PREDICTING THE SPATIAL DETERMINANTS OF HUMAN–ELEPHANT CONFLICT IN HWANGE DISTRICT

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Abstract

This study predicted the spatial determinants of human-elephant conflict in Victoria Falls town, Hwange West communal area and the resettlement areas of Don Rovin, Mubiya and Kalala. The study covered an elephant range of 4377km². The non-experimental quantitative research design was adopted for the study. Garmin GPS receiver, digitizing and observation instruments were employed for collecting human-elephant conflict location data and spatial factors. Overlay analysis was used to combine human-elephant conflict location data with the distance maps of predictive spatial factors in ILWIS. Logistic regression was used to relate human-elephant conflict data and distance values of predictive factors in SPSS. In Victoria Falls town, results indicated that human-elephant conflict probability could be predicted significantly using distance from the park boundary and settlements. Distance from the forest and elephants routes significantly explained human-elephant conflict in the communal area of Hwange West. Human-elephant conflict was significantly related with distance from the forest in the Resettlement areas. These results suggest that the most important predictor of human-elephant conflict on this particular landscape is distance from protected areas. Implementation of effective conflict resolution strategies for the three areas requires stakeholders to take cognisance of the spatial factors which are related to human-elephant conflict. In Victoria Falls town, results imply that if elephants and humans are to co-exist with minimal conflict, there is need for land use planners to focus on developing mitigatory measures which deter elephants to move freely from the park to the residential areas. A deterrent method such as the installation of electric fence around Victoria Falls town has a great potential of preventing elephants from entering settlements and minimising human-elephant conflict. Such an approach is critical as results indicated that distance from the park boundary significantly predict human-elephant conflict in Victoria Falls town. Alternatively, town planners can consider vertical expansion of the built up area to prevent encroaching into the park. For Hwange communal and resettlement areas, land use planners should prevent settlement patterns that leave crop fields vulnerable to crop raiding. In Hwange communal area, planning the position of fences and other human-elephant conflict measures should consider the position of elephant routes. Alternatively, land use planners can consider allocating land to other uses besides settlements and agriculture. Integrating the spatial determinants of human-elephant conflict with land use planning has a great potential of offering permanent solutions to the conflict problem. Further research should be conducted on monitoring elephant movement patterns in the area using satellite linked GPS collars. This information can enhance our understanding of the routes used by elephants when they move around the settlements. This enhances our understanding of how elephants interact with spatial human land use and natural factors. Such information is crucial in designing effective human-elephant conflict resolution measures.
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Dedication

To my husband Walter and my three sons, Tavonga, Tatenda and Tinotenda
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CHAPTER 1

INTRODUCTION

1.0 Chapter introduction

This chapter presents the general introduction to the thesis. In this chapter the researcher articulates the background to human-elephant conflict issues in Zimbabwe and other Southern African countries. Major drivers of human-elephant conflict are thus revealed. The chapter also exposes the gap in knowledge. This is achieved by explaining how the spatial determinants of human-elephant conflict issues are little understood in human-elephant conflict zones in Zimbabwe, particularly Hwange. In this chapter, the major issues which motivated the study are revealed. Subsequently, the objectives, hypotheses, delimitations, ethical considerations and limitations of the study are some of the key issues highlighted in this chapter.

1.1 Background to the study

Conflict between humans and elephants is one of the greatest challenges currently facing biodiversity conservation. The conflict is a global problem and occurs in situations where agriculture and settlements are located close to elephant sanctuaries (Gandiwa, 2013). Human-elephant conflict refers to the interactions which lead to negative implications for human livelihoods and elephant conservation (Nyirenda et al., 2012). Interactions between humans and elephants become a conflict when people begin to experience negative effects, such as crop raiding, human injury or death or when elephant deaths occur as a result of poisoning and snaring.
In most cases, the conflict has been observed to occur where humans and elephants share the same territory, a scenario driven by the availability of a resource preferred by both species (Parks et al., 2007). Human-elephant conflict is prevalent in situations where elephants requirements overlap with those of human populations, leading to increased competition for resources. The conflict is a major cause for concern as elephants are protected and listed as endangered species under the Convention of International Trade in Endangered Species (CITES). A conflict which leads to elephant deaths attracts a lot of attention from conservationists. From a sociological and humanitarian perspective, elephants can be referred to as problem animals, if they attack and kill people.

The problem of human-elephant conflict has been observed to be prevalent in Africa and Asian countries where elephants are common. In Africa, human-elephant conflict has been reported in Eastern and Southern Africa, which are home to large elephant herds. Many countries in Southern Africa, particularly Zimbabwe, began experiencing the problem of human-elephant conflict when settlements and agricultural activities encroached into areas formerly reserved for wildlife. Initially, these areas were reserved for wildlife due to the harsh climatic conditions such as extreme temperatures and low rainfall activity which repel human settlements. The poor, shallow and fragile sandy soils also made these areas unattractive for settlements and agriculture. Some of the areas were also tsetse infested. For instance, the Zambezi valley in Zimbabwe was initially not conducive for settlements as it was infested by tsetse fly. However, the eradication of tsetse fly resulted in the expansion and encroachment of human settlements and agriculture in the areas formerly reserved for wildlife. Wildlife habitat was being converted into cotton fields (Sibanda and Murwira, 2012).
The same situation also applies to Hwange. Initially, the area was reserved for wildlife. A combination of factors such as extreme temperatures, low rainfall and the poor, shallow fragile Kalahari sandy soils made Hwange area unfavourable for agriculture and settlements. However, the presence of tourism in Victoria Falls and the employment and business opportunities offered by Hwange Colliery attracted people to settle in the area. The forests around the park were opened to pave way for settlements and infrastructure, such as residential areas, roads, power lines, several safari areas and hotels. This increased the spatial overlap between elephants and humans in the area.

The major drivers of human-elephant conflict are well understood as this area has been largely explored. These include human population growth, land use transformation into settlements and agriculture, habitat loss, habitat fragmentation and increase in elephant population. Perera (2009) perceives that lack of proper land use planning has resulted in a marked increase in competition between wildlife and humans for land, water resources and food. Prasad (2011) suggests that the interface between elephants and human activity develop from habitat fragmentation and demand for space and resources. Habitat fragmentation is one of the world's greatest threats to biodiversity. As human population centres expand, they fracture habitat into small patches or islands that may not be large enough to support viable populations of resident organisms. An increase in human population implies increase in demand for space and resources.
This encroachment has negative ecological implications, which include range reduction, increase in human wildlife conflict and species extinctions (Foley, 2002). Range reduction due to encroachment of human land use in elephant habitat is a serious issue in areas at the periphery of wildlife sanctuaries in many African countries (Hoare and Du Toit, 1999). Migration of elephants into human settlements is inevitable since the natural resources in the protected areas are inadequate for their survival. Elephants migrate to nearby human settlements to supplement their diet through feeding on crops. This interface of humans and elephants is sparking serious conflict at the periphery of many elephant sanctuaries (Foley, 2002).

In most cases, problem elephants retaliate to habitat loss and encroachment by extending their range into human settlements. This often sparks serious conflicts which include crop destruction and raiding of food stores. Damage to water infrastructure, destruction of fences, human deaths and injuries are among some of the serious conflicts that have been observed in settlements close to elephant sanctuaries (Hoare, 1999). Loss of elephant ranges increases the spatial overlap between humans and elephants, increasing the chances of crop raids (Hoare, 1999). In this regard, elephants are regarded as the greatest threat to food security as they can devastate a farmer’s annual food supply and supplementary income overnight.
The increase in elephant population is another notable driver of human-elephant conflict. Zimbabwe and other Southern African member states ratified the CITES which restricted trade of ivory and other elephant products. Conservation programmes such as CITES led to the successful recovery of elephant populations. The ratification of CITES in the mid 1980s outlawed culling. This resulted in a marked increase in elephant population (Child, 2004). The population of elephants began to increase after the trade ban and now populations have gone above the carrying capacity (Kusena, 2009). Elephants are increasing by 5% every year in Zimbabwe. It is estimated that elephant density is now 0.73 per square kilometre in the Zambezi Valley (Kusena, 2009). To date, the increase in the elephant population has resulted in human-elephant conflict and greater antagonism to wildlife among agricultural communities at the periphery of the park. Currently, Hwange National park hosts one of the highest densities of free ranging elephants in the Southern African Region (Guerbois et al., 2012). A fraction of elephant numbers compared to the other animals has generally been increasing over the years. In 2013 there were 20 375 elephants. The total number of other animals were 35 355. According to the 2013 count, elephants constitute 58% of the animals. This means that elephants have become the predominant species in Hwange National Park.

The greatest issue associated with the escalating elephant population is the increase in human-elephant conflict as the two species compete for space and resources. This results in resentment of elephants by local people, a scenario which greatly compromises local support for elephant conservation. Community based conservation programmes such as CAMPFIRE, have been implemented to ensure sustainable biodiversity conservation. The sustainability of the CAMPFIRE programmes is being threatened by increases in human-elephant conflict.
While the major drivers of human-elephant conflict and its associated negative socio-economic effects are well understood, the spatial determinants of human-elephant conflict remains little understood. Spatial determinants of human-elephant conflict have received little attention from previous studies in Zimbabwe. No previous study has been conducted in Hwange. This is despite the fact that the problem of human-elephant conflict has been observed to be increasing in Hwange. Hence the major issue which triggered this research was the marked increase in the reports of human-elephant conflict in the area. Reported negative ecological implications of human-elephant conflict include elephant deaths through road accidents, capture in snares, and retaliatory shooting and poisoning. In 2015, elephants died from poisoning in Hwange National Park. Such human induced mortality affects ecosystem equilibrium and biodiversity conservation.

Human-elephant conflict has also resulted in economic and social costs to humans in the communal areas surrounding Hwange National Park. These include destruction and damage to property and infrastructure, such as water installations, fencing, and pipes. Negative social effects of human-elephant conflict include crop destruction from fields, the raiding of grain stores, and loss of sleep, fear and restriction of travel. In addition to this, Moyana (2014) moved around different areas in Hwange and observed that elephants are becoming a threat to food security in most areas at the periphery of Hwange National Park. Hwange has become a hot spot for human-elephant conflict because of the rising elephant population. Some beneficiaries of the land reform programme are yet to benefit from the exercise following repeated invasion of their fields by elephants. Villagers in Rural Victoria Falls reported that the Ndlovu area was hard hit by elephants from the Fuller Forestry Concession.
Elephants coming from the National Park invade fields in areas along the Victoria Falls highway. These areas include Ndlovu, Monde and Mbizha. The increase in human-elephant conflict is likely to affect food security and increase resentment towards wildlife in the affected areas. Although a variety of approaches are being used to mitigate conflict in Hwange, little attention has been paid to proper spatial analysis of this conflict. This implies that the spatial patterns of human-elephant conflict are not understood. Previous researchers concentrated on understanding the socio-economic dynamics of human-elephant conflict interaction with very limited understanding of the spatial distribution of this conflict (Mutanga and Adjorloo, 2008). Most of these studies focused on socio-economic effects of elephants on human livelihoods. Such an approach has caused difficulties in providing effective conflict resolution measures, hence the need to map spatial factors related to the occurrences of this conflict.

Currently, the greatest dilemma in Hwange is developing management strategies that limit the interactions between human land use and elephants to prevent conflict. Faced with negative ecological and socio-economic effects of human-elephant conflict, the greatest dilemma is to provide strategies which ensure persistence of elephants in landscapes dominated by expanding human land use. This is because it is not possible to eliminate conflict by removing either humans or elephants from the landscape. The major challenge in Hwange so far is to develop elephant management options which encourage the co-existence of elephants and humans (Guerbois et al., 2012). The major dilemma is to design strategies that ensure sustainable management of elephants while ensuring that conflict are minimal (Newmark and Hough, 2000).
The major question for land use planners is: how can elephants and humans co-exist given the dilemma of increasing human-elephant conflict, increasing elephant numbers and expanding human land use? In a scenario like Hwange where there is human-elephant conflict, expanding human land use and escalating elephant numbers, there is need for researchers to establish the spatial determinants of human-elephant conflict and the distribution of human-elephant conflict hot spots. This might assist policy makers to design human-elephant conflict resolution measures which ensure co-existence of elephants and humans. This is because reducing elephant numbers is not an option as elephants are protected by CITES, which regard elephants as endangered species. The measures must be taken to mitigate the negative impact while maintaining co-existence of humans and elephants on the landscape (Kumar et al., 2011). Effective solutions to human-elephant conflict require an understanding of the interaction of human settlements, habitat remnants and conflict hot spots. Determining the influence of these environmental factors on the incidence of human-elephant conflict requires consideration of their relationship in space (Kumar et al., 2011).

Providing long lasting human-elephant conflict mitigation remains a challenge due to lack of appropriate predictive models which take into cognisance both environmental factors and human-elephant conflict. Geographic Information Systems (GIS) provides a means for modelling potential determinants of human-elephant conflict and the environmental variables (Prasad et al., 2011). Though the spatial capabilities of GIS offer valuable potential for wildlife management, the application of GIS in human-elephant conflict studies remains largely unexplored.
This study addressed this research gap through predicting the spatial determinants of human-elephant conflict in the areas such as Hwange communal area, Victoria Falls town and the resettlement areas. This was done so as to provide conflict resolution measures which are more spatially informed. Effective human-elephant conflict mitigation measures require an understanding of processes and patterns associated with human-elephant conflict incidences. In order to understand the causative underlying factors embedded in the resultant processes and patterns of human-elephant conflict, there is need to determine the predictors of human-elephant conflict (Nyirenda et al., 2012). This study, therefore, predicted determinants of human-elephant conflict to guide decision making in respect to human-elephant conflict intervention in Hwange which has become a hot spot for human-elephant conflict. The current study aims at answering the following question: Which spatial factors significantly predict human-elephant conflict in Hwange? Understanding the spatial determinants of human-elephant conflict can provide valuable information for effective management of the conflict between elephants and humans.

Human-elephant conflict is a spatial phenomenon and so it is important to investigate the effects of spatially explicit factors on its distribution. GIS plays an important role in the analysis of human-elephant conflict. The GIS system allows the integration and manipulation of a range of spatial data and can be used to predict the effects of human-elephant conflict management (Smith and Kasiki, 2011). Quantifying the extent of human-elephant conflict using the participatory GIS is an efficient way to model the spatial aspects of human-elephant conflict (Mutanga and Adjorloolo, 2008).
Knowledge gained from this research can be used by wildlife managers and land use planners in Victoria Falls and other human-elephant conflict zones in their effort to mitigate the issue of human-elephant conflict. Such an approach is critical as it ensures the co-existence of humans and elephants with minimal conflict. This implies that venturing into a research on human-elephant conflict was worthwhile as the study can act as a basis upon which solutions to human-elephant conflict problems can be developed. Minimizing human-elephant conflict is mandatory as it is a major threat to the future survival of elephants in human landscape where agriculture and settlements continue to encroach into elephant habitat. Human-elephant conflict also undermines the support for elephant conservation.

1.2 Statement of the problem

The major cause for concern is the increase in the reports on human-elephant conflict in Victoria Falls town, Hwange communal area and the resettlement areas of Don Rovin, Mubiya and Kalala. Elephant numbers have also escalated beyond carrying capacity in the national park. Settlements and agricultural activities encroached into protected areas after the 2000 land reform programme. The alternative to reduce human-elephant conflict is culling which is not acceptable as elephants are regarded as endangered species under CITES. Removing humans who have settled in the resettlement areas is not acceptable from a sociological and political perspective. In light of all these problems, the major question is: How can elephants and humans co-exist given the dilemma of expanding human land use, growing elephant densities and increasing human-elephant conflict? The answer may lie in predicting the spatial determinants of human-elephant conflict. Such information is critical as it assists land use planners in developing long lasting human-elephant conflict resolution strategies which ensure co-existence of elephants and humans with manageable conflict.
1.3 Aim of the study

The aim of this study was to predict the factors (artificial water sources, settlements, roads, buffer zones, fence, crop fields, and park boundary, forest, rivers, and elephants routes) which influence human-elephant conflict in Hwange.

