where crops were destroyed.

The dependent variable was the estimated amount of the cost of damage incurred by the local communities. The cost was classified under crop damage, human injuries, human deaths and property destruction. Different cost estimation methods were used, as explained in Chapter 3.

1.5 DEFINITION OF THE TERMS

Human/wildlife conflict is a situation which arises when the basic needs of the wildlife interfere with those of the human population causing negative effects and costs to both residents and wildlife (Madden, 2008; Jack, 2009; Gore & Kahler, 2012). In this study, Human/elephant conflict was investigated.

Economic cost refers to visible costs and includes injuries and fatalities to humans, crop damage and property destruction incurred by local communities as a result of human/elephant conflict (Lamarque, et al., 2009). The cost estimate in Kenya Shillings and US Dollars was based on the compensation rate as stipulated by the Kenya Wildlife Conservation and Management Act 1989, Cap 376 (an exchange rate of Kshs 100/USD)

Property Destruction: Damage done to social infrastructure, like food stores, houses, fences, dustbins and water installations. Elephants are mostly the responsible species (Elisa, 2005).

Human Injuries and Deaths: Incidents of wildlife attacks on humans causing physical damage of the parts of the body or death (Elisa, 2005).

Crop damage: Damage done to different types of crops on the farms of affected families (Elisa, 2005).

1.6 DELIMITATIONS OF THE STUDY

- The study extracted raw data from the KWS database. The KWS recorded human/wildlife conflict incidents in Tsavo Conservation Area as they occurred. Human/elephant conflict data was extracted for the purposes of this study. The researcher did not conduct any interviews with the householders living in the target areas.
- The researcher did not generate Geographical location coordinates. Instead, Microsoft Excel 2003 - spreadsheet software (Microsoft Corporation, USA) was used to generate the Geographical Information database map from data inputs.
- The study analysed the trends and patterns of human/elephant conflict using data generated over a period of four years between 2010 and 2013.
- The study investigated the incidents of human/elephant conflict that occurred around the park. Those which occurred inside the park as result of illegal practices such as poaching, were recorded, but never eligible for

compensation by the government. This study did not analyse incidents of human/elephant conflict that occurred inside the park (at the human/elephant interface).

- The study took into account only crops damaged by elephants, not by any other wildlife like baboons, monkeys, warthogs, wild boars, antelopes, buffaloes or birds.

- The economic loss estimates using the Formula 3.1 and 3.2 as described in Chapter 3.

1.7 BENEFITS DERIVED FROM THIS STUDY

- Analysis of costs at the human/elephant interface offers a means for objective measurement of the effects of wildlife, in particular elephants, on livelihood in Kenya. This information will assist the managers of 59 National Parks and Reserves in Kenya, land use planners and agriculturalists in both Kenya and other countries, to develop strategies for co-management of human/elephant conflict and improved livelihoods, around conservation areas (Emerton, 2000; Chaminuka et al, 2012b).

- The study examined human/elephant interactions and conflict around the Tsavo Conservation Area in Taita Taveta County. It is expected that results will assist in better understanding of the patterns, magnitude and cost of human/elephant conflict at the interface. A better understanding of the interface between humans and elephants in conservation areas in Kenya will assist in conflict mitigation measures and provide avenues for involving communities in conservation as a way of ensuring they benefit more from this

important resource. The study will also be important in planning effective mitigation measures by guiding resource benefit allocation and identification of gaps in benefit distribution.

1.8 EXPOSITION OF THE STUDY

The dissertation has begun with preliminary pages that consist of a title page that includes the title of the study, name of the author and supervisor. The other pages include declaration, acknowledgements, abstract, list of abbreviations, a table of contents, lists of figures and tables.

Chapter one captures the introduction to the study. The chapter is broken down into background on human/wildlife conflicts and the negative effects they have on local communities. It also contains the statement of the problem, objectives and conceptual framework. In *Chapter two*, contains a comprehensive literature review. This covers in detail an introduction to human/wildlife conflict, including patterns, magnitude and associated costs. The chapter ends with a critical analysis. *Chapter three* is an outline of how the study was executed. In particular, the research strategy, research design, target population and sampling design is described. The chapter also explains how the cost was estimated and data analysis done. In *Chapter four*, the findings are documented and discussed. In *Chapter five,* conclusions and recommendations are outlined, areas for further research identified and limitations of the study listed. The last section of this thesis consists of the references and annexures.

1.9 CONCLUSION

Human/wildlife conflict has been increasing steadily because of the increased human population. The conflict occurs in both developed and developing countries but it occurs more in developing countries due to crop and livestock practices among local communities. Elephants account for the highest number of cases of conflict in Kenya and costs to local communities are associated with such human/elephant conflict. This is the reason why this project investigated costs of human/elephant conflict in the Tsavo Conservation Area.

The next chapter is a review of relevant literature on human/wildlife conflict, in particular, published research on the costs associated with human/elephant conflict and content analysis.

CHAPTER 2. LITERATURE REVIEW

2.0 INTRODUCTION

This chapter gives a review of research articles and materials on human/wildlife conflict, the patterns and magnitude of the human/wildlife conflict. It also presents a critical analysis of current knowledge and shows the gap that has been filled by the study.

2.1 INTRODUCTION TO HUMAN/WILDLIFE CONFLICT

Many studies have mentioned that human/wildlife conflict is on the increase both locally and globally and that wildlife as well as millions of inhabitants in local communities have been severely affected (Eliza, 2005; Chomba et al, 2012a). Lamarque et al, (2009) reported that human/wildlife conflict has become more frequent, severe and a serious obstacle to conservation efforts in Africa. The situation is more evident in Africa because communities surrounding the wildlife in protected areas, practice crop and livestock husbandry. Wildlife poses direct and recurrent threats, attacking and destroying crops and local property, injuring or killing livestock and people. In response, communities retaliate by persecuting or killing the wildlife species involved (Wiladji & Tchamba, 2003).

Human/wildlife conflict has been driven by increasing human populations, increased land use, loss of wildlife habitats and climate change. These factors have led to encroachment into protected areas by local communities, competition for natural resources like water and grazing land and illegal killing of wildlife (Brooks & Maunda, 2010; Elisa, 2005). In this situation, wildlife and local communities have been forced to coexist in close proximity to each other, resulting to human/wildlife conflict, which

undermines human and wildlife welfare, health and safety. Crop damage and livestock depredation are common and there are direct losses incurred by the farmers, - depending on agricultural activities, - whenever conflict occurs. The long-term impact of socio-economic losses to local communities is food insecurity, increased workload and economic hardship (Inskip & Zimmerman, 2009; Gore & Kahler, 2012). Local communities report to government authorities when damage occurs,. However, persistent lack of response from government authorities triggers communities into carrying out retaliatory attacks upon wildlife (Gillingham & Phyllis, 2003; Barua, Bhagwart & Jadhar, 2012).

Human-wildlife interaction is a complex situation influenced by social, historical, cultural, political, environmental and economic factors. However, it is how the socio economic losses incurred by local communities are managed, that determines the perception and level of support for wildlife conservation by the local people (WWF, 2007). All wildlife poses a threat to local people, but severe socio economic losses, are mainly inflicted by large carnivores and herbivores. The reason is that they are perceived by local communities as government property, which causes enormous and traumatic impact on local people (Lamarque et al, 2009).

Human /wildlife conflicts vary according to geographical areas, species of wildlife and type of conflict. In Kenya, with 59 National Parks and Reserves, the elephant is the dominant species of large herbivore and the main conflict is witnessed across all the protected areas (Okello et al, 2010). Most of the wildlife conflict occurs outside the protected areas.

2.2 PATTERNS OF HUMAN WILDLIFE CONFLICT

Human/wildlife conflicts are reported to be common in the proximity of protected areas, as protected areas, especially in Africa, are too small to contain the numbers of large wildlife they are protecting, forcing wildlife to leave them and coexist with the local people (Elisa, 2005). Another serious challenge is that protected areas are declared by the government, without consultation with local communities. In Cameroon, communal land was changed into national parks and local communities were forced to adopt small-scale farming around the park (Wiladji & Tchamba, 2003). Severe livestock losses, livestock depredation and deaths occurred among villagers living close to the park because local people were involved in cultivation and livestock keeping, along the corridors, breeding zones, buffer zones and migration routes of wildlife (Kissui, 2008; Gubbi, 2012). Large mammals also go beyond protected areas and live among local communities. In Kenya, over 80% of the wildlife lives outside the protected areas and are they are concentrated in arid and semi arid areas where they cause immense losses to local people (Okello et al, 2010). Some studies have also reported that human/wildlife conflict occurs inside protected areas. This was attributed to scarce natural resources like water and pastures, which led to livestock entering the park. In addition, local communities carried out illegal poaching of wildlife for food, their cultural and economic values further exposing them to risks of attack (Sangay & Vernes, 2008).

A wider range of wildlife species are involved in conflict with local people. Large carnivores such as lions, leopards, spotted hyenas, cheetahs, wild dogs and crocodiles have been associated with carnivore/human conflict in the tropics and developing countries. These carnivores are responsible for most of the livestock

depredation and human fatalities (Tweheyo,Hill & Abua, 2005; Gusset et al, 2009; Kissui, 2008). On the other hand, large herbivores such as elephants, buffalo, hippopotami, warthogs, antelopes, bush pigs and monkeys have been associated with crop raiding and damage (Linkie et al, 2006; Gillingham & Phyllis, 2003; Brooks & Maunda, 2010). The type of the conflict depends on the species of wildlife involved, the type of crop damaged and livestock depredated.