1.4 Objectives of the study

The study sought to

- Predict the spatial determinants of the human-elephant conflict probability
- Identify human-elephant conflict hot spots in the area
- Identify the causes of human-elephant conflict
- Establish the temporal determinants of human-elephant conflict
- Assess the effectiveness of intervention methods used to minimize human-elephant conflict in Hwange

1.5.0 Significance of the study

1.5.1 Significance of study to land use planners

This research established the spatial factors which determine the occurrence of human-elephant conflict in Hwange District. Therefore, the research may convince land use planners, such as district administrators, Ministry of Lands and Rural Resettlement and Victoria Falls town planners, to allocate land for agriculture and settlements while taking cognisance of elephant conservation issues. Such an approach is necessary as Zimbabwe started experiencing human-elephant conflict when settlements and agriculture encroached into areas which were strictly reserved for elephants and other wildlife.
Land use planning is critical as it has been observed to offer the best chance of long term success. Unlike strategies for mitigation and protection, land use planning tackles the root cause of the problem. It is a preventative measure designed to alleviate human-elephant conflict by creating landscapes in which people and elephants can co-exist sustainably. This research also provided management strategies which ensure the continued existence of elephants in a landscape dominated by a mosaic of human land use. The study has the potential of assisting land use planners to integrate the plight of humans and elephant conservation so as to develop a framework within which elephants and humans can co-exist sustainably. In a context such as that of Hwange where the current paradigm for sustainable development is the establishment of mega parks, like the Kavango Zambezi Tranfrontier Conservation Area, understanding the interactions between communal lands and protected areas is crucial to designing management options that will ensure co-existence of humans and elephants (Guerbois et al. 2012).

1.5.2 Significance of study to Wildlife managers

The study has the potential of assisting elephant managers since it established the spatial determinants of human-elephant conflict in the area. Such information can be used by relevant stakeholders to develop effective long lasting human-elephant conflict resolutions like the installation of electric fences around the settlements. Solving human-elephant conflict issues can assist elephant managers in several ways. For instance, the installation of an electric fence around Victoria Falls can prevent elephants from entering residential areas. This can be an advantage to the park authorities who face the challenge of dealing with problem elephants. The challenges include capturing and transporting problem animals whenever they are spotted in human settlements.
Developing effective human-elephant conflict resolution strategies can reduce the costs incurred by park authorities in dealing with problem elephants. The burden of dealing with the problem animals which include time and resources spent on such activities are some of the potential benefits that effective conflict mitigation can offer to park authorities. Such knowledge is critical for elephant managers as failure to minimise human-elephant conflict create resentment and lack of support towards elephant conservation initiative.

1.5.3 Significance of study to Victoria Falls town community

This study provided human-elephant conflict resolution measures which can be implemented in Victoria Falls town. Such valuable information can benefit the community in several ways. During the survey the researcher observed that concerned stakeholders have focused on protecting critical areas such as Victoria Falls and Victoria Falls Airport, leaving out residential areas. The researcher also observed that the electric fence around Victoria Falls National Park does not cover the whole park. Some sections of the park are not fenced. Knowledge gained from this research has the great potential of convincing relevant stakeholders to consider protecting the whole town of Victoria Falls with an electric fence. This research has the potential of assisting policy makers to develop long lasting solutions to the problem of human-elephant conflict which are unique for Victoria Falls town. Such knowledge can act as a basis for the development of mitigatory strategies which are relevant to the study area.
Predicting spatial determinants of human-elephant conflict in Victoria Falls town is critical as it assists town planners to develop mitigation strategies which ensure the co-existence of elephants and humans. Developing effective human-elephant conflict mitigation strategies is critical for Victoria Falls as the town is situated in the middle of the national parks. Solving human-elephant conflict issues is crucial for Victoria Falls as it is one of the most visited tourist destinations in Zimbabwe. People are attracted by the majestic and magnificent Victoria Falls and the wildlife of the area. Failure to address the problem of human-elephant conflict can create a bad image for this most visited tourist destination in Zimbabwe.

1.5.4 Significance of study to Hwange communal areas

Knowing that forests and elephants routes are the spatial factors which influence human-elephant conflict in Hwange West communal areas is valuable information. People in Hwange communal area can benefit from the findings of this research in various ways. For instance, the research has a potential of convincing wildlife policy makers to include a provision for compensation for damage and loss caused by elephants and other wildlife. Such a policy addresses the plight of people in Hwange communal area whose crops are destroyed by elephants every year. Land use planning strategies which discourage sprouting of agricultural activities near large elephant sanctuaries are perceived to solve the issue of human-elephant conflict effectively. However, this tends to be a long term solution as the process may involve policy changes. The land use issue also depends on whether land use planners stop resettling people close to critical elephant conservation areas.
The study can be used as a basis for developing short term and long term solutions to the problem of human-elephant conflict in the communal area of Hwange West. This is because the study identified the significant spatial determinants of human-elephant conflict issues which are relevant to Hwange communal area. Such information is critical as it assists policy makers in developing unique strategies which the area can implement in resolving the problem of human-elephant conflict. Minimising human-elephant conflict can assure the co-existence of elephants and humans in the area. Addressing the human-elephant conflict issue also improves the support for elephant conservation initiatives by the local people.

1.5.5 Significance of study to Resettlement areas of Kalala, Don Rovin and Mubiya

The study has the great potential of assisting policy makers and the community to develop conflict resolution strategies which can encourage sustainable co-existence of elephants and humans in the resettlement areas. Providing sustainable solutions to the problem of human-elephant conflict is critical for the communities in the resettlement area. This is because the area is situated in the middle of protected areas. Human-elephant conflict resolution measures should not focus on chasing elephants away from this area. Rather, mitigatory measures should encourage people to stay with elephants since people were settled in a wetland which used to provide water and food resources for elephants. This implies that this research is critical as it provided possible solutions which might encourage humans and elephants to co-exist with minimum conflict. Human-elephant conflict resolution is crucial as it can improve local support for elephant conservation measures.
1.5.6 Academic fraternity

The findings and recommendations of this research have the potential of contributing to the existing body of knowledge on human-elephant conflict. It is hoped that the findings can convince researchers in ecology to carry out further research in this academic discourse. Spatial analysis of human-elephant conflict is a relatively new field of study in human-elephant conflict researches. This implies that there is not much that is known about the spatial factors which influence the occurrence of human-elephant conflict in many elephant sanctuaries of Zimbabwe. This research is important as it is the first to predict the spatial determinants of human-elephant conflict in Victoria Falls town.

This means that elsewhere, human-elephant conflict predictors were known while little was known about the same issue in the study area. The crucial knowledge gained from this research is that human-elephant conflict can be predicted reliably using distance from the park in the town of Victoria Falls. Such knowledge is critical as it assists stakeholders to come up with human-elephant conflict mitigation strategies which ensure co-existence of elephants and humans with minimal conflict. In addition to this, the knowledge can also inform land use planners to take the position of the park into cognisance whenever they are proposing to establish a new residential area. In other words there is need to carry out a thorough environmental impact assessment of proposed projects especially housing. This can inform property developers and town planners about all the possible negative consequences of horizontal expansion in the town of Victoria Falls which include elephant habitat loss, compression and range reduction.
For land use planners, knowledge gained from this research can convince them to adopt both the ecological and the socio-economic development vision when planning. Predicting the spatial determinants of human-elephant conflict has been done for the first time in the communal area of Hwange West. Knowledge gained from this study is that distance from factors, such as the forest and elephants routes are negatively related to the probability of human-elephant conflict occurrence in the area. This information is critical as it implies that land use planners such as the Ministry of Lands and Rural Resettlement should take into cognisance the location of any proposed development in relation to the position of the Fuller forest and elephant routes. In other words, the authorities who allocate land for various projects should have both the ecological vision (elephant conservation needs) and the socio-economic development needs.

Such an approach is necessary as it is the only effective way which lessens the problem of human-elephant conflict in the area. Planning that takes into consideration conservation issues is the only effective long term solution to human-elephant conflict issues. Establishing the significant factors which explain human-elephant conflict probability has also been done for the first time since the resettlement area was established in 2000. The knowledge gained from this research is that it has identified the factors which explain human-elephant conflict for the first time. In this case the distance from the forest has been identified to be the significant human-elephant conflict predictor. The knowledge gained assists land use planners to develop human-elephant conflict mitigation measures which effectively address the issues of human-elephant conflict.
Knowledge gained from this research has a potential of informing decision makers in developing human-elephant conflict mitigatory strategies for the study areas. This is because spatial predictors of human-elephant conflict remain little understood. Previous research concentrated on addressing the negative socio-economic concerns associated with human-elephant conflict. The motives behind such research were to develop strategies of preventing elephants from entering fields and human settlements. However, human-elephant conflict continues to be a major issue in communities close to parks despite all the attempted mitigation measures, implying that there is need to tackle the root cause of human-elephant conflict which is land use planning.

Hence by unearthing the spatial predictors of human-elephant conflict, the research greatly contributed to existing knowledge on human-elephant conflict, where researchers focused on the negative implications of elephants on human livelihoods and food security, typology of human-elephant conflict as well as causes and consequences of the interactions between humans and elephants. Other areas experiencing the human-elephant conflict issue outside Zimbabwe can also apply the logistic regression models developed in the current research for human-elephant conflict research.
1.5.7 Significance of the study for elephant ecologists and conservationists

Determining the spatial predictors of human-elephant conflict is critical as it can provide long term mitigation measures. Providing solutions to human-elephant conflict is crucial from a conservation perspective as human-elephant conflict influences the attitudes of people living near protected areas. This is because most human-elephant conflict incidents involve crop raiding and human injuries or death. These communities often resent the presence of elephants and this affects elephant conservation initiatives. Providing effective human-elephant conflict solutions is critical as it improves local support to elephant conservation initiatives. Elephant conservation is crucial as elephants are listed as one of the endangered species and should be given priority when it comes to conservation.

They are protected by the CITES international law which prohibits international trade in ivory products. Spatial analysis of human-elephant conflict is critical as it might lead to the development of strategies which ensure co-existence of humans and elephants. The study suggested solutions which might minimise human-elephant conflict. Minimising human-elephant conflict is crucial as it enhances acceptance of elephant conservation initiatives. Elephant conservation is essential as the elephants play an important role in the tourism industry in Zimbabwe. The benefits of having elephants include game viewing, international sport hunting, elephant hides, meat and ivory. Tourism generates foreign currency earnings as well as income in households through ecotourism.
1.6 Delimitations of the study

The study focused on human-elephant conflict only, not any other human wildlife conflict. The justification for this is that elephants have been reported as the major problem animals in the area. This compelled the researcher to focus on human-elephant conflict, only not any other types of human-wildlife conflict. The focus of this study was also on the spatial scope of the environmental determinants of human-elephant conflict and other parameters. This is because little knowledge on the spatial patterns of human-elephant conflict. The study was conducted in the district of Hwange. The area covered included Victoria Falls town, Hwange communal areas and the Resettlement areas (figure 1). The study area is located at latitude 18° 25S and longitude 26° 18E.

Figure 1 Location of the study area in Hwange district, Zimbabwe
Victoria Falls town is located 435km from Bulawayo. The town of Victoria Falls is situated in Hwange District. As shown in figure 1, the town of Victoria Falls is situated in the middle of the Zambezi and Victoria Falls national parks. The resettlement areas are located 30km from the town of Victoria Falls. People were resettled here under the land reform programme of 2000. The resettlement areas constitute areas like Don Rovin, Mubiya, Masikiri and Kalala. The resettlement area is situated in the middle of the Fuller Forest Concession and the national park. Hwange communal area is about 40 km from the town of Victoria Falls. Hwange communal area includes the Mvutu, Ndlovu, Chidobe, Chenamisa and Chikandakubi villages.

1.7 Climate, geology and vegetation of Victoria Falls

The study area is characterized by hot wet summers which begin from November-March. Low annual rainfall that averages around 500mm or less is received in the area. The low rainfall received in the area makes surface water a scarce resource. The summer months are hot and temperatures average between 32 and 34°C. The winter months of Hwange area are cool and dry. Winter temperatures average between 25 and 27°C during the day. During the winter nights temperatures can fall between 7 and 10°C. The geology of the area constitutes the shallow stony basaltic soils and the red Kalahari sandy soils. The geology and the climate of the area greatly influence the type of vegetation found in the area. Baikiaea plurijuga and burkea Africana is found in the areas which are dominated by the well drained Kalahari soil type. The shallow stone basaltic soils are characterized by mopane and acacia woodlands. Riparian woodlands characterize the Zambezi River and a few streams found in the area.
1.8.0 Limitations of the study

Every research has some imperfections which can impair the quality of the method and data gathered resulting in the weakening of the conclusions and recommendations (Umaru, 2008). There were also notable limitations encountered during this research. Some limitations were methodological, implying that the limitations were to do with data collection instruments. Challenges encountered during the process of data collection are among the limitations noted during the research. However, the researcher anticipated all the limitations and challenges prior to data collection and analysis. In this case the researcher came up with ways of countering and addressing every limitation anticipated. This was done in order to ensure reliability and validity of the data collected and conclusions made. The different limitations encountered during the research are explained in greater detail below.

1.8.1 Limitations of the research design and methodology

The non-experimental research design used in this study has its own limitations. The major limitation of this type of design is that the independent variables cannot be manipulated. Randomization of variables is also impossible, making evidence gathered weaker and limited (Creswell, 2008). The non-experimental research has limitations in studying cause and effect compared to strong experimental research. The conclusions of cause and effect are weaker in non-experimental research compared to pure experimental research. In non-experimental research, one cannot be certain that outcome differences are due to the independent variables under investigation. This limitation did not apply to the current study as it was not assessing the cause and effect relationship.
The other limitation of the non-experimental quantitative design is that quantitative experiments can be difficult and expensive and require a lot of time to perform. The quantitative experiments must be carefully planned to ensure randomization and correct designation of control groups (Shuttleworth, 2008). This study adopted the non-experimental research design which does not require the afore mentioned treatment and control groups. Another limitation of the design is that quantitative data collected from quantitative designs require extensive statistical analysis which can be difficult for scientists who are not statisticians. To overcome this shortfall, the researcher was conversant with all the statistical tools which were used for data analysis and data collection for this particular research.

1.8.2.0 Limitations of the data collection instruments

The instruments used for data collection had their own limitations. The major limitation of using these instruments was that they were technical and required an expert to use them so as to ensure data reliability. There was need for the researcher to be conversant with the procedures related to the processes of data collection. This is because data collection procedures were predetermined since the research was guided by the quantitative ideologies. The following section describes the major limitations of instruments and the ways which were used to counter the limitations.
1.8.2.1 Limitations of the digitizing instrument

The major limitation of digitizing is that it requires an expert who is trained to use the instrument. This is because there is need for extensive checking and correcting to produce a reliable product. The quality of the data depends on the age and resolution of the maps used. Validating digital maps requires extensive ground truthing. The errors should be reduced by using the best data sources and trained personnel to collect and process this information. This limitation was overcome by the fact that the researcher has experience in using the digitizing instrument for visual interpretation and digitizing land uses from satellite images available in Google earth. Ground truthing was done to validate the digitized images and to verify the mapped unit attributes or the correctness of desk top visual interpretation as suggested by Kusena (2009). The main purpose of ground truthing was to verify the digitized classes against the ground scenario.

1.8.2.2 Limitations of the GPS instrument

The use of GPS in data collection has its limitations. It is impossible to produce error free spatial data. Errors occur when measuring geographical location which depends on the accuracy of the instruments used and surveying skills of the people involved (Smith and Kasiki, 2000). This limitation was not applicable to the researcher as she has the skills of using the GPS. During data collection the researcher recorded the coordinates of features when the GPS error was less than 10 metres to ensure accuracy of the data. The GPS equipment was also tested before the day of the survey to make sure that it was in good working condition. The GPS equipment was also set properly prior to the survey day.
1.8.3 Accessibility challenges

Accessibility challenges were some of the limitations encountered during the study. Major accessibility challenges were faced during data collection in the communal areas and the resettlement areas. Some conflict sites were located in the middle of thick forests. This made it difficult for the researcher to access such areas. The researcher addressed this challenge by getting close to the site and estimating the location of the conflict sites in UTM coordinates. Some conflict sites were not accessible by the vehicle since the vehicle had difficulties travelling on the loose kalahari sand roads in the communities. In most cases the car was skidding on the loose kalahari sands.

To overcome this challenge, the researcher parked the vehicle and walked to the human-elephant conflict sites to record the coordinates. Walking was not also easy on the loose kalahari sands. The unbearable high temperatures of the area made the task of walking very difficult. In the resettlement area, the road between Don Rovin and Kalala resettlement areas was in a bad state. The soil on the road was wet and slippery making it difficult to travel by car. This is because the study was conducted during the rainy season. To overcome this challenge, the researcher left the car on the sections of the road which were accessible and walked to the human-elephant conflict sites. One of the challenges experienced in Hwange communal area was that villages were further apart. The communal area covers a large area and this made it impossible to travel on foot from one village to the other. To overcome this a vehicle was used to travel from one village to the other. The researcher would then walk to the conflict sites to record the coordinates and take photos if there was any evidence of human-elephant conflict available.
1.8.4 Risk associated with encountering dangerous wild animals

The risk of encountering dangerous wild animals such as elephants, hyenas, leopards and lions during the survey was high. This is because Hwange is a wildlife area where animals range freely any time around the settlements and the protected areas. In most situations the researcher visited the sites where some of the serious human-elephant conflict such as elephants induced human injury or death had occurred. This was very risky as the chances of encountering dangerous elephants in these areas were high. To overcome this challenge, the researcher travelled during the day and went to the conflict sites during the day. This is because the wild animals hide in the parks and forests during the day and come to the human settlements during the night. The research assistant who was accompanying the researcher is also experienced in walking in the bush and interacting with wild animals.

1.8.5 Language barrier

Language barrier was another challenge experienced by the researcher during the process of data collection. Though the process of data collection did not require a lot of interaction with the community members, the major challenge was experienced during the process of verifying the historical records of human-elephant conflict occurrence with community members. The challenge of language was encountered in the communal areas of Hwange West and the Resettlement areas. The researcher was not conversant with the Nambya and Tonga languages spoken in the study areas. This limitation was anticipated by the researcher prior to the process of data collection. Hence in choosing a research assistant who showed the researcher areas where human-elephant conflict incidents had occurred, the language issue was considered. In this case the researcher chose a person who was conversant with the languages spoken in the study area.
This was done to counter the limitation of language barrier as the research assistant assisted with interpretation when it was required during the process of data collection.

1.9 Ethical considerations

Ethics are guiding principles that ensure that the participant in the research process is protected. Umaru (2009) suggests that every research, be it surveys, documentary, or interviews, give rise to a range of ethical issues around privacy, informed consent, anonymity, secrecy, being truthful and the desirability of research. Umaru (2009) further emphasizes that the researcher should be aware of the issues and how he / she might respond to the challenges they pose for his / her research. For this research, a number of ethical issues were considered during data collection and analysis. These ethical issues are discussed in greater detail in chapter 3.

1.10 Definition of terms

Spatial determinants of human-elephant conflict—these are factors which influence the occurrence of human-elephant conflict. These include artificial water sources, settlements, roads, buffer zones, fence, crop fields, park boundary, forest, rivers, and elephant routes. These spatial factors are also referred to as predictive factors in this research since they were used to predict the probability of human-elephant conflict

Spatial data— it is data that contains positional values or data that is geo-referenced.

Predicting spatial determinants of human-elephant conflict probability—this means estimating the spatial factors (artificial water sources, settlements, roads, buffer zones, fence, crop fields, and park boundary, forest, rivers, and elephants routes) which determine the likelihood of the occurrence of human-elephant conflict in the study areas
**Human-elephant conflict** – this refers to the interactions between humans and elephants which lead to negative implications for human livelihoods and elephants.

1.11 Chapter summary

Chapter one presented the general introduction to the thesis. Specifically, the chapter highlighted the major issue which motivated the researcher to embark on the current research. The main issue which triggered the study was explored. The chapter began by exploring the background to the issue of human-elephant conflict and explaining how human-elephant conflict started in Zimbabwe. The major drivers of human-elephant conflict were thus revealed. Key drivers of human-elephant conflict discussed in chapter one include the increase of human population, encroachment of human land use into elephant reserves and the increase in elephant population. The unresolved issues from previous human-elephant conflict studies were thus revealed. The previous researches concentrated on assessing the socio-economic concerns of elephants on the livelihoods of people living in proximity to elephant sanctuaries. This was prompted by the increase in various manifestations of human-elephant conflict near elephant sanctuaries.

The fact that human-elephant conflict continues to be an issue implies that there is need to tackle the root cause of the problem which is land use planning. However, land use planners require relevant scientific evidence to convince them to consider elephant conservation issues as well as the socio-economic concerns of people settled close to elephant sanctuaries. Hence the current study predicted the spatial determinants of human-elephant conflict using GIS techniques.
Predicting spatial determinants of human-elephant conflict is critical as it informs land use planners and other relevant stakeholders on the effective human-elephant conflict mitigation strategies which best suit the area. Statement of the problem, hypothesis, aim and objectives of the study are some of the key issues discussed in chapter one. The significance of the study to elephants policy makers, the community, the academic fraternity, land use planners and elephants conservation are among key issues which were covered in chapter one. The chapter also described the scope of the study, major limitations encountered during the study and how the researcher overcame these challenges. Subsequently, ethical issues, and definition of terms are among the key issues highlighted in this chapter.
CHAPTER 2

REVIEW OF RELATED LITERATURE

2.0 Chapter introduction

Chapter 2 identifies, evaluates and interprets the existing body of recorded work produced by previous researchers, scholars and practitioners on human-elephant conflict. The chapter presents major research on human-elephant conflict and how they have failed to offer solutions to the problem of human-elephant conflict. Apart from recognising and acknowledging what other researchers have done in the past, the chapter provides a critical review of the existing work, highlighting the gaps in knowledge that have been filled by the current study. The chapter begins by presenting the conceptual framework guiding the research. This is followed by the description of the theoretical framework for the study. This chapter also explores previous empirical human-elephant conflict literature.

The empirical literature is reviewed based upon the specific objectives of the study. The gaps existing in these previous studies which the current study filled are finally revealed, justifying why it was necessary to carry out a study on human-elephant conflict in Hwange. As highlighted in chapter one, the major issue which needs to be solved by the current research is human-elephant conflict. Human-elephant conflict continues to be a major issue in Southern Africa, particularly, Zimbabwe. This is despite the fact that several researches on human-elephant conflict are published each year by sociologists and ecologists.
The prevalence of human-elephant conflict in communal areas close to elephant sanctuaries makes the approaches used by previous researchers to address the issue of human-elephant conflict questionable. This is because solutions to problems pestering human lives are expected to come from researchers. However, if a particular issue continues to persist despite volumes of publications, there might be a possibility of a missing link in the way the problem is being dealt with. In such a scenario the best solution is to change the previous approaches and adopt strategies which are perceived to offer effective solutions to the prevailing problems. This chapter, therefore, explores the previous studies on human-elephant conflict and how they have failed to offer solutions to the conflict issue. This is done to show the extent to which the current study contributed to the existing body of knowledge.

2.1 Conceptual framework

The main concepts guiding the research are depicted in figure 2. These concepts include human-elephant co-existence, increasing human population, increasing elephant population and the resultant human-elephant conflict. Figure 2 illustrates the resultant conflict which occurs when elephants and humans co-exist.
As illustrated in figure 2, if humans and elephants co-exist, increases in either human or elephant population results in the compression of the elephants range. In such a scenario, elephants often retaliate by extending their home ranges into human settlements, sparking serious conflict such as human deaths and injuries, crop raids, and destruction of homes and fences (Kusena, 2009). The persistence of the problem of human-elephant conflict in areas like Hwange is undermining the successful conservation programmes, such as CAMPFIRE (Hill et al., 2002).
2.2 Theoretical Framework: Community Based Natural Resources Management

Theoretical framework is a collection of interrelated concepts guiding research. It can also be referred to as a collection of ideas that influences one’s thinking (Kurasha, 2013). The ideas which influence the current research are guided by the Community Based Natural Resources Management (CBNRM), which is the overarching theoretical framework. The key concepts which are integrated by the CBNRM theory are humans and elephants. The CBNRM theory prioritises elephant conservation needs in the protected areas as well as the socio-economic development needs of the people residing at the periphery of the protected areas.

The rationale for choosing the CBNRM theory is that it is a critical approach in addressing human-elephant conflict issues as it ensures sustainable co-existence of elephants and humans in situations where a mosaic of human land use is located close to the parks (Brandon and Wells, 1992). In Zimbabwe, the CBNRM theoretical framework such as Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) was introduced after realizing that co-existence between humans and elephant was inevitable. CAMPFIRE was regarded as one of the ways to ensure that there is no conflict between the economic survival of agricultural communities and foraging needs of elephants (Gandiwa et al., 2013). CAMPFIRE emphasised the need to ensure the involvement and participation of local people in biodiversity conservation in protected areas. Sustainable development practices of CAMPFIRE focused on the provision of direct incentives for conservation of biodiversity through the harvest of plant or animal recourses. CAMPFIRE was launched as one of the key initiatives adopted to ensure that there was no conflict between the needs of people and those of elephants. The CAMPFIRE concept was successful since it created opportunities for employment and infrastructural development.
The increases in human-elephant conflict in many protected areas of Zimbabwe have undermined the sustainability of the CAMPFIRE programme. This situation has been worsened by the fact that the wildlife policy does not have provisions for compensation for lose and damage caused by elephants (Gandiwa, 2013). In Zimbabwe, studies done around CAMPFIRE areas focused on the social effects of elephants on humans owing to the increase of human-elephant conflict. Such solutions have been in vain as the problems of human-elephant conflict remain a major cause for concern in many communal areas at the periphery of elephant conservation areas. The current study proposes that researchers should divert their attention from considering the social template only and adopt an integrated conservation and development approach which takes both the ecological template and the social template into cognisance.

However, studies done around CAMPFIRE have not contributed much in terms of offering solutions to human-elephant conflict as they focused on assessing the attitudes of communal people towards such projects. The researchers were also trying to convince communal people to accept elephants since they would reap benefits accrued from trophy hunting. Hence if CAMPFIRE projects are to be sustainable, researchers must focus more on venturing into studies on predicting the spatial determinants of human-elephant conflict so as to establish the spatial distribution of human-elephant conflict hot spots. Such studies are crucial as they provide management options which encourage the co-existence between humans and elephants.
Failure to address the issue of human-elephant conflict might also affect the sustainability of Trans Frontier Conservation Area (TFCA), such as Kavango-Zambezi. TFCA is defined in the SADC Protocol on Elephants Conservation and Law Enforcement (1999) as a component of a large ecological region that straddles the boundaries of two or more countries encompassing one or more protected areas as well as multiple resource use areas. TFCAs are founded with the aim of collaboratively managing shared natural and cultural resources across international boundaries for improved biodiversity conservation and socio-economic development. As observed by Cumming (2008), The Kavango-Zambezi, also known as the KAZA Trans Frontier Conservation area, is the world’s largest Trans Frontier conservation area.

The size of the park is approximately 400 000km$^2$. The KAZA Park occupies the Okavango and Zambezi River basins and consists of the areas within the borders of Angola, Botswana, Namibia and Zambia and Zimbabwe. The KAZA Trans Frontier Park consists of game reserves, forest reserves, game management areas and conservation and tourist resort areas. The area consists of parks such as the Hwange National Park, Botswana National Park, Chobe National Park, Okavango delta and the Victoria Falls. The KAZA TFCA is critical for Zimbabwe as Hwange National Park is among the parks that are situated in this large conservation area (figure 3).
The TFCA is home to approximately 1.5 million people, whose livelihoods include pastoralist, hunting, fishing, growing crops and employment in the tourism sector. Under the TFCA, the local people were not resettled outside the boundary of the park, but remained encompassed within the park with the aim of improving the socio-economic conditions of the people infrastructural development and employment in tourism areas. KAZA has approximately 250000 elephants. About 76% of the KAZA TFCA area is made up of communal land. Only 22% of the KAZA TFCA falls within unsettled protected area. Cumming (2008) proposes that there is need to address human-elephant conflict as well as ensuring the provision of benefits to communities located in the KAZA-TFCA.
This also decreases the rate at which natural habitats are opened up to pave way for agriculture and human settlements. Expansion and encroachment of human land use into elephant habitat may fragment the protected area which will be transformed into ecological islands (Cumming, 2008). The sustainability of such large parks relies on the possibility of co-existence between humans and elephants. Guerbois, et al. (2012) also emphasised that understanding the interactions between communal lands and protected areas is crucial to designing management efforts which encourage human-elephant co-existence. It is therefore critical for researchers in different conservation areas to venture into studies which ensure the persistence of elephants in a mosaic of human land use. This may be possible through venturing into studies on predicting the spatial determinants of human-elephant conflict.

2.3.0 EMPIRICAL LITERATURE

This section reviews previous literature related to the current study. The literature is reviewed based upon each of the specific objectives of the study which include identifying the causes of human-elephant conflict, predicting the spatial determinants of the probability of human-elephant conflict, identifying intervention methods used to minimise human-elephant conflict and suggesting management options which ensure co-existence of humans and elephants with minimal conflict. After reviewing literature, there is a section that depicts a gap in knowledge. In this section, all the gaps in knowledge existing in previous literature for each of the objectives are thus revealed.
2.3.1.0 CAUSES OF HUMAN-ELEPHANT CONFLICT

The causes of human-elephant conflict are well known as this area was largely researched. However, little is known about the causes of human-elephant conflict in the area of Victoria Falls and Hwange West communal land. This implies that in other human-elephant conflict zones, human-elephant conflict causes are well known while there is not much that has been done to establish the causes of conflict in the area under study. This section, therefore, explores the causes of human-elephant conflict based upon previous findings. The gaps in knowledge existing in these previous studies are explained in greater detail in section 2.4.1.

Parker et al. (2007) suggested there are two categories of the causes of human-elephant conflict. These are direct and indirect conflict. Direct human-elephant conflict refers to the negative socio-economic effects of elephants on the livelihoods of communities. These include, damage to crops, livestock, property as well as human deaths and injuries (Parker et al., 2007). Indirect human-elephant conflict is psychological. It does not involve damage to property, crop destruction or human deaths and injuries. Indirect conflict refers to the fear of elephants experienced by people living close to protected areas. These fears hinder normal activities, such as walking during the night, collecting firewood, bathing, gathering fruits, hunting, fetching water, school attendance and work attendance. Indirect conflicts are also experienced when people spent most of their times guarding crops and protecting property. The following section describes the different causes of human-elephant conflict.
2.3.1.1 Crop damage and food insecurity

Crop raiding is one of the leading causes of conflict between farmers and elephants throughout the African continent. Crop raiding has serious repercussions to the livelihood of the farmer as elephants usually target staple food crops such as maize and cash crops. Large elephant herds are also capable of destroying large crop fields over night. Crop destruction is a major cause for concern as it results in food insecurity, hunger and starvation, malnutrition and kwashiorkor (Parker, 2007). In Zimbabwe, elephants are estimated to be responsible for up to three-quarters of all crop damage caused by elephants (Muruthi, 2005 in Perera, 2009). In the area around the Kakum National Park in Ghana, 80 to 90 percent of crop-raiding is attributed to elephants (Osborn and Parker, 2002). In the Luangwa Valley in Zambia, elephants destroyed stores of the fruits which had been collected by the farmers to supplement their diet.

The adult male elephants are the major crop destroyers because they can enter human settlements without much fear (Parker, 2007). This is different from female elephants which tend to avoid human settlements. Elephants raid food stores (Perera, 2009). Raiding of food stores by elephants has been observed to occur after the period of harvesting. The loss of this stored food is considered far more disruptive to farmers than the raiding of crops while they are still growing in the fields (Larmaque, 2009). This is because it is difficult to replace a food store. Damage to field crops can be negated by planting replacements especially if the damage occurs early in the growing season. Food stores cannot be replaced until the following growing season (Parker, 2007). Larmaque (2009) further suggests that the consequences of the human-elephant conflict are more serious in the developing countries where livestock holdings and agriculture are the main sources of rural people’s livelihood and income.
2.3.1.2 Human deaths and injuries

Human deaths and injuries are among the most serious manifestations of human-elephant conflict in the Southern part of Africa. The attacks usually take place during the night. Most of the victims are men who will be coming from beer drinking. Some incidents also occur while guarding crops, herding cattle and walking at night (Parker, 2007). Perera (2009) also noted that human deaths and injuries are the most severe manifestations of human-elephant conflict. As observed by Larmaque (2009), injuries to people mostly occur as a result of chance encounters with elephants, usually along paths between dwellings. Different phases of reproduction also modify the behaviour of male elephants. During the rutting or musth period, plasma testosterone levels increase. This in turn results in increased aggression towards other elephants and humans (Larmaque, 2009). The aggressive behaviour can cause elephants to attack, injure or kill people. Nursing female elephants become aggressive in the presence of youngsters and can even attack humans. The danger of elephant attacks is that they restrict some activities considered at risk, such as walking at night, guarding crops and bathing (Larmaque, 2009).