Crop damage is often seasonal. Previous studies have documented that crop damage especially by elephants, occurs during the wet season when the crops are maturing. Insects, birds and rodents damage crops when they are matured and in store (Hoare, 1999; Osborn & Parker, 2003). A recent study carried out in Southern India showed that 73% of the crop damage was associated with the cropping month every year (Karanth et al, 2012). In contrast, in Namibia, where there is the largest elephant population in the world, crop damage, damage to water installations and food stores, were reported to occur during the drought period (Jones & Barnes 2006). Livestock depredation has been described as occurring at night (Lamarque et al, 2009). However, the time of depredation is also influenced by other factors like availability of predators and the time of the year. Carnivores prey on livestock during wet seasons because of the availability of green pasture close to the park and lush vegetation that serves as hiding places (Kissui, 2008).

Recent studies have started attributing human/wildlife conflict to social and demographic factors. Gender is one of the factors that has been cited as having significant influence on human wildlife conflict and conservation mechanisms (Gore & Kahler, 2012). Lamarque et al (2009), asserted that men are killed more often than women, as they are exposed to greater perils. Men are involved in high risk activities

such as protecting crops at night, livestock herding, walking at night, poaching and drinking alcohol. All these activities expose them to wildlife. However, both men and women have equal risks when working in their farm fields. Other studies have also shown that women perceive greater risk than men, especially when there is direct contact with wildlife. However, women suffer to a greater extent due to socio economic impacts on their families (Gore & Kahler, 2012; Muthali & Soto, 2002; Elisa, 2005).

2.3 MAGNITUDE OF HUMAN/ WILDLIFE CONFLICT

Human/wildlife conflict is multifaceted and can take any form, depending on the wildlife species involved and circumstances. Crop damage and livestock depredation are common conflicts across the world. Other conflicts include human death and injuries, wildlife transmitted diseases and destruction of social infrastructures (Lamarque et al, 2009). The impact of crop damage and livestock losses on local people who are already poor makes these two conflicts prominent, prevalent and severe.

2.3.1 Crop Damage

This is the most prevalent conflict in Africa because of the farming activities in which local people are involved. People carry out farming at the transition zones and around protected areas (Eyebe, Dkamela & Endamana, 2012; Linkie et al, 2006). Elephants have been documented in most of the studies to be responsible for the crop damage although other wildlife like baboons, monkeys, warthogs, wild boars, antelopes, buffaloes and birds are also culprits (WWF, 2007; Eniang et al, 2011; Eyebe, Dkamela & Endamana, 2012). Previous studies have reported that different types of crops are destroyed. Studies carried out in Sumatra and Tanzania showed

that crop damage varies according to the inflictor species of wildlife. Crop damage was experienced by 86% of the farmers and bush pigs, monkeys and birds were mainly responsible for the damage (Linkie et al, 2006; Gillingham & Phyllis, 2003). In addition, studies carried out in Botswana, Cameroon, Central India and Nigeria indicated that elephants were responsible for destruction of maize, millet, cotton and sugarcane (Brooks & Maunda, 2010; Eyebe, Dkamela & Endamana, 2012; Gubbi, 2012; Eniang et al, 2011).

2.3.2 Livestock depredation

Large carnivores are responsible for livestock depredation and fuel carnivore/ human conflict. It is common in pastoralist communities (Lamarque et al, 2009; Brooks & Maunda, 2010; Eyebe, Dkamela & Endamana, 2012). Different species of carnivore have been reported to be responsible in different countries for depredation on different livestock species. In Tanzania, lions, hyenas and leopards were reported to attack cattle, donkeys, goats and sheep (Kissui, 2008). In Botswana, cattle and goats were attacked by lions, leopards, spotted hyenas, cheetahs, wild cats and wild dogs (Gusset et al, 2009; Brooks & Maunda, 2010). In Cameroon, the civet was responsible for most of the livestock loss (Lamarque et al, 2009). In the Kingdom of Bhutan, livestock loss was associated with leopard attacks. Cattle and horses were also victims in the human/wildlife conflict interface (Sangay & Vernes, 2008).

2.3.3 Human fatalities and injuries

This is the worst form of human/wildlife conflict but it rarely happens in comparison to crop damage and livestock depredation. A recent study carried out in Cameroon stated that there were few incidents of human attacks attributed to lions, elephants and hippopotami (Eyebe, Dkamela & Endamana, 2012). However, a study carried

out in Zambia, showed that it was a serious problem, as 49 people per year were killed by crocodiles, elephants, hippopotami or lions (Chomba et al, 2012). Deaths have also been reported in other countries. In Kenya, during a seven year period, 200 people were killed by elephants. In Tanzania, which has the largest population of lions in Africa, lions killed 30 people between 1990 and 2004 and in Mozambique 70 people were killed by crocodiles over a period of 18 months between 2000 and 2002, mainly linked to severe rains and floods (Elisa, 2005).

2.3.4 Other losses and damage caused

Other losses and damage are rarely reported and quantified. A study carried out in Pakistan recorded a high loss of livestock due to disease. Over 73% of the farmers lost livestock due to wildlife-transmitted diseases (Johnson et al, 2006). Some wildlife diseases like foot and mouth disease and anthrax outbreaks can result in high losses, although vector borne diseases like East Coast Fever and Nagana are also important causes of recurrent mortalities in livestock (Coetzer, Thomson & Tustin, 1994; Chaminuka et al, 2012b, Elisa, 2005). Destruction of social infrastructure like food stores, houses, fences, dustbins and water installations have been reported where there is elephant/ human conflict. Wildlife associated traffic accidents, have also been reported to cause deaths in people (Elisa, 2005).

Many studies on human/wildlife conflict have discussed crop damage and livestock depredation. In most instances, they have documented the proportion of the population that have been affected by the losses. However, few studies have gone further to quantify the amount of damages and estimate their costs (Eniang, et al., 2011; WWF, 2007).

2.4 COSTS OF HUMAN/WILDLIFE INTERACTION

Wildlife contributes directly or indirectly to both local and national economy through many ways that include wealth creation, employment and revenues. However, the individual cost for poor communities who are already poor and rarely compensated, is very high (Gillingham & Phyllis, 2003). The frequent threats and losses impair benefits received from wildlife and deepen negative perceptions and attitudes toward them (Gusset et al, 2009). The damages deny local communities food and income especially where there is no compensation (Osborn & Parker, 2003).

Compensation schemes have been ineffective because they are focused on addressing visible losses and neglect the more grievous hidden costs (Jack, 2009; Jadhar & Barua, 2012). Visible costs include injuries, human fatalities, crop and livestock losses, while hidden costs include increased family indebtedness due to the death of a bread winner, poor health, poor child development, lost schooling, lost work, additional labour and constant stress due to fear (Jadhar & Barua, 2012; Lamarque et al, 2009). Hidden costs are uncompensated because of the difficulties in quantifying them. Some of the compensation schemes have failed because of inequitable payments and through lack of funds. Exaggeration of the losses by affected communities has also been cited as a cause of non-payment of compensation (KWS, 2011; Linkie et al, 2006; Wiladji & Tchamba, 2003).

Several studies have established visible socio economic costs of the losses incurred by farmers. In Kenya, in over 46% of losses incurred annually (both crop and livestock) due to actions of elephants, lions, spotted hyenas and baboons, there is no compensation (Okello et al, 2010). Similarly in Namibia, it was estimated that crop and livestock losses accounted for a reduction in family gross income of US $ 78

annually, yet the government does not pay for these losses (Jones & Barnes, 2006; Elisa, 2005). Similar findings were obtained in Cameroon, where between 18 and 30% of family income was lost due to livestock losses and crop damage respectively (Wiladji & Tchamba, 2003).

Studies focused on livestock losses due to damage causing animals have shown significant economic impacts on local communities. For instance in Zimbabwe, 12% of the family income was lost due to attacks from lions, baboons and leopards between 1993 and 1999. Private ranches in Kenya lost 2.4% of the cattle herd per year due to crocodile attacks, accounting for about US $ 8,749, 958 over this period (Elisa, 2005).

2.5 CRITICAL ANALYSIS

From the literature reviewed, it is clear that socio economic losses from human/wildlife conflict have significant adverse impacts on local communities, reasons being that most of these poor communities depend on subsistence farming for a living. When there is crop damage and livestock are lost, there is both an immediate impact (visible costs) and long-term effects (hidden costs). If compensation is not paid, economic hardship and food insecurity ensues.

Conservation efforts have made few gains because there is limited information on socio-economic costs even on widely documented crop and livestock losses caused by wild animals (Chaminuka et al, 2012b). At the same time, knowledge about the magnitude of damage caused by wildlife is scanty and inadequate. No nation or state holds statistics on the level of damage associated to socio economic costs (Jack, 2009).

Furthermore, estimation of the socio economic costs is difficult and challenging. It is documented across all the compensation schemes that local communities exaggerate the losses. Therefore obtaining accurate data may require triangulation. of data. Accurate information on livestock depredation is also difficult because the nature of predation' cannot always be completely attributed to predators. Human factors such as poor management and animals that are not eaten by predators, but scavenged after death due to malnutrition or disease may be reported as depredated animals. It may also be even more difficult to attribute the action of wild animals in other losses such as human deaths, injuries and infrastructure destruction. Failure to calculate actual losses incurred by the local communities has led to ineffective human/wildlife conflict management (Barua, Bhagwart & Jadhar, 2012).

Few studies have estimated the actual benefits that households have received from wildlife conservation, although there have been several claims that communities have benefitted from tourism linked to wildlife; this has not been substantiated (Coetzer, Thomson & Tustin, 1994). Taking into account the challenges in estimating costs of human wildlife conflict, this study focused on analysing published data on costs of crop damage, human injuries and deaths resulting from human/elephant interactions, based on KWS reports between 2010 and 2013.

2.6 CONCLUSION

Studies reviewed in this chapter have acknowledged that human/wildlife conflict has become frequent, severe and serious in both developing and developed countries. It has negatively affected people in the communities living around wildlife conservation areas worldwide. Food insecurity and economic loss are possible long term effects of human/wildlife conflict. Crop damage and livestock depredation are also important

negative results of human-wildlife interactions, with crop damage probably most common in Africa due to crop farming activities that are attractive to large herbivores Elephants have been recognised as contributing more to crop damage than smaller herbivores (Mamo, Bouer & Tesfay, 2014; Pittiglio, 2008). While much has been published on the negative effects of the human/wildlife conflict, few studies have been done on economic cost, necessitating this study to investigate the socio economic aspects of human/elephant conflict.

The next chapter describes how the study was executed by outlining how data was collected, analysed and report generated. The chapter also position the study to a relevant research design and describes the study area and study population.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 RESEARCH STRATEGY

This study used a quantitative descriptive research methodology to collect, analyze and quantify retrospective (secondary) data extracted from the KWS human/wildlife conflict database, over a four year period between 2010 and 2013. The variables captured were types of human/elephant conflict, numbers of incidents, and estimated cost of the types of conflict (Appendix 5). This data was analysed to describe the patterns of human/elephant conflict as well as estimating the cost of the damage compensated by the government and association between specific variables (type of conflict, area of conflict) and economic cost.

3.2 RESEARCH DESIGN

This was a quantitative descriptive survey focused on collecting data from Tsavo Conservation Area to describe the occurrences, distribution and magnitude of human/elephant conflict. The quantitative data was generated from secondary (retrospective) data obtained from the KWS database and records that already existed.

3.3 SAMPLING DESIGN

A total of 2,637 human/elephant conflict incidents were extracted from the Kenya Wildlife Service (KWS) occurrence database. After data cleaning, 2149 incidents were discarded because they had incomplete data. The sample size analysed for this study was therefore 488 incidents of elephant/human conflict reported to and recorded by the KWS between 2010 and 2013.

3.3.1 Study Area

At about 40,000 km^2, Tsavo conservation area is the largest conservation area in Kenya. Located in south-western Kenya bordering Tanzania, it forms a continuous ecosystem with Mkomazi reserve in Tanzania and Amboseli National Park in Kenya. The ecosystem consists of Tsavo East National Park, Tsavo West National Park, Chyulu Hills Park and about 27 community ranches that form a critical dispersal area of wildlife inhabiting the three divisions of the parks. With a population of more than 12,000 elephants, Tsavo contains a third of Kenya's estimated 35,000 elephant population). The vegetation type in Tsavo is mainly mixed Commiphora-Acacia woodland, grassland and riverine vegetation. Two rainy seasons lasting from March to May and November to December are clear, but the spatial and temporal rainfall distribution is difficult to predict (Andanje & Ottichilo, 1999).

The study targeted 22 sub locations in the larger surrounding Tsavo conservation area. The County shares 80% of its perimeter with the protected areas. These sub locations border Tsavo West National Park, Tsavo East Park and Chyulu Hills Park. The area is unique in that conservation areas appear to encircle the villages.

3.3.2 Study Population

The human population of the greater Taita Taveta County was estimated at 393,250, with an annual growth rate of 3.8 %. The Tsavo conservation area has 22 sub locations with a population of 94,021 people out of the 393,250 population of Taita Taveta County (GoK, 2010). These rural areas are sparsely populated, the principal inhabitants being the Taita tribe. Farming involves growing crops, vegetables and fruit as well as livestock keeping. The community is officially organized into sub locations at its lowest administrative levels and details about divisions, locations and sub-locations are given in Table 3.1.

Table 3. 1. Study Population in Taita District, around Tsavo Conservation Area

Division	Location	Sub location	Total	House hold
Tausa	Ngolia	Ghazi	3073	754
Mwatate	Maktau	Godoma	2700	727
Mwatate	Bura	Ilole	1634	370
Voi	Voi	Kaloleni	20418	5119
Voi	Sagalla	Kishamba	1849	429
Wundanyi	Kishushe	Kishushe	3617	971
Mwatate	Maktau	Maktau	2593	662
Nyangala	Kasigau	Makwasinyi	2847	606
Nyangala	Marungu	Maungu	7608	1686
Wundanyi	Mghange	Mgangenyika	2489	621
Nyangala	Marungu	Miaseni	1409	322
Mwatate	Mwatate	Modambogho	5380	1378
Tausa	Mbololo	Mraru	5806	1413
Mwatate	Mwachabo	Mwachabo	5711	1349
Voi	Voi	Mwangea	17354	5003
Mwatate	Mwatate	Mwatate	6339	1715
Voi	Sagalla	Ndara_sagala	3073	805
Tausa	Ndolia	Ndome	2846	723
Wundanyi	Wumingu	Nyache	3008	713
Mwatate	Bura	Nyolo	3288	1103
Nyangala	Kasigau	Rukanga	3965	942
Tausa	Mbololo	Tausa	2831	748
Voi	Sagalla	Teri	2517	708
Mwatate	Mwachabo	Wumari-sechu	3974	1110

Source: GoK, 2010 Census Report Extract.

3.4 DATA COLLECTION

Secondary data was collected from the KWS database on crop damage, human injuries, human deaths and crop damage associated with human/elephant conflict around Tsavo Conservation area. This data is normally logged in an Excel (Version 2003, Microsoft Corp., USA) spreadsheet by field officers in the park after elephant/human conflict has occurred. Data on elephant/human conflict incidents collected by KWS between the year 2010 and 2013 and kept in an electronic database (MIST) was extracted, cleaned and analysed to describe the patterns and type of conflict in the 24 sub locations surrounding the Tsavo Conservation Area. The data included the areas where the conflict occurred, names of the locations, dates and month of incidences, type of conflict, type of crop, acres of land affected and yield loss (Kilograms).

The study also obtained data from KWS records, on compensation paid for human Injuries, human deaths and crop destruction affecting communities situated within the 24 sub locations mentioned earlier. This data was used to estimate the actual costs of each incident of human/elephant conflict. The cost was done for crop damage, human injuries and deaths and not for property damage because the rates in the Wildlife Conservation and Management Act 1989, Cap 376, do not indicate this compensation rate.

3.5 DATA ANALYSIS

ArcGis spatial analysis using ArcGIS Ver 10.1(Esri, 2012) was used to generate raster surfaces to describe conflict patterns in areas around the Tsavo Conservation Area. A digitized map of the Tsavo conservation area, showing different

administrative land parcels in different administrative sub locations where human elephant conflict cases occurred was extracted using ArcGIS 10.0 (Esri, 2012) and exported as a Microsoft Excel ™ Ver 2013 (Microsoft Corporation, USA) file. The total number of human elephant conflict cases, in each administrative land parcel in Tsavo conservation area, were then summarised into a database in spreadsheet form using Excel. The Excel file was then exported to ArcGIS 10.0 (Esri, 2012) and using the command “join and relate table”, the Excel file was joined with a digitized map of Tsavo conservation area which contained the different administrative land parcels in Taita Taveta County. Using the “symbiology” command in ArcGIS 10.0 (Esri 2012), different land parcels were categorized into three zone classes as low, medium or high level human elephant conflict zones with each zone represented by a different colour.

3.5.1 Calculation of crop losses, human injuries and deaths

For human injuries and deaths, the Wildlife Conservation and Management Act of 1989, Cap 376, section 62 stipulates that compensation for any human injury regardless of severity is 50,000 Kenya Shillings (Kshs) or 500 USD-(exchange rate of Kshs 100/USD). For any death, regardless of sex and age, it is 200,000 Kshs or 2000 USD- exchange rate of Kshs 100/USD. These set values were used to calculate the loss by multiplying the number of persons and the set value.

Total human injuries (HI) or deaths (HD) = Numbers of persons (Per) x Kenya Wildlife value/persons **(Equation 3.1)**

To calculate the crop damage eligible for compensation, an indirect method was used as applied in Nepal (WWF, 2007, p.25). In this method used, monetary values to calculate crop damage loss (Kshs/kg /household) is obtained by multiplying

average yield per acre of crop destroyed incurred per household, areas of crop damaged and the average market price in Kshs/kilogram.

$$Li = Ai \times Yi \times Mi$$

where,

Li = Loss of a given crop (kg/year) incurred by household i

Ai = Average Area damaged by elephant as reported by household i

Yi = Average yield in (kg/year/unit area) for a given crop as reported by household i

Mi = Average market price in Kenya Shillings/Kilograms **(Equation 3.2)**

The average prices of crops grown in the study area at the time the research study was undertaken are given below in Table 3.2.