2.3.1.3 Elephant damage to property

Elephants have been observed to destroy infrastructure, such as fencing and water installations. The unavailability of surface water makes elephants destroy water installations in search of water. As observed by Parker (2007), water installations were repeatedly destroyed by elephants in search of water in Chobe National Park. These incidents were recorded during the dry season when water is scarce. This eventually led to the abandonment of the tourist camp site (Parker, 2007). Elephants have also been reported to kill livestock.
In the Zambezi valley, cattle were killed close to water sources during the night. In Kenya elephants have been reported to kill and chase cattle.

### 2.3.1.4 Fear of death and injuries

As suggested by Parker (2007), indirect human-elephant conflict includes humans fearing to come into direct contact with the elephants. Fear of elephants disturbs activities, such as gathering wild fruits, fetching water, bathing, school and work attendance. In the Zambezi valley, elephants feeding on fruits caused fear among communities nearby. Loss of sleep is one of the indirect effects of human-elephant conflict. During the cropping season people spent more time guarding crops to prevent elephants raiding. This leaves farmers with very limited time for sleeping. Guarding the fields also wastes time that would have been spent on other activities. Guarding also exposes farmers to the risk of contracting malaria. The indirect forms of conflict significantly impact upon people’s lives as fear of elephants causes psychological stress (Parker, 2007).

### 2.3.1.5 Politics and media

Human-elephant conflict also attracts political attention. In most cases, the affected communities expect authorities to compensate them for the damage and lose caused by elephants. Failure to compensate communities for the damage induced by elephants usually causes people to resent elephants (Larmaque, 2009). Human-elephant conflict becomes sensitive from a political perspective when the government fails to offer compensation.
Failure to address conflict between humans and elephants make people feel neglected and resent those who represent them in parliament.

2.3.1.6 Elephant conservation

Human-elephant conflict has negative effects on elephant conservation (Larmaque, 2009). When elephants destroy crops, injure or kill people, communities usually retaliate by poisoning and illegally hunting elephants. Such practices are not acceptable as elephants are legally protected by CITES. Elephants are regarded as endangered species under CITES. Retaliatory killing of elephants can lead imprisonment. In this regard, people can resent elephants and fail to support elephant conservation initiatives. In addition to this, conflict can also result in antagonism between communities near elephant sanctuaries and wildlife managers.

2.3.2.0 POTENTIAL DETERMINANTS OF HUMAN-ELEPHANT CONFLICT

A lot of research has been carried to assess the potential factors which influence the occurrence of human-elephant conflict. While other potential determinants of human-elephants are well understood, much has not been done to assess the spatial factors which influence human-elephant conflict occurrence. This section, therefore, examines previous literature on potential factors which influence human-elephant conflict. The major gaps existing in these previous studies are explained in greater detail in section 2.4.2. The occurrence of human-elephant conflict is influenced by a variety of factors (Parker et al., 2007). The occurrence of human-elephant conflict varies spatially and temporally. Other factors also influence the occurrence of human-elephant conflict besides temporal and spatial factors. The following section describes the determinants of human-elephant conflict based upon previous findings.
2.3.2.1 Crop cultivation and water points

The presence of water and crop cultivation is the key determinants of human-elephant conflict in most areas in proximity to protected areas. Kumar *et al.* (2011) predicted the spatial determinants of human-elephant conflict in Valparai India. Results indicated that human-elephant conflict could be predicted reliably using crop cultivation. Elephants are usually attracted by food crops which are more palatable. The presence of water points have also been regarded as significant human-elephant conflict predictors. Such situations have mainly been observed in dry areas where water scarcity forces people and elephants to compete for water.

Parker (2007) noted that crop raiding incidents are more prevalent close to water sources. Elephants opportunistically raid crops when they come to drink water from nearby rivers or dams. Smith *et al.* (2000) carried out a spatial analysis of human-elephant conflict in Kenya and observed that human-elephant conflict takes place wherever humans and elephants compete for similar resources. Crop damage has been observed around water points in Taita-Taveta and close to water points in Zimbabwe’s Mid-Zambezi Valley. Elephants are highly water-dependent and where water is limited the potential for conflict is high (Parker et al., 2007). In Namibia’s Kunene Province elephants regularly damage water installations. In northern Kenya elephants may become aggressive at water sources and have been known to chase and even kill livestock attempting to reach the water.
2.3.2.2 Distance from protected areas

Distance from protected areas was identified as one of the spatial factors which influence human-elephant conflict (Smith and Kasiki, 2000). The chances of human-elephant conflict incidents are higher close to the boundary of the protected areas. This implies that human-elephant conflict incidents decrease with increasing distance from the boundaries of protected areas. Elephants usually raid crops from fields located close to the boundary of the park. High canopy densities near protected areas provide a cover which makes it difficult to detect elephants (Parker, 2007). Elephants prefer to raid crops near the park boundary and shun going deeper into communities for fear of victimisation. During the day elephants use protected areas as refugees. When night falls they move from the parks to nearby communities and raid crops. In worst case scenarios, elephants hide in the bushes and attack unsuspecting people.

2.3.2.3 Distance from forest and settlements

Human-elephant conflict vulnerability is greatly influenced by forests and the presence of settlements. Prasad (2011) predicted the determinants of human-elephant conflict in Western Ghats, India. Results indicated that distance to forests and settlements were significant human-elephant conflict predictors across the landscape.
2.3.2.4 Vegetation type

Vegetation type influences human-elephant conflict occurrence. This is because elephants have certain preferences to certain types of vegetation. Nyirenda et al.’s (2012) study examined the environmental factors which influence crop raiding in Luangwa valley, Zambia. Results indicated that vegetation type at the periphery of fields was one of the major influences of crop raiding incidents. Similar observations were noted in mid Zambezi valley where elephants were attracted to the area by the masawu fruit. Elephants opportunistically raided vegetable gardens when they came to enjoy the masawu fruit. The same situation was observed by Parker et al. (2007) in the forests of Cameroon. The secondary growth of elephants’ favourite vegetation around the fields also attracted elephants. Elephants discovered the crops and opportunistically raided them when they come to forage their favourite vegetation.

2.3.2.5 Types of Crops grown

Cultivation of crops which are palatable to elephants encourages crop raiding (Parker et al., 2007). Maize crops are more vulnerable to raiding since they are more palatable to elephants compared to other crops. Other food and cash crops which are palatable to elephants include cotton, sunflowers, ground nuts, water melons, millet, onions, beans, mangoes, cassava, sugar cane, pumpkins, potatoes, plantain, okra, tomatoes and cocoyam. This ability to target many crops makes elephants the greatest threat to food security to communities close to protected areas (Parker et al., 2007).
2.3.2.6 Human population growth

Population growth is one of the key drivers of human-elephant conflict in many areas close to protected areas. The growing human population competes for space and resources with elephants (Perera, 2009). The transformation of forests into agriculture and settlements has compressed elephant habitats. The encroachment of human settlements into elephant sanctuaries has led to the creation of new bush paths between these settlements (Perera, 2009). In Zimbabwe, the increase in population has forced people to encroach into areas which were strictly reserved for elephants. Zimbabwe’s population increased by 62% from around 8 million 35 years ago to 13 million in the last count in 2012. Population growth has pushed the demand for space for settlements and cultivation (Hoare, 1999). Encroachment into protected areas has increased deforestation as areas are opened to pave way for cultivation and settlements (Kusena, 2009). Human encroachment into elephant habitat has sparked serious human-elephant conflict which the country is battling with (Perera, 2009).

Human-elephant conflict is more prevalent around protected areas where elephant populations are greatest and between protected areas where migratory corridors cross unprotected community land (Brooks et al., 2010). Expansion of human settlements and agriculture in the semi arid areas where most elephants survive has been cited as a major threat to the survival of elephants (Granados et al., 2012). Kusena (2009) suggests that the increase in human population adjacent to protected areas and the resultant encroachment are the key determinants of human-elephant conflict. Deforestation is a major cause for concern as it is linked to habitat fragmentation and habitat loss (Kusena, 2009). Increasing human population in areas where elephants and humans co-exist reduces elephant home ranges.
This is because increasing human population is related with increased deforestation for settlements and cultivation. This situation threatens elephants since it leads to habitat destruction, encroachment and poaching (Hoare and Du Toit, 199). Parker et al., (2012) also suggest that increasing human population and expanding agriculture have increased the potential of conflict between humans and elephants in many areas at the periphery of the park. Elephants have been compressed into smaller ranges. Settlements and agriculture has blocked elephant migration routes. In ecology elephants routes are critical as they enable them to obtain resources such as water, salt licks and foliage. This leads to serious competition for land and other resources. Agricultural field expansion into natural habitats has been described as a threat to the persistence of elephant species in Southern Africa by Murwira and Skidmore (2005). Figure 4 depicts how the removal of the forest leads to the process of habitat fragmentation. Habitat fragmentation is a process whereby a large continuous area of habitat is both reduced in area and divided in two or more fragments.

![Habitat fragmentation diagram](image)

Figure 4 Habitat fragmentation
Box 1 in figure 4 depicts an undisturbed habitat which can be a thick forest or woodland. Box 2 (figure 4) indicates the effects of opening up land for settlements and agriculture. In this case the once continuous habitat is fractured and reduced into small patches. Box 3 in figure 4 depicts the worst case scenario of the effects of converting natural elephant habitat into human land use. The whole habitat has been transformed into human land use (Kusena, 2009). In most cases problem elephants retaliate to habitat loss and encroachment by extending their range into human settlements. This often sparks serious conflict which includes crop destruction, raiding of food stores. Some of the serious human-elephant conflict manifestation includes damaging of water infrastructure, fences or barrier and human deaths and injuries (Hoare, 1999).

The serious effects of habitat fragmentation are migration of elephants since they require large habitat. Rood (2008) also notes that continued existence of elephants on landscapes dominated by human land use is greatly threatened by encroachment of human activities into elephant habitat. This encroachment has negative ecological implications which include range reduction, increase in human-elephant conflict and species extinctions (Foley, 2002). Range reduction due to encroachment of human land use in elephant habitat is a serious issue in area at the periphery of elephant sanctuaries in many African countries (Hoare and Du Toit, 1999). Human-elephant conflict is a major cause for concern as it creates resentment and lack of support for elephant conservation initiatives.
2.3.2.7 Increase in elephant population

Human-elephant conflict is also attributed to the successful recovery of the once declining elephant populations through improved conservation. Increase in elephant population has forced them to move out of protected areas into adjacent settlements and agriculture to maintain their home ranges (Zvidzai, 2013). This has increased competition for scarce resources such as water, sparking serious conflict. This situation has been noted in Southern Africa where Zimbabwe and other Southern African member states ratified the CITES conservation programme which restricted trade of ivory and other elephants products. The increase in elephant population has resulted in human-elephant conflict and greater antagonism to elephants among agricultural communities at the periphery of the park. Bull elephants have been identified as the problem animals in many conflict zones. The bulls usually raid crops in communities as they can take more risks compared to cows. Female elephants avoid taking the risk of raiding into the interior communities as they do not want to risk of exposing their lives to the danger of attack by humans. Hoare (1999) studied the factors which influence human-elephant conflict in the Northern Sebungwe region of Zimbabwe. All the potential predictors of human-elephant conflict failed to explain human-elephant conflict in this area. The unpredictable nature of human-elephant conflict was attributed to the behavioural ecology of male elephants (Parker, 2007). In Kenya bull elephants were found close to towns than cows.
2.3.2.8 Temporal determinants of human-elephant conflict

Temporal human-elephant conflict determinants are well understood. Crop raiding has been observed to increase during the cropping season. Crop raiding incidents usually reaches peak when crops mature. Elephants prefer to raid mature crops since their bodies and seeds are highly nutritious. In some situations, crop raiding occurs during the rainy season and the dry season. During the rainy season elephants raid crops from the fields. In areas where the presence of wetlands allows cultivation of vegetables during the dry season, elephants also raid these gardens opportunistically when they come to drink water from the water points. In most cases the crops are grown at the fringes of major rivers for easy access of water for irrigating the crops.

These crops are used for supplementing the diet of most farmers throughout the dry season. In worst situations the gardens are completely destroyed forcing farmers to abandon them. In Zimbabwe’s Zambezi Valley, farmers grow crops such as maize, cotton and sorghum extensively through the wet season. These rain-fed crops represent the main food and cash harvest for the year. Such fields are sporadically raided by elephants, but rarely are entire fields destroyed. Farmers treat damage to their main crops as severe because they rely on these crops to feed them through the dry season. Parker (2007) says that, the majority of elephant crop-raiding occurs during the hours of darkness. In Trans Mara, Kenya, all recorded crop raids occurred between 19:00 hours and 05:00 hours, with a peak of activity at 20:00 hours. Elephants usually raid crops during the night since they take advantage of using the darkness and cover which makes it difficult for people to detect them.
2.3.2.9 People`s perceptions

People`s perceptions are critical as they play a great role in influencing human-elephant conflict. In most communities close to protected areas, people perceive elephants as pests since they devour crops, injure and kill people (Treves, 2007). This normally leads to resentment of elephants by local people. Negative perceptions of people towards elephants can prevent communities from participating in other critical environmental issues such as soil erosion, pollution and water resources management (Parker et al., 2007).

2.3.3.0 HUMAN-ELEPHANT CONFLICT MANAGEMENT METHODS

A lot of effort has been dedicated towards researching on human-elephant conflict mitigation methods. This implies that the strategies which can be implemented in human-elephant conflict management are well known. The major gap existing in these previous studies is that they lack the concept of spatial analysis. In this section, different human-elephant conflict mitigation strategies are discussed based upon previous findings. Detailed explanation of gaps existing in previous literature on human-elephant conflict is covered in greater detail in section 2.4.3.

According to Larmaque (2009), human-elephant conflict can be managed through a variety of approaches. These include prevention strategies, protection strategies and mitigation strategies. Prevention strategies are aimed at avoiding the occurrence of the conflict. Prevention strategies mainly address the root causes of human-elephant conflict. Protection strategies are implemented when the conflict is certain to happen or has already occurred. Mitigation strategies attempt to reduce the level of impact and lessen the problem. As suggested by Larmaque (2009), there are various human-elephant conflict management strategies.
The following section describes the different types of human-elephant conflict management strategies. These mitigation measures are discussed under 2 broad categories which include the lethal and the non-lethal methods.

2.3.3.1 Non lethal human-elephant conflict mitigation measures

The ratification of conventions such as CITES by many African countries have resulted in the banning of practises such as culling of elephants. Such practices have been regarded as contributing to the decline of elephants numbers which are viewed as endangered species. This implies that killing of elephants as a way of addressing and reducing human-elephant conflict is no longer acceptable. Criticism of the killing of elephants as a human-elephant conflict mitigation measure has led to the development of deterrent methods which scare away elephants without causing any harm.

2.3.3.2 Community awareness

According to Larmaque (2009), awareness campaigns in the communities play a great role in managing human-elephant conflict. Educating rural villagers is a way of giving them essential skills to deal with human-elephant conflict issues (Larmaque, 2009). This result in a change of behaviour among local populations resulting in reduced risks. Equipping communities with skills of dealing with human-elephant conflict is crucial as it reduces vulnerability. There are various projects which have been developed to teach farmers on ways of preventing crop loss in Southern Africa (Larmaque, 2009). These include the Kakum Project which produced a farmer’s manual on protecting crops from damage by elephants.
The Kakum project is a Community-based problem animal control which ensures livelihood security for people living in elephants range. Such tools are useful for raising awareness of human-elephant conflict at local level (Larmaque, 2009).