Table 3. 2. Average market price of the crops

Crops	Average Yield per acre (kg)	Average Price Kshs/kg
Maize	270	40.00
Beans	270	60.00
Green grams	270	60.00
Cowpeas	270	60.00
Mangoes	2,000	20.00
Pawpaw	19,200	30.00
Sugarcane	10,000	30.00
Cassava	4,000	50.00
Banana	7,200	10.00
Watermelon	2,000	50.00
Pigeon peas	270	60.00
Tomatoes	8,000	60.00
Kale/spinach	3,000	30.00

Source: Agricultural Extension Report, 2010-2013

Both descriptive and inferential statistics were applied to analyze the data. Mean and standard deviation was used to analysis the continuous variables namely number of cases, frequency of households with property damaged, size of land(acres) with crop destroyed, volume of crop yield(kg) lost and yield value(Kshs) of the loss. Frequency distribution was also used to analyse categorical variables such as location where conflict occurred, types of the human/elephant conflict, seasons (in months), years when conflict occurred and types of the crops destroyed.

The Pearson's Chi Square test of Independence (which tests whether unpaired observations on two variables, expressed in a contingency table, are independent of each other) was applied to find out whether there was a significant association between months of the years (seasons) when human /elephant conflict occurred and types of human/elephant conflict.

Analysis of Variance (ANOVA) was also used to find out if there was a significant difference ($p>0.05$) in compensation among the types/forms of human elephant conflict (crop related and human death/injury related) and years (2010 to 2013) when conflict occurred. Property damage was not included in the ANOVA, because it was not compensated by the government and therefore the cost could not be estimated from available data.

There was no analysis done on the livestock depredation associated with elephant because there were no cases reported and captured by KWS.

3.6 CONCLUSION

This chapter was structured to guide data collection and analysis. This was a descriptive survey of selected quantitative secondary data, which was then analysed using quantitative methods. The human/elephant conflict incident data was extracted from KWS database. Compensation levels were analysed using the published government rates as per the Wildlife Conservation and Management Act 1989, Cap 376. Cost of the crop damage was estimated using the equations derived in this Chapter, as well as government criteria outlined in Table 3.2.

The next chapter is a presentation of the research findings and discussion. The findings are based on descriptive and inferential statistics. The analysis was based on the three objectives of the study mentioned in Chapter 1, section 1.3.

CHAPTER 4. RESULTS AND DISCUSSION

4.1 INTRODUCTION

Descriptive and inferential statistical analysis was done as described in Chapter 3 (Methods) and results presented according to the study objectives. This chapter also discusses the research findings with reference to research findings from other published work.

4.2 HUMAN ELEPHANT CONFLICT ZONES

The first objective in this study was to determine the geographical locations where elephants mainly interacted with humans around the Tsavo Conservation Area. The 488 cases analyzed were summarized under 21 different sub locations (the administrative unit of the government) as shown in Table 4.1.

Table 4. 1. Human/ elephant conflict zones around Tsavo Conservation Area

Sub location	Frequencies	Percentage
Ghazi	1	0.2
Godoma	110	22.5
Ilole	40	8.1
Kaloleni	25	5.1
Kishamba	16	3.3
Kishushe	8	1.6
Maktau	30	6.2
Makwasinyi	4	0.8
Maungu	9	1.9
Mgangenyika/Miaseni	13	0.2
Modambogho	5	1.1
Mraru	8	1.7
Mwachabo	21	4.4
Mwangea	43	8.8
Mwatate	13	2.7
Ndara_sagala	11	2.2
Ndome/Nyache	11	2.0
Nyolo	93	19.1
Rukanga	12	2.5
Tausa	1	0.2
Teri	7	1.4
	488	100.0

The mean number of incidents per sub location over the four years was 20 (SD = ± 5 incidents). The mean number of incidents of human/elephant conflict per year were 122 and per month 10 incidents.

The Godoma sub location had the highest number of human/elephant conflict incidents (23%), followed by Nyolo (19%) while Ghazi and Mgangenyika sub locations had the lowest number of human/elephant conflict incidents (0.2%) (Table 4.1).Figure 4.1 below displays human/elephant conflict zones in the Tsavo conservation area, derived from the KWS data analysed.

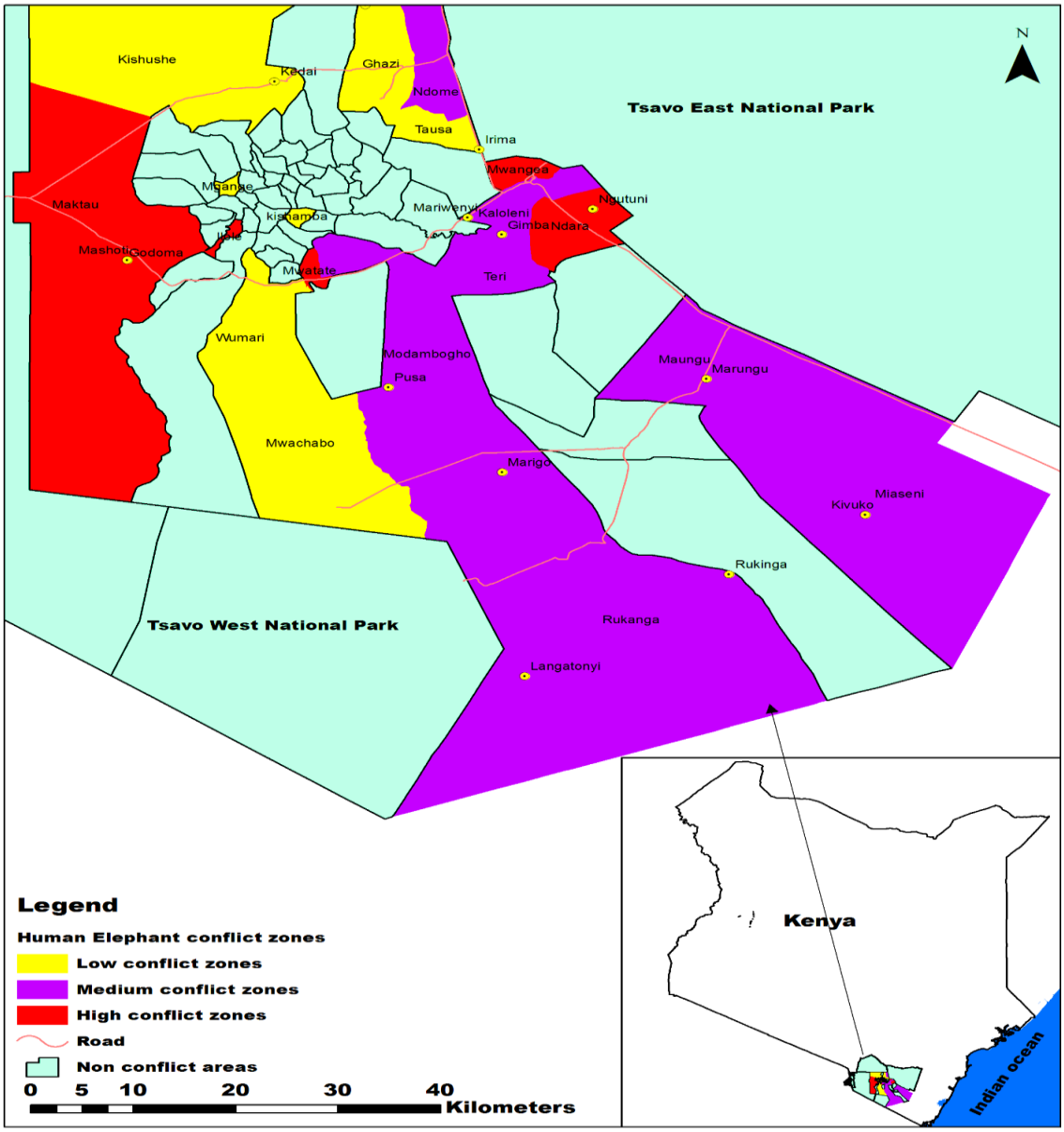

Figure 4. 1. Human elephant conflict zones in Tsavo conservation area

Nb: Drawn using ArcGIS, 2012.

Using ArcGIS 10.0 (Esri, 2012) human/ elephant conflict densities were categorized into three classes with Nyolo, Godoma, Ilole, Mwangea and Kaloleni and Ndara having the highest conflict densities while Kishushe, Ghazi, Nyache, Teri, Makwasinyi among others had the lowest human elephant conflict densities (Figure 4.1).

4.3 HUMAN/ELEPHANT CONFLICT IN TSAVO CONSERVATION AREA

The second objective was to establish the extent and nature of damage caused by human-elephant interactions (human/elephant conflict) around Tsavo Conservation area.

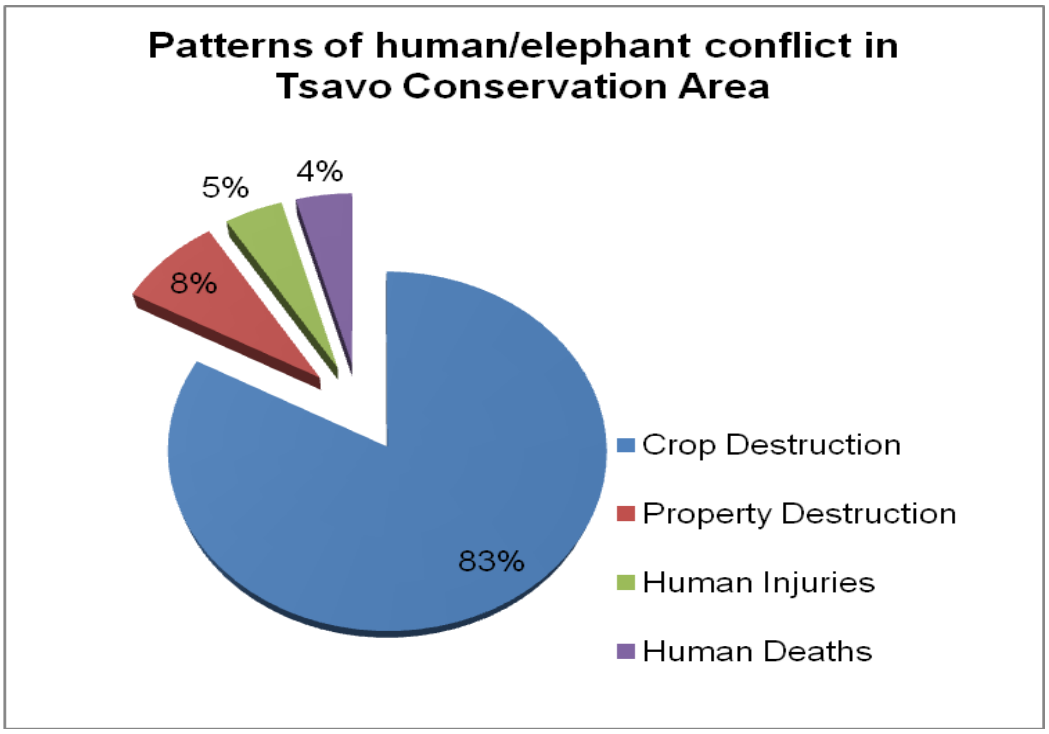

Figure 4. 2. Human/elephant conflict Incidents in Tsavo conservation area

The study established that there were four forms of adverse interactions namely crop damage, property destruction, human injuries and human deaths. Figure 4.2 shows the proportion of each of these adverse interactions over the period 2010 to 2013. According to Figure 4.2 above, it can be seen that most (83%) of the reported incidents of human/elephant conflict seen in Tsavo Conservation area resulted from crop damage.

4.3.1 Crop damage

The trendline of crop damage incidents over time, is shown in Figure 4.3.

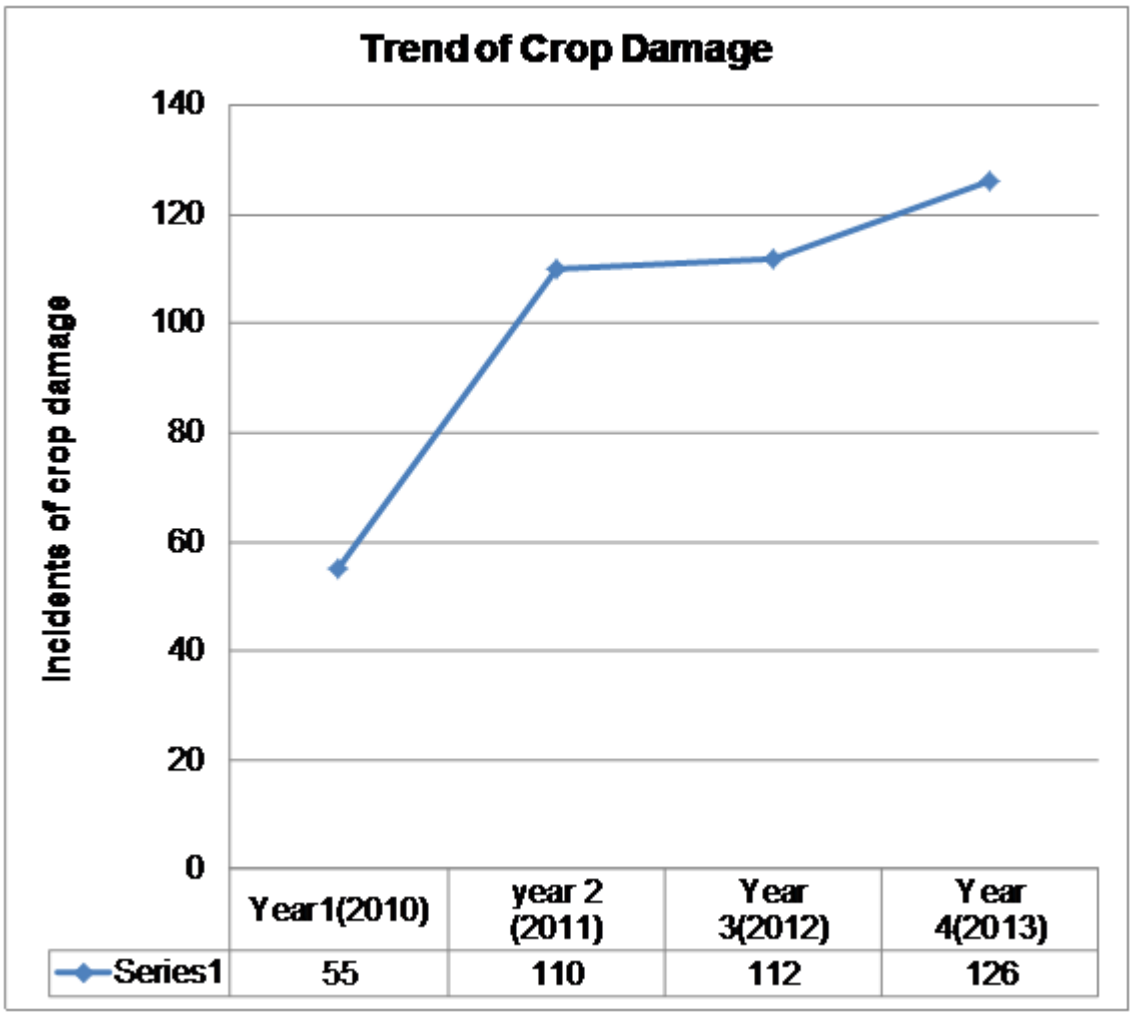

Figure 4. 3. Crop destruction trend around Tsavo Conservation area

The number of crop destruction incidents increased with time between 2010 to 2013 (Fig 4.3). The average number of incidents of crop damage per year was 101 and there were, on average, 8 incidents per month.

Figure 4.4 shows the monthly frequency of incidents of crop damage by elephants in the study area.