2.3.3.3 Direct Compensation

Compensation is used to reduce the negative effects of loss caused by elephants. The loss can be through human deaths or injuries, crop destruction and infrastructural damage. Compensation to crop damage is difficult as it is difficult to objectively assess the damage caused by elephants. Verification of claims also requires dedicated and trained personnel (Fernando et al., 2008). Payment of compensation for human injuries, deaths, and property loss has been made to victims of elephant depredation through the state forest departments or the elephants departments in India (Fernando, 2008). These schemes are often funded by a conservation organization and the government (Larmaque, 2009). The purpose of the schemes is to increase damage tolerance levels among the affected communities. In addition to this, the schemes also meant to prevent retaliatory killing of elephants through poisoning and snaring and illegal hunting by affected communities. Such schemes are critical as they prevent resentment of elephants by the locals which undermines the support for conservation initiatives (Larmaque, 2009). There is very little compensation for loss caused by elephants in Africa. This means that most African countries do not pay compensation. The main argument is that compensations are ineffective ways of reducing the human-elephant conflict. Larmaque (2009) also indicated that there is need to improve the compensations. The compensations are criticised on the basis that they can only address the symptoms and not the cause of the problem.
In Zimbabwe, a pilot testing of the compensation was carried out. The increase in the number of claims for compensation led to the abandonment of the compensations (Taylor, 1993 in Larmaque, 2009). Compensations were also adopted by the government of Mozambique in 2005. This project involved paying compensation for loss and damage caused by elephants in the area at the periphery of Maputo special reserve. However, the increase in the levels of crop loss due to elephant raids made it difficult for the government to get enough food for compensation. The government of Mozambique then decided to resort to fencing in order to prevent crop loss (Larmaque, 2009). The idea of compensation for loss caused by elephants was also adopted in Kenya. This system became ineffective and was abandoned in 1989 after failing to replace and repair the installations that were destroyed by wild animals (Thouless, 1993 in Larmaque, 2009). In some countries like Ghana, the wildlife policy does not have a provision for compensation for loss and damage caused by elephants. As suggested by Larmaque (2009), one of the limitations of a compensation system is that it requires a lot of funding from both the government and the nongovernmental organisations. Lack of funding has led to the abandonment of this system by many African countries. The system also causes farmers to relax and not take necessary measures to prevent crops from being raided.

2.3.3.4 Indirect compensation

Indirect compensation is a type of compensation which gives communities in the proximity of national parks the right to utilise natural resources. This type of compensation relies on giving out licenses to companies to exploit natural resources, through tourism, hunting or collecting fuel wood, timber, mushrooms, and fodder (Larmaque, 2009). This form of compensation is a more practical solution to the human-elephant conflict compared to the monetary payment.
Benefits obtained from the use of natural resources are also critical as they influence the attitudes and perceptions of rural residents (Larmaque, 2009). Land owners staying close to elephant sanctuaries can also benefit from such schemes in recognition of the role they play in hosting elephants on their land and covering associated costs. This improves the attitudes and perceptions towards elephants. In countries like Mozambique, the local communities living in areas where natural resources are exploited get 20% of the proceeds realised from the exploitation of that particular natural resource. The benefits are obtained from activities such as hunting and tourism (Larmaque, 2009). A variety of compensations can be adopted to offer indirect benefit from the local people staying in proximity to elephant sanctuaries. Employment opportunities created by the tourism industry can also act as a form of a benefit for the local people staying adjacent to elephant sanctuaries (Larmaque, 2009).

2.3.3.5 Insurance schemes

An insurance scheme is a form of compensation where farmers pay a premium for cover against the risks associated with loss and damage caused by elephants (Muruthi, 2005). The method requires expertise and personnel who can estimate and quantify the damage caused by elephants. Expertise is also required to accurately ascertain the cause of crop damage, livestock depredation, human injury or death. The key strength of this method is that it encourages farmers to take the responsibility of adopting crop raiding prevention techniques (Larmaque, 2009). One of the positive effects of compensations is that they provide relief to people who would have experienced loss and damage induced by elephants. Compensations may increase tolerance levels of people towards elephants (Fernando, 2008).
The major limitation of compensations is that they have experienced a lot of challenges. Several factors have contributed to the failure of compensations in many African countries. Failure of compensations has been attributed to corruption, cheating, fraudulent claims, time and the high costs associated with running the schemes. Most farmers also found it difficult to submit a compensation claim because of high levels of illiteracy among rural farmers (Larmaque, 2009). In some instances, compensation claim forms have been rejected. Such factors have discouraged farmers from submitting claims (Larmaque, 2009). In addition to this, compensations encourage communities near the protected areas to get involved in crop cultivation. Expansion of agriculture and settlements is a major cause for concern as it reduces elephant habitat through fragmentation, compression and range reduction. As suggested by Fernando (2008), the abuse of compensations has led to further antagonism between authorities and people. There are often high chances of antagonism between elephant management and conservation authorities and the local people who are usually victims of various human-elephant conflict manifestations.

People may retaliate through illegal hunting, snaring and poaching elephants. Such activities may lead to resentment of elephants by the locals and this has a great potential of undermining acceptance of conservation initiatives by the local communities. Compensation may lead to reduced efforts by local people to guard their crops thus exacerbating conflict with elephants. They may also cause an increase and expansion of agricultural activities into elephant habitats which eventually leads to local extinction of elephants (Fernando, 2008). In most cases, people tend to over claim, and when such claims are not met, it leads to antagonism between authorities and people. The payment of false claims leads to widespread abuse and unsustainable expenditure. This implies that managing compensations is difficult.
The same issues apply to insurance. Fernando (2008) emphasises that paying compensation by a government authority reinforces the feeling that they are responsible for all harm caused by elephants. People develop a perception that it is the responsibility of the authorities to address human-elephant conflict issues. Such perceptions lead to anger against the authorities when an incident of damage occurs and it can lead to a severe straining of relations between authorities and people.

2.3.3.6 Community-Based Conflict Mitigation

Community-Based Conflict Mitigation (CBCM) is a relatively recent approach to human-elephant conflict. The programme which empowers communities to address their own conflict problems was formed after the realisation that rural communities could not rely upon outside agencies to solve their conflict problems. CBCM uses effective, low cost human-elephant conflict mitigation techniques that rural farmers require to prevent crop raiding incidents. The CBCM programmes have been tested extensively in Zimbabwe and Kenya and have been successfully implemented by Elephants Pepper in a number of countries, including Ghana, Mozambique, Zambia, Botswana and Namibia (Parker et al. 2007).

2.3.3.7 Community-based natural resource management programmes

Community-based natural resource management programmes (CBNRM) are projects that have been developed to address the problems of poverty and natural resource degradation. The projects are managed through local authorities such as the village assembly, the village natural resources committees, the village environmental committees and Rural District Councils (Murphree, 1993). CBNRM projects are not structured to generate revenue for households.
Most benefit-sharing programmes provide social services such as schools, water or roads instead of direct income (Dzingirai, 2003). CBNRM projects have been established in various African countries. Zimbabwe operates CAMPFIRE projects in different areas. In Botswana, Community Based Organisation (CBO) has been established. The Namibian Government’s approach to CBNRM focuses on encouraging and recognizing communally defined and owned conservancies. Small-scale CBNRM in Malawi focuses on management of fisheries, reforestation, and other sustainable agricultural practices (Dzingirai, 1995). The CBRNM projects such as the CAMPFIRE have been widely accepted socially as most researchers have focused on providing answers and solutions to the social aspects of the CBRNM projects.

In most cases researchers assessed the attitudes of communal people towards such projects. The researchers were also trying to convince communal people to accept elephants since they would reap benefits accrued from trophy hunting, tourism, meat cropping and infrastructural development (Dzingirai, 2003). The CAMPFIRE theoretical framework has, however, been affected by human-elephant conflict which has resulted in the resentment of elephants by local people who stay close to the protected areas. This implies that failure to address the human-elephant conflict issue has got a great potential of undermining conservation initiatives. In Namibia, CBNRM was established in 1998 through the conservancy programme in the Caprivi region. The ecotourism industry and hunting concessions were used to generate revenue to support the local communities. This system was implemented with the intention of ploughing back some of the revenue in the communities. Such an approach is critical as it improves the support of the elephant conservation by the local communities.
2.3.3.8 Intensifying human vigilance

Vigilance is an important component of crop or livestock protection and human-elephant conflict management. Elephants usually fear the presence of humans and, therefore, cannot raid crops in the presence of people. In Kibale National Park in Uganda, elephants waited at the forest edge until farmers left the fields before they could enter (Naughton-Treves, 1998 in Larmaque, 2009). Elephants in the area around the Kakum Conservation Area in Ghana do not raid crops from fields where people are guarding (Barnes et al., 2003 in Larmaque, 2009). According to Parker et al. (2007), farmers who actively guard their fields have a greater chance of reducing crop damage. In Trans Mara, Kenya, farmers have established guard towers at the edge of fields which enable them to observe approaching elephants in safety. They use powerful torches to locate the elephants before they enter the farms. Such an approach has been highly effective, as demonstrated by reduced incidents of crop-raiding.

This strategy is especially successful where farmers practice collective guarding. There are different methods used to intensify human vigilance. The use of watch towers is one way of intensifying human vigilance. Watchtowers provide good vantage points. They are usually built around cultivated fields and have a great potential of assisting farmers to detect elephants before they raid crops. Farmers need to practise collective guarding and take turns in guarding crops. Some people guard during the day and others guard during the night. This method has been used successfully in Zimbabwe, Mozambique and Zambia (Larmaque, 2009). Those who guard during the night take turns to sleep. If an elephant is sighted, other farmers are woken to chase them away (Thouless, 1994 in Larmaque, 2009).
Simple alarm systems, using a network of cowbells or tins filled with stones connected along a length of twine, are effective and prevent the farmer from staying alert all night long (Muruthi, 2005 in Larmaque, 2009). Such teams mainly comprise of the males. In the high human-elephant conflict area of Kakum in Ghana, the FAO project set up a cadre of community scouts to provide vigilance and promote community-based problem animal control. About 11 communities were selected and grouped into a community scout cadre with an average membership of 5 scouts per community. Each group had a leader and a secretary who was responsible for the custody and updating of the patrol record book. This record book was available for inspection by other community members and stakeholders (Larmaque, 2009).

2.3.3.9.0 Barriers

Barriers are methods which are used to keep elephants within protected areas or prevent their entry to villages (Perera, 2008). Physical barriers are not always an economical management practice. They frequently require additional labour from farmers and their family members and never ensure complete protection (Larmaque, 2009). Barriers physically exclude elephants from the crop fields. Fernando et al. (2008) defines a barrier as an obstruction constructed on the boundary between human settlements and elephant sanctuaries. It can be used to prevent elephants from entering human settlements and fields. Barriers can also be used to contain elephants in a protected area and prevent them from entering fields and settlements.
For a barrier to be effective, it needs to restrict elephants to one side of the barrier. Fernando (2008) further emphasises that if a barrier is to be constructed through an area inhabited by elephants, all elephants have to be physically removed from the side they are to be excluded from. The barrier should prevent elephants from crossing from one side to the other. When confronted with a barrier, elephants tend to walk along it for many kilometres in an attempt to find an opening. All potential openings such as where the fence crosses streams, rivers, gullies and roads should be secured (Fernando, 2008).

2.3.3.9.1 Electric fences

Electric fencing is one form of a barrier which is used to prevent elephants from entering human settlements and fields. Electric fencing is very effective in terms of preventing elephants and other elephant species from entering fields and settlements (Larmaque, 2009). As Parker et al., (2007) noted, electric fences come in a variety of designs and have been used to protect small farms. In some situations, electric fences are used to protect elephant sanctuaries. Elephant fences are usually high-voltage. It is critical to protect the fence from elephant attacks. Elephants are notorious at identifying weak points of fences (Fernando, 2008). The use of electric fences has been regarded as the most effective way of preventing elephants from entering human settlements and fields. They do not cause physical harm to elephants but they give a powerful and unpleasant electric shock upon contact (Fernando, 2008). Installing electric fences is expensive. However, the costs incurred during the installation of an electric fence depend on the type of material used (Larmaque, 2009).
The success of electric fences largely depends on ownership. If a fence is constructed and maintained by a government, people from the nearby communities usually view the fence as a government property. In such situations, the fence is subject to vandalism as communities feel that it is the responsibility of the government to maintain the fence. In such scenarios, the electric fence deteriorates due to vandalism and lack of maintenance as the government might not have adequate financial resources of maintaining the fence. If the fence is constructed by the donor agency and the responsibility of maintaining the fence is given to the village herds, the fence may be effective as people from the community become fully responsible for the fence.

One major advantage of using electric fencing is that it is effective as animals are shocked by the electricity if they try to go near the fence. In Kenya electric fencing is successfully used to separate elephants from human settlements and agricultural areas. Larmaque (2009) further suggested that the electric fencing of the cultivated areas of Kimana and Namelok in the AWF Kilimanjaro Heartland has significantly reduced the levels of elephant crop damage. Installing electric fences in high human-elephant conflict zones in Kenya has proved to be the most effective long term human-elephant conflict mitigation strategy (Kioko et al., 2008 in Larmaque 2009). Electric fencing has also been used effectively to prevent and reduce large scale occurrence of human-elephant conflict levels in the in the East Caprivi region of Namibia. The use of electric fence has proved to be the only long-term deterrent to elephants (Larmaque, 2009).
Though installing and maintaining electric fence is associated with a high cost, this method has effectively reduced various forms of human-elephant conflict manifestations in high human-elephant conflict areas. Electric fences have been difficult to maintain in many communities where human-elephant conflict is a problem. The major limitation associated with the use of electric fencing is that the cost of installation and maintenance is higher than for simple fences (Hoare, 1992).

### 2.3.3.9.2 Biological fences

Biological fences are also another type of a barrier used to prevent elephants from entering fields and settlements. According to Fernando (2008), biological fences are the thorny plant species such as agave, cacti and bougainvillea. Larmaque (2009) refers biological fences to plant hedges. These fences are used to prevent elephants from entering human settlements (Larmaque, 2009). One major limitation of the use of plant hedges as a way of preventing elephants from entering fields is that they are slow to establish. In most cases the hedges are ineffective in preventing elephants from entering fields and raiding crops (Larmaque, 2009).

### 2.3.3.9.3 Ditches / trenches

Ditches or trenches are other forms of barriers which can be used to prevent elephants to enter human settlements. Trenches have been widely used in Africa to keep elephants from cultivated areas (Larmaque, 2009). Parker et al. (2007) suggested that in Asia, trenches have been dug along protected area boundaries or around water points with varying degrees of success. A trench has to be wide and deep enough to ensure an elephants cannot step over it. This is because elephants are not able to jump (Parker, 2007).
In some places, trenches have been filled with pointed sticks to further deter elephants from crossing. Trenches in conjunction with electric fences have worked well where both have been well maintained.

2.3.3.9.4 Covered trenches

Covered trenches can alternatively be used to prevent elephants from entering fields. Experiments with shallow trenches overlain with branches and leaves have been successful in India. When an elephant treads upon the leaves it feels the substrate give and fears it will plunge into a pit, so it withdraws. The trench need only be 30 cm deep but it must be wide enough to prevent an adult bull from stepping right over it. The covering must be well maintained, because once an animal realises that it is a hoax this tactic will become useless. This method requires a great deal of labour and in high rainfall areas soil erosion may be a problem. The use of trenches or ditches has limitations. Fernando (2008) observed that the main problem with trenches is erosion and caving-in of the side walls which fills up the trench, enabling elephants to cross it. The likelihood of erosion and caving-in depends on soil condition and rainfall.

The sides of trenches can be stabilised with concrete, stones and tar or asphalt. Stabilising trenches with concrete is, however, expensive as it increases the cost significantly. Construction and maintenance of trenches is labour intensive. In India nearly 95% of expenditure on trenches is spent on hiring labour (Fernando, 2008). Fernando (2008) noted that the effectiveness of trenches in preventing elephants incursions into crop lands depends on factors such as environmental factors such as erosion, deliberate filling-in by people and elephants, and non maintenance.
Other factors, such as filling in of trenches due to dumping of soil by people and breaking of sides by elephants determine the effectiveness of trenches. Another major drawback with trenches is that they encourage soil erosion. Elephants have also been known to fill them in by kicking soil from the edges into the trench, thereby enabling them to cross. Trenches require a large investment of labour, or mechanized digging equipment, and intensive maintenance. Elephants and calves may fall into trenches and get stuck or drown (Fernando, 2008). Trenches with concrete side walls are particularly dangerous because elephants are unable to climb out if they fall in. It is thus important to construct points in the trenches where elephants can climb out to the side they are to be restricted to in the case of a fall.

2.3.3.9.5 Non-electric fences

Non electric fences are some of the barriers which can be used to prevent elephants from invading human settlements. The fences constructed using strong materials such as galvanized steel wire protect crops successfully against many mammals (Larmaque, 2009). The non-electrified fences are used to restrict elephant movements in many parts of Africa and Asia. These fences are usually built with wooden or steel poles driven vertically into the ground. Heavy gauge wire or cable is strung between the poles and drawn tight. While these fences have met with some success, they can be expensive to erect and maintain. There is also a large labour investment required and expert advice needed (Parker et al., 2007). The use of fences has some limitations. The major factor limiting the wider use of elephant fences is their cost. As suggested by Larmaque (2009), the cost varies significantly depending on many factors such as topography, type of fence and the species it is designed to contain.
The use of fencing is associated with high maintenance cost. This explains why many farmers resort to other cheaper methods of preventing elephants from entering crop fields or settlements. Managing fences is difficult and ineffective unless such projects are managed by commercial farmers for high-value crops such as sugar cane or citrus. This option is beyond the means of emerging farmers or subsistence growers (Larmaque, 2009). However, there are some benefits associated with the use of elephant barriers. According to Fernando et al., (2008), the successful deployment of a barrier will prevent elephant intrusion into human areas thereby providing safety from elephant depredation. In an area where elephants suffer morbidity and mortality from actions of humans, keeping them away from such areas could provide benefit.

2.3.3.9.6 Buffer crops and unpalatable crops

According to Fernando et al., (2008) this technique involves substituting crops consumed by elephants with those that they do not. Elephants eat many or most of the food crops usually grown adjacent to elephant areas, the exception being crops such as tea, coffee, tobacco, medicinal crops, spices, sesame, chilli and citrus. However, individuals may try out new plants and adapt to them, especially as they become more abundant, and subsequently even crops formerly not consumed may be regularly raided. There are some crops which are less palatable to elephants than others. Growing of crops which are not palatable to elephants has been identified as an effective measure of preventing elephants from raiding crops. In areas around Kakum National Park in Ghana, people have been encouraged to grow crops such as ginger and chilli (Larmaque, 2009).
In high human-elephant conflict zones of Ghana, farmers have been encouraged to shift from growing food crops, to growing other crops such as cocoa and ginger, to sell at the local market in Foso. Chilli peppers have also been grown in the Salambala Conservancy in Caprivi, Namibia. In Zimbabwe the production of chilli peppers have been encouraged in high zones of human-elephant conflict to repel elephants. Chilli peppers have also been grown for export in Zimbabwe (Larmaque, 2009). Theoretically, it should be possible to reduce human-elephant conflict and eliminate elephants from areas by planting crops not eaten by elephants. The critical factor, however, is the scale and homogeneity of the area transformed into unpalatable crops. If many hundreds of kilometres are completely planted with unpalatable crops it is likely to reduce the conflict because of the absence of elephants due to lack of food.

However, areas of the scale of tens of kilometres or less will not have a major impact because elephants may travel through such areas and in the case of tree crops, may use them for cover during day time. The same applies to cultivating buffers of unpalatable crops around crop areas. Unless the buffer is at least a few km broad and is completely homogenous, it is unlikely to have a significant impact. Cultivating unpalatable crops has got some advantages. As observed by Fernando (2008), the economic loss to farmers from crop raiding by elephants may be decreased by cultivating crops that are not consumed by elephants. However, some loss may yet be incurred from damage caused by trampling when elephants walk through such areas. Elephant death and injury due to human-elephant conflict may be decreased.
The cultivation of unpalatable crops can have negative effects on the farmer. Alternative crops may not have a good market and loss due to trampling by elephants that move across such plantations may be substantial there by negating the value of switching to alternate crops. Land converted to crops unpalatable for elephants are lands that elephants cannot use. Growing unpalatable crops over large areas will result in loss of habitat and ranging areas, threatening the survival of elephants that used to range in such areas (Fernando, 2008). Human-elephant conflict can be reduced, and in some cases totally prevented, by implementing changes to the resource that causes the conflict. This can be achieved by altering the resource itself, or the way it is managed or making changes to the surrounding landscape so that the problem-causing animal is more vulnerable, making it easier to spot by people and dogs, and generally feel less ease in the area (Muruthi, 2005 in Larmaque, 2009). Another alternative way of mitigating human-elephant conflict can be achieved through changing the time a crop is planted or harvested.

The use of early maturing maize varieties which can be harvested earlier than other food crops can be effective in addressing the issue of crop raiding by elephants. Such varieties are also less vulnerable to crop damage, which tends to occur late in the growing season (Larmaque, 2009). Intensifying agriculture also has a great potential of managing the problem of human-elephant conflict. This may involve increasing inputs and boosting yields so that farmers are able to maximize their returns from smaller plots. Intensification of agriculture means the use small plots which are easier to defend against crop-raiding elephants. Intensification of agricultural production can be achieved through the adoption of practices such as mulching, and the use of organic fertilizers and liquid dung.
Consolidating farms and practising communal farming can also act as a mitigation measure against the problem of human-elephant conflict. This can be achieved by adopting a landscape approach which involves growing crops in large communal fields with straight edges, fences or thorny or spiny hedges, and also removing nearby cover and habitat for elephants (Muruthi, 2005). Cultivating crops in large communal fields is a better way of lessening the issue of human-elephant conflict. This is because small islands of crops scattered across a landscape inhabited by elephants are more vulnerable to destruction than those that are clustered together.

2.3.3.9.7 Cleared boundaries and simple demarcation of fields
Clearing boundaries and simple demarcation of fields is a type of non-lethal methods which can be used for human-elephant conflict mitigation. This technique of clearing a margin of about 50 metres around crops does help as a preventive measure, since elephants are wary of crossing these open areas (Larmaque, 2009). Fernando et al., (2008) observed that the methods, such as clearing a strip of vegetation, stringing audio tape on a line of stakes, placing a line of lamps or lights along the perimeter of a field, can scare away elephants from entering human settlements and fields. They indicate human presence, thus discouraging elephants fearful of humans from raiding. The disadvantages are that elephants soon learn that they do not represent a real threat, making them ineffective in the long term (Larmaque, 2009). However, the low cost associated and their combined use with other crop guarding methods may be successful in decreasing depredation.
2.3.3.10 Deterrents

Deterrent methods are designed to repel animals from the targeted resource. They are categorized according to the sense they target (Larmaque, 2009). They are methods used to prevent elephants from entering fields and villages (Perera, 2008). Traditional deterrents are those that have been developed by rural communities living at the periphery of elephants sanctuaries. 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, tins, cracking whips and yelling and whistling to chase elephants away. Farmers may also use catapults, or throw rocks, burning sticks and occasionally spears at crop-raiding elephants (Parker et al., 2007).

2.3.3.10.1 Acoustic deterrents

Acoustic deterrents are those that scare away elephants through the production of an unexpected loud noise or specific sounds known to scare elephants. Traditional acoustic methods are mostly adopted by farmers in Africa as a way of scaring elephants away (Larmaque, 2009). These methods include beating of drums, tins and cracking of whips. In addition to this shouting, yelling whistling, and setting off of explosive devices such as bamboo blaster using calcium carbide or fertilizers, pipe bombs are some of the methods which have been used to prevent elephants from entering fields and raiding crops. Some of these methods have been used to successfully deter elephants in high human-elephant conflict zones of Zimbabwe. Homemade gun powder has been used in Zambia to chase elephants away from human settlements and fields (Larmaque, 2009). Activities such as noise-making, shouting and throwing of objects are reactive and confrontational (Fernando et al., 2008).
The problems with using elephant vocalisations as a repellent are that it is of very low frequency and thus require expensive equipment to record and playback. A large repertoire of recordings would probably have to be used to avoid habituation. There is also need for a lot of research to assess the effectiveness of these methods.

2.3.3.10.2 Alarm System

Alarm System is another form of deterrent which can be used to scare elephants away. According to Parker et al. (2007), alarm systems are acoustic devices that are usually established at the boundary of the farms and set off by a tripwire. Alarm systems established at the boundary of farms and set off by a tripwire, such as electric sirens, have been adopted successfully in Namibia. The alarm systems can also be set up directly on fences. These include the use of cow-bells which is a common practice in Zimbabwe. The noise produced by these cow-bells alert farmers to the presence of elephants. The noise also has a deterrent effect since it scares elephants away (Larmaque, 2009). Their primary goal is to alert farmers to the presence of elephants, but they also have some deterrent effect.

Researchers have tested a system using sirens that are triggered when elephants made contact with a trip wire set up around the fields and they reported some success. However, the limitations are that in high rainfall conditions it is difficult to maintain alarm systems and they are also vulnerable to theft. Alarms can play a critical role in crop protection as they offer security to the farmers. Farmers in Zimbabwe found them to be critical to field guarding as they always knew when the elephants were approaching. The noise from the bells sometimes drove the elephants away.
Many farmers complained that it was exhausting guarding the fields all night and it was impossible to maintain constant vigilance. For this reason alarm systems were highly regarded because they allowed farmers to sleep whilst maintaining a level of vigilance. According to Fernando et al.(2008) methods such as locating alarms on the periphery of crop fields work by demarcating and emphasizing human areas and alerting farmers. The farmers` responsibility is to respond to the alerts and prevent crop raiding by chasing elephants away. The major shortfall of the use of alarms is that they can become ineffective as elephants learn and habituate to the lack of serious threat or physical harm. However, when situated on the periphery of fields or a further outer boundary, alarms can help farmers detect elephants before they enter fields. Peripheral alarm systems allow farmers to relax from keeping constant vigil thus relieving psychological stress and sleep deprivation in situations where depredations are infrequent.

2.3.3.10.3 Disturbance shooting

Disturbance shooting is used to deter elephants from raiding crops or invading human settlements. This involves the firing of gunshots over the heads of crop-raiding elephants. This method has been a long-standing deterrent, but it needs the intervention of problem animal control units or administration representatives. Sound aversion barriers generating a frequency that causes pain have also been considered. However, this technique is impractical for large areas, and has several limitations. For instance, it is difficult to trigger. The signal generation is expensive and it can potentially cause auditory damage to non-target species. Disturbance shooting at roost sites is a method easy to implement once all roost sites are known (Larmaque, 2009).
As suggested by Parker *et al.* (2007), disturbance shooting has been used across the continent since colonial times. However, it is also associated with some limitations. For instance, research has established that elephants habituate to gunshots if exposed to them for a prolonged period of time. This method is usually carried out by wildlife authority game scouts responding to the problem from a central location. This implies that the programme can be constrained by transport and logistical problems. Slow response times are considered the greatest problem, with scouts arriving at the scene of crop damage long after the elephants have moved on.

2.3.3.10.4 Play back sounds

The other form of deterrents involves the use of play back sounds of elephants to scare other elephants away. These are sophisticated techniques which are being used as tape recordings for scaring away elephants. The techniques are currently being tested in Kenya, where play-back of Massaï cattle noise to elephants in Amboseli National Park scared off elephants which are periodically hunted or injured by the local Massaï tribesman. Researchers have recorded elephants warning calls. The warning calls have been played back to elephants in order to scare them away in Namibia (Larmaque, 2009). Fernando *et al.* (2008) indicated that playing back alarm calls from elephants has also been tried on a small scale in Africa with no clear success, as different elephants responded differently to play back sounds. The major shortfall of this method is that it requires expensive and sophisticated equipment that cannot be put to use over a large area.
Parker et al. (2007) noted that researchers have tried playing back a range of noises to influence the behaviour of elephants including playing recordings of cattle noises to elephants that had been periodically hunted or injured by pastoralists. The elephants appear to associate the cattle noises with the danger presented by their herders. Bull elephants have been successfully attracted by playbacks of recorded post-copulatory rumbles. There are a number of other calls that could be used to attract or repel elephants, such as low frequency distress calls emitted during culling.

2.3.3.10.5 Visual deterrents

Farmers can alternatively use visual deterrents to scare elephants away and prevent crop raids. Visual deterrents are a traditional method (Parker et al., 2007). This technique involves the hanging of bright coloured cloths and plastic from a simple fence at the edge of fields. Lighting fires at the boundaries of fields produces flames and smoke of fires which can be used by farmers to prevent elephants from entering fields. This is because the presence of fire scares elephants away. Alternatively, farmers can also burn tyres which produce a noxious smoke which affects both visual and olfactory senses, and increases the deterrent effect.

2.3.3.10.6 Olfactory deterrents

Olfactory deterrents are another method which farmers can use to prevent elephants from raiding crops. This technique involves the use of some chemical compounds to deter elephants from entering fields. The chemicals usually generate an unpleasant or painful smell or by simulating a targeted compound such as a hormone that triggers fear (Larmaque, 2009). Parker et al. (2007) argued that olfactory deterrents are chemical compounds that animals taste or smell.
For instance, capsaicin resin extracted from chilli pepper causes an extremely unpleasant irritation and burning sensation is the most widely used elephant repellent chemical. The technique of using chillies deterrent is effective as elephants do not like the irritation caused by the chilli peppers. The chilli deterrents are found in different forms. These include the chilli-impregnated twine and burning balls of elephants dung containing chillies which have been used successfully in Zimbabwe (Parker and Osborn, 2006). As suggested by Parker (2007), repellents based on resin from peppers have been used to alter the behaviour of animals such as elephants. The resin contains capsaicin, a chemical found in fruits of peppers, which is the agent that makes them taste hot.

This chemical produces a burning sensation that mammals find extremely unpleasant. A capsaicin aerosol has been tested extensively as an elephant deterrent in Zimbabwe and has been found to effectively repel crop-raiding elephants. In the high human-elephant conflict zone of the Kakum National Park in Ghana, the use of chilli based deterrents managed to scare away elephants from the fields. This resulted in a better harvest compared to the previous years when farmers were not using the chilli based deterrents (Larmaque, 2009). Dry chilli pepper should be ground to a fine powder and mixed with old engine grease. If no grease is available then palm oil residue, or used car oil will work just as well. Chilli grease can be smeared on bits of cloth and hung on the fence, and also smeared upon the string itself.
The chilli will deter the elephants from touching the fence (Parker et al., 2007). Fernando (2008) noted that some elephants in Sri Lanka have taken to consuming chilli plants in recent times resulting in growing inefficacy of this method. However, the limitations to this method are that the system is relatively expensive and the delivery of the pepper spray to the elephants is reliant upon wind direction. Lighting fires has been a universal method of guarding crops against elephants and other wild animals since ancient times. The presence of humans, noise making, fires keep elephants away from crop fields or their vicinity by presenting cues that are clearly associated with humans.

2.3.3.11 Crop protection by knoonkies

Knoonkies can be used in human-elephant conflict mitigation. This technique involves the use of tame elephants or knoonkies to chase away crop-raiding elephants (Fernando, 2008). This technique is, however, applicable and effective where points of incursions are limited so that knoonkies can be stationed at strategic locations for quick response. Where raiding incidents occur over large areas, and getting to the breach site takes a long time, using knoonkies may be inefficient and inappropriate. The advantage of using knoonkies is that it provides employment to a large number of people. Where such guarding is successful and prevent raiding through non-injurious and non-lethal methods, the decrease in human-elephant conflict may be of benefit to elephants.
Using knoonkies in preventing crop raids has its own limitations. Fernando (2008) pointed out that the use of knoonkies may sometimes put mahouts in danger during the operations, especially when large herds are being driven. The operation may result in knoonkies panicking due to aggressive reactions by wild elephants. Firearms may cause injury or prove fatal in situations involving inexperienced users. Therefore, use of firearms should be limited to trained personnel. With increasing habituation of wild elephants towards these methods, teams are likely to employ more lethal and injurious means, including firearms and physical force with heavy equipment, such as bulldozers and excavators to push elephants out of protected area and protect themselves.