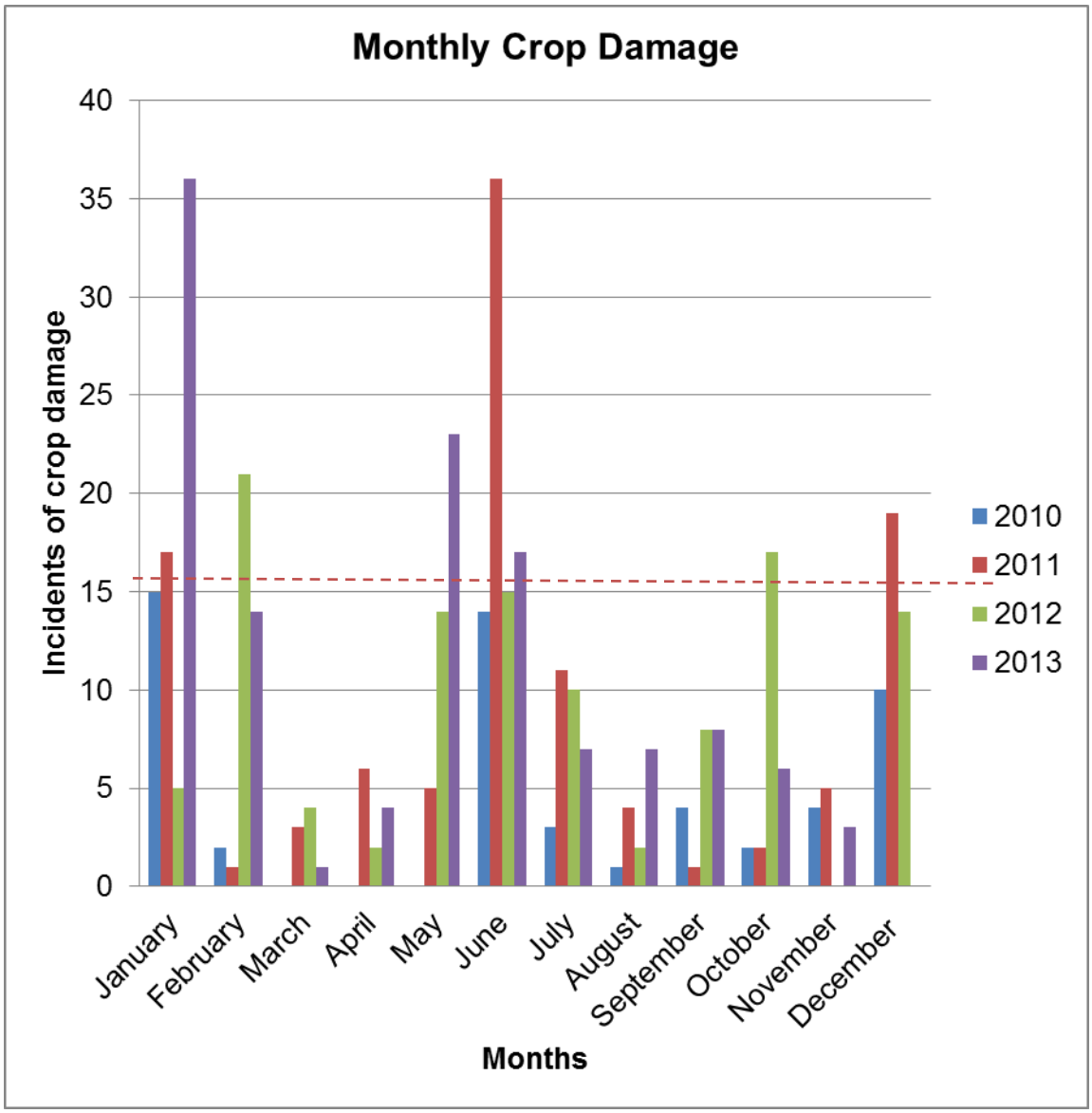

Figure 4. 4. Monthly crop destruction in Tsavo Conservation area

From Figure 4.4, it can be seen that in 2010, crops were destroyed more frequently in January than other months. In 2011, crop destruction occurred in January, June, July and December. In 2012, crop destruction occurred in February, May, June, July and October and December. In 2013, crops were destroyed in February, May and June. In summary, it was found that crop damage occurred more often in December to February and May to July than other months. The two peaks in each year correspond to the two wet seasons witnessed around Tsavo Conservation area. However, 2012 was a unique year with crop destruction happening in October, while

in 2013 there was a low frequency of crop destruction during December and January.

It was also found that the main crop damaged by elephants was maize as a single crop (53% of the cases). This happens between November and December and May and July when crops are growing. It also happens in January and August when is being harvested. In the other incidents maize and other crops were damaged together in the same incident. Other crops destroyed included pawpaw, cow peas, beans, pigeon peas, mangoes, bananas, cassava, sugarcane, groundnuts, watermelons, apples and passion fruit.

The research further showed that crops were destroyed on a total of 278.38 acres of land with an average farm or smallholding size of 0.70 acres (SD = 0.99 acres). The smallest land size was 0.13 and largest was 12 acres. The majority (76%) of the cases of crop damage occurred on land smaller than the average size of land owned by local communities around the Tsavo Conservation area. Only 24% occurred on land more than 0.7 acres in size.

The findings also showed that a total of 604,432 kg of yield was destroyed in four years with an average of 1530 kg (SD =4,902 kg) per year. This is an estimated dry weight of the crop yields from growing crop and harvests destroyed by elephant.

4.3.2 Human injuries and deaths

Table 4.2 shows the frequency of cases of human deaths and injuries resulting from elephants.

Table 4. 2. Incidents of human injuries and deaths

Year	Elephant/Human Interaction				
	Injuries		Deaths		Total
	Male	Female	Male	Female	
2010	5	0	5	0	**10**
2011	8	1	6	0	**15**
2012	5	0	8	0	**13**
2013	2	3	2	0	**7**
Total	**20**	**4**	**21**	**0**	**45**

The results showed that there were 45 incidents of deaths or injuries due to elephants reported in the study area over 4 years (Table 4.2). Human injuries occurred in both males and females around the Tsavo Conservation area, with an average of 6 persons injured every year. In relation to gender and human injuries and deaths, the findings further showed that the 21 deaths were men. Among the injuries 4 were female and 20 were male.

4.3.3 Property Destruction

Table 4.3 shows the frequency and type of property damage over the study period by elephants, in the study area.

Table 4. 3. Types of property destroyed

Year	Property					
	Water Pipes	**Water Tanks**	**Houses**	**Store**	**Others**	**Total**
2010	7	2	0	0	0	**9**
2011	4	0	5	0	3	**12**
2012	1	0	3	2	0	**6**
2013	4	3	5	0	1	**13**
Total	**16**	**5**	**13**	**2**	**4**	**40**

It can be seen from Table 4.5 that a total of 40 households had their property destroyed in Tsavo Conservation area. The water pipes and houses were most destroyed in affected households**.**

4.4 COMPENSATION PAID

The third objective of the study was to determine the economic cost of Human/elephant conflict. It was established that the government compensated victims for crop damage, human injuries and deaths as stipulated in the Wildlife Conservation Act,1989 Cap 376. However, this legislation does not recognise the compensation of the property destruction. This study also recognised that there are other invisible costs that the government does not take into consideration as it estimates the cost and give compensation to the affected households. These costs include inconvenience, loss of breadwinner, and psychological trauma among others. This means then that the costs that a household bear from the human/elephant conflicts could be higher. This study having relied on secondary data from KWS, actual household costs could not be estimated given that the data

on invisible costs was missing. The study therefore equated compensation done to the affected households to the estimated cost of the human/elephant conflicts. According to the Act, human injury compensation is Kshs 50,000(USD 500 - exchange rate of Kshs 100/1USD) and death is Kshs 200,000(USD 2000 - Exchange rate of Kshs 100/1USD). On the crop damage, the Act stipulate that the compensation depended on types of crop, the size of the land with crop damaged, predetermined specific crop yield per acre by the Ministry of Agriculture and the current market price of the crop.

The findings indicated that the crop damage compensation accounted for Kshs 13,575,748(USD135757 - exchange rate of Kshs 100/1USD), human injuries compensation was Kshs 1,250,000(USD12, 500 - exchange rate of Kshs 100/1USD) and Human deaths was Kshs.4, 400,000((USD 44,000 - exchange rate of Kshs 100/1USD). The findings presented in Tables 4.4 and 4.5 show the mean compensation over the study period per incident reported.

Table 4. 4. Mean compensation paid (Kshs and USD)*

Type of Conflict	**N****		**Mean**	**Std Deviation**	**Minimum**	**Maximum**
Crop damage	395	Kshs	34,368	74,032	1,350	576,000
		USD	344	740	14	5,760
Human injuries	22	Kshs	59,523	33,982	50,000	200,000
		USD	595	340	500	2,000
Human deaths	21	KShs	209,523	43,644	200,000	400,000
		USD	2095	436	2000	4000

* An US dollar is equivalent to 100Kshs.

** Number of the incidents reports

The findings presented in Table 4.4 show that human deaths had the highest mean compensation while crop damage had the highest maximum compensation paid by the government.

4.5 INFERENTIAL STATISTICS

A Chi Square test was also conducted between the months of the year and type of human/elephant conflict. The result (X^2(33, N = 405) = 90.550, p = 0.00), showed that the months of the year (seasons) during which human elephant conflict occurred were significantly (p= 0.000) associated with types of human/elephant conflict in Tsavo Conservation area.

The ANOVA was also conducted to find out if there was difference in compensation by years and three negative interactions (crop damage, human injuries and deaths). The results are presented in Tables 4.5 – 4.7.

Table 4. 5. ANOVA results for months of the year and crop damage compensation

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.091E12	11	3.719E11	1.915	.036
Within Groups	8.292E13	427	1.942E11		
Total	8.701E13	438			

Table 4. 6. ANOVA results for years and crop damage compensation

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.573E11	3	5.243E10	9.172	.000
Within Groups	2.767E12	484	5.716E9		
Total	2.924E12	487			

Table 4. 7. ANOVA results for type of the human/elephant conflict and compensation

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.916E11	3	2.305E11	49.980	.000
Within Groups	2.232E12	484	4.612E9		
Total	2.924E12	487			

From the findings presented above in Tables 4.5 - 4.7 it can be seen that there was a significance relationship ($p = 0.36$) between the economic compensation and the types of human elephant conflict across the 12 months of the year. This meant that different months had a significant difference ($p= 0.036$) in compensation for different types of human elephant conflict. There was also significant relationship ($p < 0.00$) between the compensation paid in different years and different types of the human elephant conflicts.

4.6 DISCUSSION

4.6.1 Human Elephant Conflict Zones

According to the findings, it was clear that human/elephant conflict occurred around Tsavo West and Tsavo East Game Park. The study established that there were sub locations where there were high, medium and low incidents of human/elephant conflict.

According to the findings presented in Table 4.2 and Figure 4.1, Godoma, Mwatate, Ngutuni and Mwangea had the highest number of conflict incidents. These conflict zones had a higher number of incidents because of three main reasons:

- One of the reasons is the fact that the conflict zones borders the part of the park that do not a fence. This situation allows the elephant to have unrestricted movement from the park into the settlement areas.

- Secondly, these conflict zones have highest population density and majority of who conduct crop farming. In search for arable land, the community have encroached into the buffer zone and to an extent into the park for farming purposes. The crops planted (mainly maize) provided the elephant with available and accessible fodder to feed on.

- The third reason for high incidents of the human/elephant conflict is the fact that Tsavo conservation area is located in a semi-arid part of Coast province.

- During the dry season, the water sources in the park reduce, motivating elephants to get out of the park in order to search for water within the

settlements. In the process, the elephant pass through the farms and homesteads, causing property destruction and human injuries/deaths at the main water sources.

The study also shows that medium human/elephant conflict happened in Ndome, Tari, Mwenda bogo, Miasenyi, and NyaniKanga. A common feature in these conflict zones is the presence of community and private ranches, which are involved in conservation of wildlife. There are new human settlements within the ranches and other areas with wildlife. Many settlements are emerging along the Mombasa-Nairobi road that divides the Tsavo into east and west, from other parts of the Taita Taveta County. Whenever the local communities settle, they start crop farming and destroy the wildlife habitats. This gradually has attracted the elephants and increased human/elephant conflict in these sub locations.

4.6.2 Elephant Human Interaction In Tsavo Conservation Area

The study established that crop damage (83%) had the highest numbers of incidents in contrast to human injuries, human deaths and property destruction. This is because the local communities living around the Tsavo Conservation area practice crop farming. The elephant being a browser, feeds on grass and vegetation, consequently the crops planted by local communities provide readily available fodder. As elephants move out of the park unrestrictedly, they interact with people and human habitats on the farms and along pathways. The findings of this study are similar to a study conducted in Northern Cameroon by Wiladji & Thcamba (2003). The study examined conflict between people and wildlife within the Bernoue Wildlife Conservation Area. It was established that the wildlife/conflict resulted mainly in of crop damage (86%) and elephant were associated with 97% of this crop damage. A

similar study conducted around Kerinci Seblat National Park (Sumatra) by Linkie et al (2006) found out that crop damage was common along the protected area boundaries and it was poor communities who incurred the individual costs of crop damage.

The study further established that crop damage happened throughout the year but mostly during the wet seasons (December to January and April to June). During the wet seasons, the crops planted on farms have reached to the level of flowering and maturity. As elephants moved out of the park, they browsed on the young crops in the farm. Maize accounted for the most (53%) of crops destroyed because it was planted by the majority of the communities in Taita Taveta County. Other food crops included pawpaw, cow peas, beans, pigeon peas, mangoes, bananas, cassava, sugarcane, groundnuts, watermelons, apples and passion fruit. The findings of this study concur with a study conducted in Northern Cameroon that established that maize and bean crops were mostly damaged around Lolkisale, Naitolia and Loborsoit A villages inMonduli and Simanjiro Districts of Tanzania, between 2006 and 2008 (Pittiglio, 2008). Similar seasonal occurrence of human/elephant conflict was found in another study carried out in Southern India. It established that 73% of the crop damage was associated with the cropping month every year (Karanth et al, 2012).

The current study in Kenya established that 76% of the populations affected by human/elephant conflict had less than 0.7 acres of land. This shows that the majority of the local communities are smallholder farmers and practice subsistence farming. Any destruction of their crops would affect their food security as well as livelihoods. In relation to yield lost, the findings showed a total of 604,432 kg lost during the 409

incidents in four years. On average, crop damage was 151,108 kg in a year and 1530 kg per incident. This loss is severe given that the majority of smallholders (70%) have less than 0.7 acres of land. A single incident could result to total loss of the crop on the farm.

There were fewer incidents where human injuries and deaths, or property destruction occurred. The findings on human deaths reported in this study concur with published findings in Cameroon (Eyebe, Dkamela & Endamana ,2012) and Zambia (Chomba et al .,2012). The two studies found that human deaths were serious problem and elephant were also associated with fatalities in other wildlife.

The findings of this study shows that both women and men were injured but only men were killed by elephants. The reasons for men being killed included; being on their farms doing cultivation, at home protecting their property or at night when travelling. These findings agree with a study carried by Lamarque et al (2009) who suggested that men are killed more often than women because they are involved in high risk activities such as protecting crops at night, livestock herding, walking at night, poaching and drinking alcohol.

In regard to property, the current study showed that water pipes and houses were most often destroyed by elephants. Water pipes were destroyed mainly during the dry season as elephants searched for water. Jones and Barnes (2006) reported similar findings from Namibia. In Namibia, where there is the largest elephant population in the world, crop damage and destruction of water installations and food stores, were reported to occur during the drought period.

4.6.3 Compensation for incidents of human/elephant conflict

The study could only establish the costs of the crop damage, human injuries and deaths that were eligible for compensation by the Government of Kenya, as explained in Chapter 5. The study did not estimate the cost of the damage per house hold, but per incident. The total estimated economic cost of crop damage, human injuries and death was Kshs 19,225,748($ 192257 - exchange rate of Kshs 100/1USD) was incurred by the communities in the study area over the study period (four years). Crop damage accounted for 71% of the total because it affected about 76% of the local population with less than 0.7 acres of land. Crop damage incidents left the communities with endemic food insecurity and poorer than before. This was similar to the findings of the study conducted in Namibia, where it was estimated that crop damage together with livestock loss accounted for a reduction in family gross income of US $ 78 annually, yet the government did not compensate those affected(Jones & Barnes, 2006; Elisa, 2005).

Chi square test analysis comparing seasons (in months) with the type of incident revealed that there was a significant relationship between the two factors. According to Figure 3, section 4.2, it is clear that human/elephant conflict incidents occurred more frequently during the months of December to January and April to June. These are the wet seasons months and crops were about to mature. As elephant movement out of the park is unrestricted, elephants feed on smallholder crops causing damage. Humans suffered injuries and deaths if they encountered elephants on farms.

The findings from ANOVA analysis further showed that in 2012, there was a higher economic cost associated with crop damage than in 2010, 2011 and 2013. This was

probably because there was higher rainfall during that year and a rapid increase in new settlements. In addition, the study showed that there was significant ($p>0.05$) difference in compensation between 2010 and 2013.

Climate change that affected rainfall patterns within the year, is one of the explanations that can be given for this difference. Climate change has caused the dry seasons to get longer and sometimes the rain become unpredictable. A possible explanation for reduced human/elephant conflict incidents was the building of a park fence around the Godoma area from 2011 and still the work is going on around the park.

4.7 CONCLUSION

In summary, the findings have showed that there are four forms of human/elephant conflict in Tsavo conservation area. These were human injuries and deaths, crop damage and property destruction. It was shown that 83% of human/elephant conflict incidents involved crop damage. Crop farming is a prominent occupation in the local communities. Factors that affected the frequency of incidents of human/elephant conflict were proximity to the park, size of the farms, months of the year (seasons) and human population.

The next chapter is about the conclusions and recommendations derived from the findings and discussions outlined in this chapter. The conclusions are based on the main objectives of the study.

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSION

Human/elephant conflict is prominent in Tsavo Conservation area. The main conflict zones identified in this study were areas around the park and main water points within the community. These areas include Godoma, Mwatate, Ngutuni and Mwangea sub locations. However, there are emerging conflict zones caused by new settlements by local communities near the park, community ranches and the Mombasa road. These areas included Mwachabo, Ghazi and Magange.

Crop damage had a higher number of incidents than human injuries, human deaths and property destruction. Local communities living along the park were found to be predominantly involved in smallholder crop farming, with maize being the predominant crop. The highest frequency of incidents occurred around the park where there was no game fence, an area which the local community may have increasingly encroached to conduct crop farming. This proximity of new settlements to the park is probably an important reason for increased human/elephant conflict related to crop damage. The study further established that 76% of the affected farmers were smallholders with a land size of > 0.7 ha with a crop loss of between 440 to 2408 kgs of crop yields per year.

The proportion of the economic loss compensated in the areas around the park was high, in relation to subsistence livelihoods. On average, a cost of Kshs. 6,177 of crop damage per household was lost per month to human elephant conflict.

5.2 RECOMMENDATIONS

From the above conclusions, the following recommendations are made:

- The government should invest in putting up the fence round the park. This will prevent the movement of the elephant from the park to the farms near the park.
- The government should regulate new settlement schemes by allocating farming areas to communities away from the park and prevent further encroachment into the park.
- The KWS should develop a mechanism of compensating for property loss in addition to crop loss and death/injury to persons. This has not been included in the current government regulations.
- Community-based solutions should be promoted that are aimed at preventing and managing human-elephant conflict. Prevention and education materials and tools that could help address both immediate and long-term issues should be developed.
- There should be information sharing, cooperation and collaboration among all levels of government, non- governmental organizations and individuals with an interest in elephant conservation and the food security and safety issues of local communities. Together, all these stakeholders should review and discuss human- elephant conflict, make recommendations and identify potential response roles.
- Public understanding and awareness about human-elephant conflict should be increased by;
    - Informing the public about actions by humans and elephants that result in the conflict.

  - Raising awareness of the public regarding the implications of their actions. For example the encroachment into the park.
  - Incorporating information regarding human-elephant conflicts into educational curriculum at all levels.
- Extensive scientific studies should be conducted and knowledge expanded on life history characteristics of elephant species, including their population dynamics, behaviour and habitat requirements.