2.3.3.12 Musth secretions

Musth secretions are another form of human-elephant conflict mitigation measure. Compounds from musth secretions seem to have some potential as an olfactory deterrent. It has been observed that elephants do not consume food items encircled by rings of dilute concentrations of one natural ketone in particular. Parker (2007) suggested that the method has been observed in high human-elephant conflict zones in Africa. Deterrent techniques are effective but they are also associated with several notable shortfalls. The techniques are subject to habituation. Male elephants appear to habituate to traditional methods of crop protection more readily than females in herds (Fernando, 2008). Females usually do not want to take chances with danger as they will be having their calves. With time elephants get used to these deterrents and discover that they pose no real threat and ignore them (Larmaque, 2009). This implies that the methods become less effective with time. Alternatively, communities can be encouraged to use several methods to prevent habituation. Deterrent involves getting close to the elephants. This exposes the operator of the deterrent to greater danger of being attached by elephants (Larmaque, 2009).
Maintenance of the deterrent usually requires maximum support from the government or NGOs. These support measures are difficult to provide in rural areas. Crop guarding gives farmers a sense of empowerment. Because the above methods are non-lethal, they do not cause significant harm to elephants (Fernando et al., 2008). Failure of deterrent methods may cause people to resent elephants (Fernando et al., 2008). Farmers can resort to more harmful lethal methods such as illegal hunting, poisoning and snaring. This negative attitude can also affect elephant conservation initiatives. The acceptance of elephants also becomes compromised.

2.3.3.13 Organised crop protection by teams

In this case, responsible teams are chosen to protect crops from elephant raids. The technique is expensive as it requires trained staff. It is suitable for large plantations owned by companies (Fernando et al., 2008). The technique works well if a barrier, usually an electric fence, usually an electric fence is constructed between the boundary between the plantation and elephants habitat. The barriers should be guarded by teams of people in watch huts. The main deterrent is the electric fence and not the intensive guarding as the fence prevents the majority of elephants from entering the plantations. However, male elephants may challenge such barriers. The patrol teams usually have a hotline number used by the communities to communicate if elephants try to invade fields. These methods work well if there is radio communication between mobile patrols and the one who man watch huts. In this case mobile patrol teams are chosen to respond to crop raiding incidents. However, its success depends on the accessibility by vehicle to the conflict sites (Fernando, 2008).
2.3.3.14 Supplementary feeding of elephants

Supplementary feeding is when few individuals provide food for elephants so that they will not raid crops (Fernando, 2008). Providing supplementary feeding which is nutritious has a great potential of preventing crop raiding. Supplementary feeds are placed strategically in areas where elephants come to raid crops. The food can attract elephants from raiding crops. In some areas elephants break into houses in search of salt. Hence providing salt licks has a potential of preventing elephants from invading houses in search of salt. Providing supplementary food to elephants is, however, difficult.

For instance, a single wild elephant approximately consumes 150-300 kg of food daily. This makes providing food difficult and unsustainable (Fernando, 2008). The method becomes difficult if there is no support. Communities in high conflict zones are usually disadvantaged people who survive on food aid, implying that such people cannot sustain supplementary feeding activities. The major shortfall of supplementary feeding is that if crops are used, this may encourage elephants to raid from the fields. The situation becomes worse if the provision of this food is discontinued. Providing supplementary feeding also results in increased contact of elephants with the people. This can lead to aggressive behaviour in elephants. This aggression is worse in male elephants compared to female elephants (Fernando et al., 2008).
2.3.3.15 Translocation of problem elephants

Human-elephant conflict can be mitigated through translocation. This method involves the removal of elephants from a conflict area and their release in a safe area (Fernando et al., 2008). The technique is usually used where problem animals such as adult male elephants become aggressive and begin causing human-elephant conflict manifestations such as habitually raiding crops, breaking houses, or killing people. Printer Wolman (2012) also noted that during translocations, elephants can be transferred from areas with high levels of human-elephant conflict to areas where human-elephant conflict is minimal. This procedure reduces the number of elephants at the origin. It also provides the remaining elephants with more resources. The translocated elephants are put in sparsely populated where there is minimum interaction with humans. Translocating elephants has a great potential of reducing human-elephant conflict. Larmaque (2009) further suggests that translocation applies in areas where there are suitable habitats.

The first stage in the translocation process is the identification of the problem animal. The second stage involves capturing the problem animal. The proper identification of problem animals is important for the success of the exercise. However, in most cases crop raiding by elephants and human induced elephant deaths or injuries occurs at night. This makes the process of accurate identification of the responsible problem animal difficult or impossible. The authenticity of the information of the whereabouts of the problem elephants is questionable since it is usually obtained from villagers. In some cases it may be possible to track an individual from the scene of an incident, leading to a positive identification (Fernando et al., 2008).
The capture team also takes more time before reaching at the conflict site. This makes it difficult to positively identify the problem animal. In addition to this, many cases of human injury and death by elephants are accidents. This makes attributing a particular elephant to the incident difficult except with males or habitual raiders that are aggressive and liable to cause such incidents. As indicated by Fernando (2008), capture is usually done by drug immobilization using an anaesthetic dart fired from a capture gun. The response of darted animals depends on the nature of the particular animal, its awareness of the darting team, degree of disturbance. Some animals tend to run as soon as the dart hits them, some may remain still or walk around a little while others may respond aggressively and charge. The removal of a problem animal through translocation has been used in Kenya and South Africa.

Translocation is a more ethical human-elephant conflict management compared to killing problem elephants. However, the cost of translocation is extremely high and the operation involves specialist equipment and skills. This method has been noted to have some failure rates. Elephants may die during the process of translocation. One major noted failure of this method is that it may solve human-elephant conflict problem by creating another problem. This means that the method can address the problem of human-elephant conflict at the source area and take it to other areas which were not experiencing the problem (Fernando, 2008).
As observed by Fernando *et al.* (2008), if the correct problem elephant is identified and removed, human-elephant conflict can be reduced. This is because the process involves the removal of a few adult males that are very aggressive and responsible for causing human-elephant conflict. Removing problem elephants plays a great role in elephant conservation (Fernando, 2008). This is because if the problem animal is not removed, people can retaliate and kill it. There are some major limitations associated with using translocation as a human-elephant conflict mitigation measure. In Sri Lanka ecologists monitored translocated elephants using satellite radio telemetry. Results showed that removing problem elephants to a particular area may transfer the problem to a new area. Male elephants are the most affected as they find it difficult to adapt to new environments. Translocation usually disrupts their behaviour. Lack of knowledge of the area they are translocated to increases the greater chances of interacting with people.

This can worsen the human-elephant conflict problem. In most situations male elephants are attributed to human-elephant conflict incidents. However, the removal of male elephants from small populations may lead to the depletion of the local genetic pool. This situation may lead to skewed sex ratios (Fernando, 2008). As noted by Perera (2008), moving elephants during the wet season is often accompanied by logistical difficulties. The process of identifying problem elephants is difficult. A particular elephant may wrongly be identified as a habitual crop raider or human killer. The process of translocation of elephants also requires experienced and trained staff. In most cases elephants die during the process. Experienced personnel are required to reduce injury and death of elephants.
2.3.3.16 Elephants Drives

Human-elephant conflict can also be mitigated through elephant drives. This technique aims to reduce human-elephant conflict as well as safe guarding elephants. This is achieved through safe guarding elephants through the removal of groups of elephants from a conflict area to a safe area. Elephant drives usually apply where large numbers of elephants are to be removed. The driving is carried out by a group of people walking through the forest. The people create a lot of disturbance and attempt to chase the elephants in a particular direction (Fernando, 2008). These elephants are driven to forest habitats that become their new home range. Elephant drives can be carried out by people or trained elephants. Alternatively vehicles or aircraft can be used to drive elephants away to new habitats (Perera, 2008). This process is most effective if elephants are driven into a national park and a barrier is established to prevent them from returning. Major elephant drives involve many people and is conducted over many months.

During drives, people start from one end of the drive area. Large firecrackers are lit to scare the elephants. The banging of tin cans, shouting and shooting in the air are some of the methods used drive elephants from high conflict zones. In some instances water bodies are guarded to prevent elephants from drinking (Fernando et al., 2008). This compels elephants to move to the next area. For this process to be effective elephants should be put in temporary electric fences to prevent them from returning to same areas. The dry season is the most conducive for conducting elephants drives compared to wet seasons. Wet seasons are usually associated with logistical challenges. The scarcity of water during the dry season makes the process of driving elephants easier.
As observed by Fernando et al. (2008) elephants drives tend to be well received by people. Successful removal of problem elephants from high conflict areas can greatly reduce the conflict. Driving male elephants from areas where they are causing conflict can greatly reduce human-elephant conflict. One of the main objectives of a drive is to remove elephants from an area where they are under threat to an area where they would be safe (Fernando et al., 2008). Elephant drives are successful where there is an area with adequate unexploited resources, which can accommodate the driven elephants. Elephant drives are not always effective. For instance studies done in Sri Lanka indicate that drives remove herds and not adult males. Fail to remove adult males which are the source of most conflict renders elephants drives an ineffective human-elephant conflict mitigation measure (Fernando, 2008). The response of elephants to being driven is partly dependent on their previous exposures to conflict with people. Failure to handle elephant drives may result in increased levels of human-elephant conflict. Driving elephants may result in habituation of elephants to these techniques and shifting of problem to new areas.

2.3.3.17 Capture and Domestication

This involves capturing and domestication of elephants. As observed by Fernando (2008), the process of domesticating elephants is difficult and expensive. In addition to this, the lifetime of elephants in captivity is short. The method of capture and domestication is an ineffectiveness human-elephant conflict mitigation technique. However, this technique has played a great role in maintaining a high level of tolerance and appreciation of elephants in parts of Asia. In situations where elephants and people do not interact, these close ties will not develop. This implies that capturing and domestication of elephants is critical as it improves tolerance and acceptance of elephants by the locals.
This makes it easier for people to tolerate elephants and support elephant conservation initiatives. The process of capturing and domestication of wild elephants has its own limitations. This makes such management be limited to a few elephants at extremely high costs. The process of keeping elephants in captivity is also expensive (Fernando, 2008).

2.3.3.18 Contraception

According to Perera (2008), this technique involves controlling elephant population using contraceptive methods. The major limitation of these methods is that the drugs are difficult to administer. Capturing free ranging elephants is also a difficult task. In addition to this, several health-related issues need to be resolved before fertility control becomes acceptable. The first attempts to use immune-contraceptive methods in elephants were made in Kruger National Park in 1996. A contraceptive vaccine elaborated with antigens from pork zone pellucid was used. This contraceptive was, however, unsuccessful. The procedure was difficult as it required several repeat injections. The procedure also required a mandatory monitoring of the vaccinated females. This resulted in aggressive behaviour both in treated females and in rutting males which were chased off by the females. A second solution explored was that of chemical castration by selectively destroying the pituitary gland cells that produce gonadotrophin (Larmaque, 2009). This system works by stopping spermatogenesis in males and ovulation in females. This inhibits sexual behaviour. The major shortfall of this method is that it is still being tested and its side effects are not known. Controlling elephant population is critical. This is because as elephant population expands, elephants extent their ranges into human settlements. Spatial overlap between elephant habitat and human settlements increases and this sparks serious conflict.
2.3.3.19 Land-use planning

Larmaque (2009) regard land-use planning as a basic human-elephant conflict management strategy. This is because it offers the best chance of long-term success. Land use planning is, therefore, a preventive approach designed to alleviate human-elephant conflict by creating landscapes in which people and elephants can co-exist (Larmaque, 2009). The technique requires government support. There is also need for legislation and policy changes in order to implement it successfully. For such strategies to be successful, they should be designed through a coordinated approach involving all government departments such as elephants and national parks, and relevant development projects. One way of addressing human-elephant conflict through land use planning involves the creation of elephant corridors and increasing elephant habitat. This involves linking of fragmented habitats. The creation of elephant corridors is one possible option for using land-use planning to prevent and mitigate human-elephant conflict (Larmaque, 2009).

This strategy can help alleviate human-elephant conflict. Perera, (2008) further emphasises that increasing the area available to elephants addresses the cause of human-elephant conflict instead of mitigating the effects. Creating elephants corridors through which animals can safely disperse and migrate between protected areas can address the human-elephant conflict issue. Creation of elephant corridors has its own major limitations. Acquiring land which is dedicated to elephants is associated with political challenges. The larger the area involved the more the stakeholders which need to be consulted. There is also need to consult many managerial levels from villages and districts to countries and governments. Creating elephants corridors also require funding to purchase and lease land and to establish and maintain them.
Establishing and maintaining large Trans Frontier Park typically requires the involvement of large international agencies such as the World Bank. Funds are also usually drawn from several international agencies and businesses. This might result in conflicting interests. The incentives of business investors who hope to gain from potential increases in tourism might be very different from those of donating conservation agencies whose goal is to preserve nature. Proper land-use planning can help decrease human-elephant conflict (Fernando, 2008). Effective land use planning should include strategies for translocation of elephants as well as management techniques. For example, where there is a development project that will change natural habitat into a form that is incompatible with elephants, the elephants in the area would need to be translocated to safe areas. Human-elephant conflict management methods entail constructing and maintaining elephant barriers on the boundary of the developed area.

This can allow the elephants to have the opportunity to move away rather than be isolated in remnant non-viable patches of habitat, which increases human-elephant conflict. Land-use planning can help identify human activities that are compatible with elephant presence. These include seasonal cultivation, forestry and tourism. Developing land use planning strategies which support elephants’ presence is critical as it ensures the co-existence of people and elephants. The realization of the consequences of such developmental activities is more likely to result in management plans that address human-elephant conflict. Decrease in human-elephant conflict brought about by land-use planning will directly benefit elephants by reducing morbidity and mortality (Larmaque, 2009).
One major limitation of land use planning is that it is expensive to implement. Hence land-use plans are rarely implemented on a large scale in Africa. Land use plans are also difficult to implement at large scale.

2.3.3.20 Role of policies in human-elephant conflict management

Policies are other strategies which can be used to address the problem of human-elephant conflict. Clear policies dealing with human-elephant conflict help to establish options that can be implemented by different stakeholders in addressing the human-elephant conflict issue. Policy implementation should be adopted through a bottom-up approach involving all stakeholders and particularly local communities. Policies should also be supported by the appropriate government departments such as those concerned with elephants. Policies are critical as they assist in formulating sound legislation and contribute to the success of human-elephant conflict management. Most African countries do not have national policies on human-elephant conflict. Namibia is one of the few African countries which have an elephant policy (Larmaque, 2009).

2.3.3.21 The role of Information systems in addressing human-elephant conflict

Advance warning of elephant movements through technologies such as GPS may help reduce human-elephant conflict. This is achieved through monitoring the movements of problem elephants which habitually raid crop, kill and injure people. Problem elephants can be monitored through GPS satellite radio collars and warn villagers of their presence in a particular location. This exercise becomes effective when a problem animal is identified. After identifying the problem elephants, the next step is collaring the problem elephants. The routes which are used by elephants when they enter the communities can be mapped.
Such information is critical as it can be used to inform the particular farmers who are at risk. The use of GPS collars is critical as it can inform land use planners on the areas which are at risk in terms different human-elephant conflict manifestations (Fernando, 2008).

2.3.3.22 Lethal human-elephant conflict mitigation measures

Lethal control involves the killing of problem elephants with the purpose of resolving the human-elephant conflict problem (Larmaque, 2009). The method has been widely used in Africa. In this case, shooting a problem causing animal is believed to be the best way of warning the others away. With lethal control stakeholders are concerned with killing problem elephants. The major challenge is that it is difficult for wildlife managers to obtain permission to shoot an animal quickly. In most instances elephants are killed to satisfy the demand for action and revenge by the aggrieved community. This especially happens in the case of loss of human life or the killing of livestock. Killing elephants is not acceptable as elephants are protected by CITES.

Wildlife managers consider the killing of problem elephants a last resort (Parks et al., 2007). Shooting an elephant while it is crop raiding has been considered the best way to teach the other elephants to stay away from crops. The meat is usually given to the people to appease their anger and to provide some form of compensation for crop loss. Printer Wolman (2012) also emphasises that lethal control techniques are mostly applied to elephants that habitually raid crops. The problem elephants may be shot. The process of identifying the problem causing animal is difficult. The killing of problem elephants is carried out by public services.
Local populations or trophy hunters can also kill problem causing elephants. Sometimes the national army can also kill problem causing animals. This was practiced in Ghana in the early 1970s. It was a common practice for rampaging elephants to be killed by a team of military personnel, in order to reduce crop damage within the Kakum conservation area.