5.3 LIMITATIONS OF THE STUDY

One of the limitations on the human/elephant interaction is missing information on the number of persons injured and killed. Among the 21 incidents reported, 7 had not provided the information on the number of person's injured and their gender. A large proportion (2149 cases) was left out of the analysis because they had incomplete data.

The study could not estimate economic loss per household because the information availed was only on incidents. One could not tell which incidents occurred to which households.

5.4 RECOMMENDATION FOR FUTURE RESEARCH

There is need to conduct a longitudinal study to establish the actual long term costs to households and individuals resulting from human/elephant conflict.

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ANNEXURES

Annexure 1: Official Letter from the Animal Ethics Committee

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Animal Ethics Committee

PROJECT TITLE	**Assessment of socio-economic benefits and cost of human/wildlife interaction in Tsavo Conservation area, Kenya**
PROJECT NUMBER	**V024-14**
RESEARCHER/PRINCIPAL INVESTIGATOR	**Dr. J Poghon**

STUDENT NUMBER (where applicable)	**105 56 088**
DISSERTATION/THESIS SUBMITTED FOR	**MSc**

ANIMAL SPECIES	**Web-based MSc**	
NUMBER OF ANIMALS	**n/a**	
Approval period to use animals for research/testing purposes		**May – October 2014**
SUPERVISOR	**Prof. C McCrindle**	

KINDLY NOTE:

Should there be a change in the species or number of animal/s required, or the experimental procedure/s - please submit an amendment form to the UP Animal Ethics Committee for approval before commencing with the experiment

APPROVED	Date	26 May 2014
CHAIRMAN: UP Animal Ethics Committee	Signature	

Annexure 2: Official Letter to Stakeholders

Dr. Jeremiah Poghon
P O Box 14 - 8300 – 00101, VOI
+254 722 888 034
jpoghon@yahoo.com

20th March 2013

Director of Kenya Wildlife Service

Dear Sir/Madam

RE: REQUEST TO CONDUCT RESEARCH

I am a student at Pretoria University. For the award of my Masters' degree I am required to carry out a study on *Assessment of Socio-Economic Losses and Benefits of Human –Wildlife Conflicts at Tsavo Conservation Area.* I am writing to inform you that I have sampled your organization to be involved in this study. The survey requires the researcher to conduct interviews with key informants from all stakeholders of the Tsavo Conservation Area. The purpose of the study is purely academic, to enable me fulfill the requirements for the award of Masters of Science in Animal Health - University of Pretoria. The participation by Key informants is on volunteer basis and consent must be sought before conducting the interview. The findings will be shared with you upon approval by University of Pretoria.

Thank you in advance.

Yours faithfully

Dr. Jeremiah Poghon

Annexure 3: Written Permission to conduct Research

KENYA WILDLIFE SERVICE

ISO 9001:2008 Certified

Winner: COYA 2010 Awards in Corporate Citizenship & Environment, and Human Resource Management.

KWS/BRM/5001

27 May 2013

Dr. Jeremiah Poghon Kaitipok
Tsavo Conservation Area (TCA)
P.O.Box 14
VOI
e-mail: Poghon@kws.go.ke

Dear Dr. Poghon,

PERMISSION TO CONDUCT RESEARCH IN TSAVO CONSERVATION AREA (TCA)

We acknowledge receipt of your e-mail dated 24th May 2013 requesting for permission to conduct research on a project titled: '*Assessment of Socio-Economic Losses and Benefits of Human/Wildlife Conflicts in Tsavo Conservation Area, Kenya*'. The study will generate data and information that will assist in mitigation of human/wildlife conflicts in Tsavo Conservation Area.

You have been granted permission to conduct the study from **May 2013 to May 2014**. However, you will abide by the set KWS regulations and guideline regarding the conduct of research in and outside protected areas. You will also be required to work closely with our Senior Scientist in-charge of Tsavo Conservation Area (TCA), whom you will give a copy of the research proposal and progress report on the study.

You will submit a bound copy of your MSc thesis to the KWS Deputy Director, Biodiversity Research and Monitoring on completion of the study.

Yours Sincerely,

SAMUEL M. KASIKI, PhD, OGW
DEPUTY DIRECTOR
BIODIVERSITY RESEARCH AND MONITORING

Copy to:
- AD, TCA
- Senior Warden, Tsavo East N. Park
- Senior Warden, Tsavo West N. Park
- Senior Scientist, TCA

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Email: kws@kws.go.ke Website: www.kws.go.ke

Annexure 4: Statistician Commitment Letter

Center For Analytical
Research In Development

Centre for Analytical Research in Development (CARD)
P.O.BOX 00101-102468 | NAIROBI - KENYA
Tel: +254 910 367 | +254 737 211 514 | +254 755 148 019
E-mail:cardke@gmail.com | info@cardkenya.com
Website:www.cardkenya.com

30th May, 2013.

Dear Sir/Madam

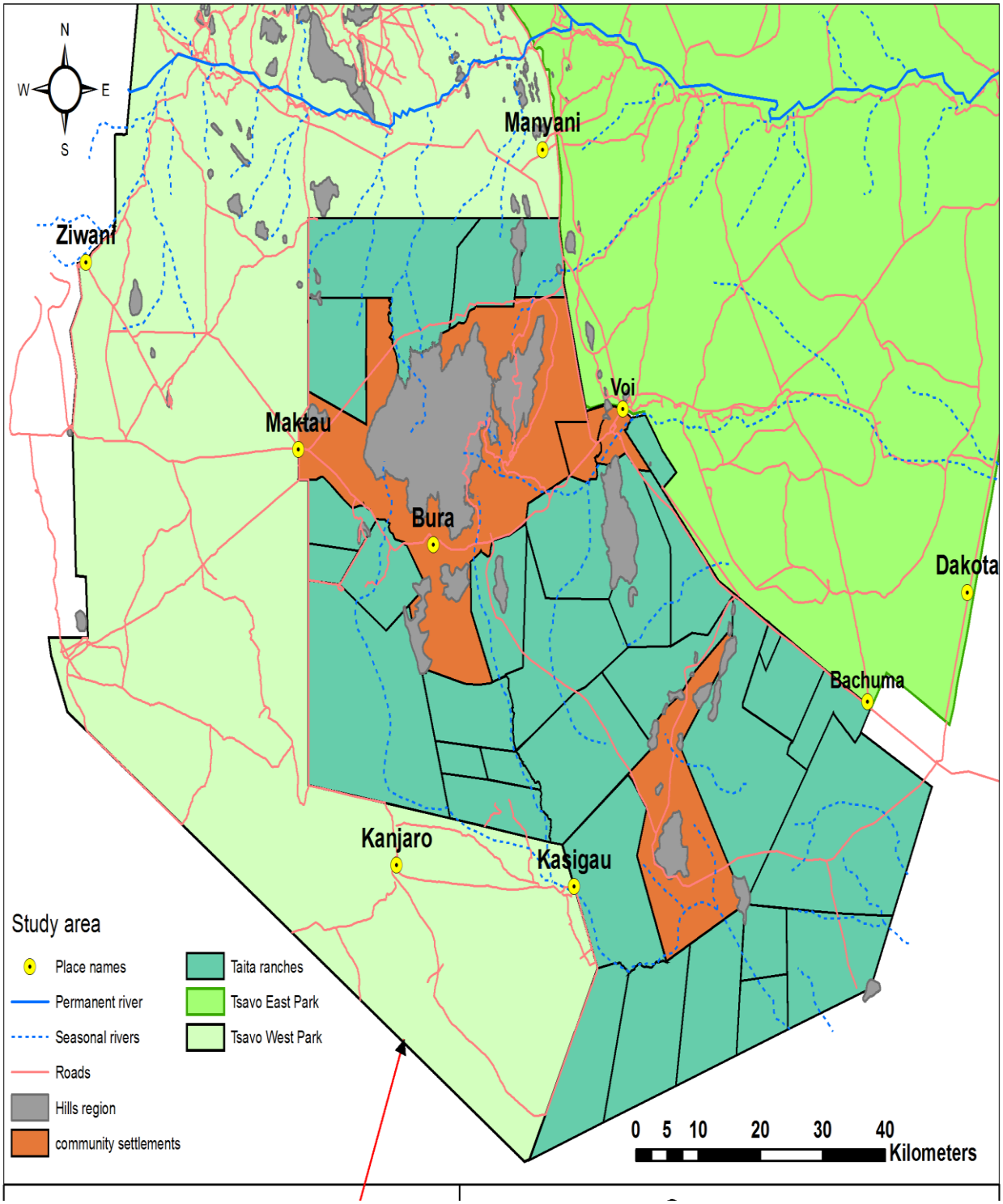
RE: CONSULTATIONS

This is to inform you that Dr. Jeremiah Poghon has sought assistance from me as the team leader in this company on his study design, sample size estimation, sampling techniques, data collection procedures and data analysis. I'm willing to continue giving him necessary support until his project is complete upon his request.

Yours Faithfully

Thomas Kimathi Nyaga

Annexure 5: Map of the Tsavo Conservation Area



Annexure 6: Data Extraction Form

Date	Month	Year	Problem	Crop	Acres	Yield	Value	Area	Sub-location