The meat proceeds of these elephants were shared among community members as a way of compensating them for their crop loss. The culling of problem animals is usually carried out by wildlife officers. Problem animal control units are authorised to kill animals since they have all the required clearances and the necessary material available to solve human-elephant conflict. The main challenge of these human-elephant management is that most conflict zones are inaccessible. This often delays the response times. Farmers can also be involved in the elimination of problem-causing animals. Farmers can also kill elephants if their lives are at danger. However, in some countries it is illegal to kill protected species, even in self-defence. Elephant numbers can be regulated through trophy hunting (Larmaque, 2009).

Controlling problem animal using trophy hunters is a low-cost technique that has the potential to raise public tolerance towards elephants (Muruthi, 2005 in Larmaque, 2009). The proceeds obtained by the sale of licences or trophy fees can fund conservation activities and the protection of human settlements. In Namibia’s Kunene and Caprivi regions, a substantial part of the trophy fee is paid to the community and distributed through the Conservancy Committee to those who have suffered loss (Larmaque, 2009). Using lethal control as human-elephant conflict mitigation has its own limitations. The effects of culling are usually short-term. In Ghana crop damage ceased for three to five years after raiding elephants were eliminated.
The killing of problem elephants also disturbs the ecosystem function and dramatic changes in the populations of other species. It is often difficult to identify specific animals causing problems to be shot by sport hunters. Most incidents require a rapid response. Inaccessibility makes it difficult for the sport hunter to reach the location on time. In addition to this, trophy hunters seek the largest animals, while the culprit in human-elephant conflict incidents may not fit this description. The process of sport hunting requires policies and regulations. Regulated culling of animals through hunting is not always effective in reducing crop and livestock loss since the method does not ensure that the culprit is removed (Larmaque, 2009).

The method is considered unethical as killing of elephants is illegal since they are regarded as endangered species under the CITES legislation. The method does not permanently address human-elephant conflict. Response times are slow due to accessibility challenges. Elephant personnel may arrive days after the problem occurred. In most cases the elephants responsible for the damage cannot be identified. The reaction of the other elephants can be to change areas of raiding rather than to stop crop-raiding altogether. This was noted in Sengwa, Zimbabwe where elephants returned to raid crops in a field where an elephant had been killed the previous night (Larmaque, 2009).
2.4.0 GAPS IN KNOWLEDGE EXISTING IN PREVIOUS LITERATURE

This section reveals the gaps in knowledge existing in previous literature reviewed above. The gaps in knowledge are identified based upon each of the specific objectives of the study. In addition to this, the section also describes how the current research filled in some of the gaps which were left by previous researchers.

2.4.1 Gap in knowledge in literature on causes of human-elephant conflict

Previous studies considered the effects of elephants on human livelihoods without assessing the spatial factors which predict human-elephant conflict. This implies that the major gap which remains is predicting spatial determinants of human-elephant conflict. Developing solutions to the issue of human-elephant conflict requires researchers to focus on how spatial factors determine human-elephant conflict, distribution instead of concentrating on human livelihoods. Studies which focus on the effects of elephants on human livelihoods are not useful in terms of providing solutions which encourage co-existence between human land use and elephants. This study, therefore, filled this gap by establishing the causes of human-elephant conflict as well as identifying the spatial determinants which predict the location of this conflict. It is believed that this information can be employed in informing concerned stakeholders to develop long term human-elephant conflict solutions which will ensure the co-existence of elephants and humans with minimal conflict in the area of Hwange.
2.4.2 Gap in knowledge in literature on determinants of human-elephant conflict

While the major drivers of human-elephant conflict and its associated negative socio-economic effects are well understood, the spatial determinants of human-elephant conflict remain little understood. Previous researchers concentrated on understanding the socio-economic dynamics of human-elephant conflict interaction with very limited understanding of the spatial distribution of this conflict (Mutanga and Adjorloolo, 2008). In reaction to increase in human-elephant conflict near protected areas, some researchers focused on identifying the major causes of conflict as well as developing strategies to deter elephants from raiding crops from grain stores and fields. For instance, Sitati (2006)’s major objective was to develop methods to defend farms from crop raiding by elephants. Hedges (2010) and Parker (2006) attempted to develop an unpalatable chilli capsicum cash crop as a way of addressing human wildlife conflict. Such studies are crucial but they offer temporary solutions to the human-elephant conflict issue.

The deterrent methods do not permanently address the human-elephant conflict problems. Permanent solutions to the human-elephant conflict issue require an understanding of the spatial determinants of human-elephant conflict. Such knowledge is critical as it assists land use planners in developing permanent human-elephant conflict resolution strategies. Spatial analysis of human-elephant conflict remains largely unexplored as most studies presented above focused more on the perceptions of people as determinants of human-elephant conflict. However, perceptions of people on human-elephant conflict are well known since they have been largely explored. It is obvious that if elephants invade fields, injure people or damage infrastructure, people will have antagonism towards the animals.
In most cases communities can retaliate through poisoning or snaring elephants. The main issue which has received little attention from previous studies is locating human-elephant conflict hot spots. This can be achieved effectively through predicting the spatial determinants of human-elephant conflict. Such knowledge is crucial for designing long lasting solutions to human-elephant conflict.

As presented above, previous literature focused more on assessing the temporal determinants of human-elephant conflict. However, temporal and spatial determinants are well understood. There is, however, little knowledge on the spatial patterns of human-elephant conflict as this area has not been well researched. The current research, therefore, established the spatial determinants of human-elephant conflict in the area of Hwange with the intention of filling in this gap in human-elephant conflict studies. The other gap is that of knowledge on the spatial patterns of human-elephant conflict which is still little since very few studies have been carried out. The major limitation of the few studies on spatial analysis of human-elephant conflict is that they focused on crop raiding without taking other human-elephant conflict manifestations into cognisance. Such studies are incomplete as they can only provide management strategies to mitigate crop raiding and not the other forms of conflict like human death and injury, vehicle road accidents and infrastructure damage. Such studies might not be very useful in the area of Hwange since the area is affected by other forms of human-elephant conflict issues besides crop raiding. These include vehicle road accidents, human deaths and injury, and infrastructural damage. In other words, it is impossible to generalise the findings of these previous studies to Hwange since they are based on only one type of conflict which is crop damage.
The current study adopted a holistic approach by mapping the location of all the types of human-elephant conflict incidents. This research took into cognisance all the manifestations of human-elephant conflict. Such a research is relevant in Hwange as the results can be used to provide mitigation measures for all the human-elephant conflict manifestations in the area. The other limitation of the studies on the spatial determinants of human-elephant conflict is that they were carried out in other areas which are different to Hwange area in terms of geographic location and climate. For instance, Kumar et al. (2011) carried out his study in India. The ecology of Asian elephants tends to be different from that of African elephants making it difficult to generalize their models for African elephants. This implies that venturing into a similar study in Hwange was necessary.

This implies that the spatial determinants of human-elephant conflict remain unknown in the area of Hwange communal area and Victoria Falls town. Hence there was still need to venture into a related study area. This is because spatial variation of human-elephant conflict has shown few universal trends, making it difficult to predict where conflict will take place (Sitati et al., 2003) Elephants may cause severe localised damage and can destroy entire fields of crops. It is, therefore, critical to gain a thorough understanding of the problem of human-elephant conflict at a local level in order to direct mitigation strategies. This implies that it was still critical to carry out a spatial analysis of human-elephant conflict in the area of Hwange and Victoria Falls and come up with models for the area which can be used to ameliorate the negative effects of human-elephant conflict. The factors that determine spatial human-elephant conflict patterns at these sites may differ from Victoria Falls and Hwange.
2.4.3 Gap in knowledge in literature on human-elephant conflict management techniques

Previous studies which were carried out mainly by sociologists were biased towards one side as they focused more on the social template (the effects of elephants on humans) due to the prevalence of human-elephant conflict in many protected areas (Leimgruber 2003, Foley 2002, Hoare and Dutoit, 1999). In a bid to solve human-elephant conflict, researchers have emphasised on developing strategies to deter elephants from raiding crops from grain stores and fields. For instance, Sitati (2006)’s major objective was to develop methods to defend farms from crop raiding elephants. Tchamba (1996) described elephants as problem animals as they destroyed crops and caused human deaths in the Logone region of Cameroon. Hedges (2010) and Parker (2006) developed an unpalatable chilli capsicum cash crop as a way of addressing human-elephant conflict.

Hedges and Gunanyadi (2009) cite crop raiding as the most serious form of human-elephant conflict. The development of methods which prevent elephants from invading and destroying crops was considered a priority by Hedges and Gunanyadi (2009). Different forms of chilli which deter elephants from entering human settlements include chilli grease applied to rope fencing around crop fields and chilli dung which is burnt to produce a noxious smell (Hedges and Gunanyadi, 2009). Mupangwa et al. (2015) determined the levels of conflict between the Dande community of the mid Zambezi valley and the elephants. Specifically, they focused on points of conflict, the problem animal control strategies employed by the villagers against elephants and how sustainable these measures were. The study revealed that the main points of conflict were cropping fields, followed by vegetable gardens and homesteads.
However, the points of conflict were based on people’s perceptions. Such approaches are biased as they are based upon the views of a few people selected as a sample from the whole population. The current research, therefore, proposes that significant elephant hot spot conflict should be established through collecting and analyzing data objectively using statistical methods (Mupangwa et al., 2015). Developing methods of preventing elephants from entering fields is critical. However, such mitigatory and deterrent methods do not eradicate the problem. Deterrent methods only focus on the social needs of people without considering elephant conservation issues. Human-elephant conflict is a land use issue. In order to solve human-elephant conflict issue successfully, there is need to integrate human land use and elephant distribution (Brooks et al., 2010). Guerbois et al. (2009) suggests that integrating the human and elephant components is critical in understanding how elephants and humans can co-exist sustainably.

Combining elephant distribution and human land use is considered to be effective as it reduces the negative socio-economic impact of elephants on people who are in the conflict zones as well as ensuring that the conflict does not lead to the decline of the elephant populations. In addition to this, after developing the deterrent methods, the farmers need to know the location of the human-elephant conflict hot spots to put the chilli bombs. This exercise is not possible without the knowledge of the location of these hot spots in human land use. Establishing human-elephant hot spots can be effectively done through venturing into studies which analyze the influence of human land use factors on the spatial distribution of human-elephant conflict. The current study therefore, filled in this gap by establishing the determinants of human-elephant conflict as well as identifying the location of human-elephant conflict hot spots in the area of Hwange.
2.4.4 Gap in knowledge in literature on research design and methodology

One of the major gaps in previous human-elephant conflict literature lies in the research design and methodology adopted. The major shortfall of previous studies is that they were descriptive and qualitative in nature and based upon people`s perceptions. Qualitative designs are critical but they need to be complemented by scientific evidence. The current research filled this gap by adopting the non-experimental quantitative design which makes it possible to integrate human-elephant conflict presence/absence and the predictive spatial factors. Previous studies have used the qualitative designs which resulted in these studies focusing more on the socio-economic effects of elephants on humans without considering the effects of expanding human land use on elephants. The prevalence of various forms of human-elephant conflict in areas close to protected areas saw many researchers focusing on developing strategies to prevent elephants from entering human settlements.

The current research propose that solutions to human-elephant conflict requires researchers to take into cognisance both human needs and elephant conservation needs. This can objectively be achieved by adopting a quantitative approach which makes it possible to combine human needs and elephant conservation needs. Moreover, human-elephant conflict is a spatial phenomenon, implying that it is crucial for researchers to focus on establishing the location of human-elephant conflict hot spots in a given area. This can be achieved through taking into cognisance both the human land use and the elephant distribution in human-elephant conflict studies. Solutions to human-elephant conflict require researchers to focus on locating hot spots for the conflict.
This implies that there is need to quantify human-elephant conflict and hypotheses on causal factors which must be tested before any management recommendations can be made to ameliorate its effects. The current study, therefore, quantified predictive factors and human-elephant conflict in the study area. The major drawback to venture into researches on the spatial analysis of human-elephant conflict has been attributed to technological limitations which made it impossible to collect human-elephant conflict spatial data on human land use and natural variables. The major limitation was the absence of an instrument for collecting spatial data such human-elephant location and environmental factors. The advent of the satellite linked GPS receiver instrument has made it possible to collect human-elephant conflict data (Forley, 2002). The introduction of the GIS software has allowed spatial data analysis through the integration of human-elephant conflict data and human land use data layers. This has made it possible for elephants ecologists to establish the main factors affecting the distribution of human-elephant conflict across landscapes (Ngene, 2009).

The introduction of GIS has made it possible to collect and analyze spatial data and this has seen few researchers venture into spatial analysis of human-elephant conflict. The current research, therefore, filled this gap by using GIS instruments which include the GPS and the digitizing technique to collect spatial data on human-elephant conflict and spatial predictive factors. The current research employed the GIS softwares to carry out a spatial analysis of human-elephant location data and the spatial predictive factors. Spatial analysis of human-elephant conflict is critical as it can assist policy makers and relevant stakeholders in developing effective human-elephant conflict resolution measures.
Considering human-elephant conflict from a spatial perspective is critical as the problem of human-elephant is a spatial issue. Land use planning is critical as it has been observed to be the basic human-elephant conflict management strategy which offers the best chance of long term success. Unlike strategies for mitigation and protection, land use planning tackles the root cause of the problem. It is a preventative approach designed to alleviate human-elephant conflict by creating landscapes in which people and elephants can co-exist sustainably. Land use is a long term process which requires government support, legislation and policy changes (Lar macque et al., 2009). The process of land use planning should be designated through a coordinated approach involving all stakeholders concerned such as elephant managers, Ministry of Lands and Rural Resettlement, village herds and councillors. Coordinated planning promotes planning with both the ecological and socio-economic development vision.

However, convincing land use planners to allocate land with both the ecological and the socio-economic development vision requires researchers to refocus their attention from assessing the socio-economic implications of elephants on the livelihoods of people and concentrate on researches which deal with the spatial analysis of human-elephant conflict. Studies of this nature are critical as the root cause of human-elephant conflict lies with land use planners, implying that human-elephant conflict is a spatial issue. Establishing how elephants respond when agriculture and settlements activities located at the periphery of elephants sanctuary is considered to be the best way of convincing land use planners to allocate land to settlements and agriculture activities with the understanding of the associated negative consequences.
It has been observed that crop raiding occurs when farmers grow food crops close to areas inhabited by elephants. This situation has been noted in most conservation areas of Zimbabwe where human-elephant conflict started when agriculture and settlement activities encroached into areas which were formerly reserved for elephants. Therefore, resolving the issue of human-elephant conflict requires land use planners to come up with effective land use planning policies which deal with the problem of human-elephant conflict effectively. Larmaque et al. (2009) suggested that the most practical land use planning techniques for managing human-elephant conflict with farming communities is to remove agriculture from elephant ranges. Moving crop fields from the forest edge close to settlements and reducing settlements encroachment into elephants range by repositioning the boundaries of protected areas or creating buffer zones is considered another strategy to address human-elephant conflict. This means that the best approach to the issue of human-elephant conflict is the clear designation of areas suitable for human activities and areas devoted to elephants.

In other words, spatial analysis of human-elephant conflict remains largely unexplored. This implies that the causative underlying factors of human-elephant conflict have not been explored from a spatial perspective. It is believed that failure to do spatial analysis of human-elephant conflict is the major reason why human-elephant conflict continues to be a major problem in situations where agriculture communities are located at the periphery of the park. Human-elephant conflict is a spatial issue, implying that its solutions lie with land use planners such as the District Administrator, Ministry of Lands and Rural Resettlement, councillors and village herds.
Hence solutions to human-elephant conflict depend on the nature of human-elephant conflict studies and the type of evidence which is available to convince the land use planners to plan with both the ecological (elephants conservation) and sociological vision. This can be effectively achieved through predicting the spatial determinants of human-elephant conflict. However, most previous researchers reacted to the issue of human-elephant conflict by focusing more on the socio-economic concerns of people as elephants were wreaking havoc by destroying crops, infrastructure and causing death to people in areas situated at the periphery of the elephants refugee areas. The motive behind these studies was to develop strategies of preventing elephants from entering human settlements (Tchamba 1996, Sitati 2006, Hedges 2010). The other group of studies focused on the assessment of the typology of the human-elephant conflict, the causes and consequences of the conflict on the livelihoods of people and food security (Parks, 2007, and Hedges, 2006).

These previous studies have yielded important information on human-elephant conflict. However, the motive behind most of these studies was to portray elephants as pests which greatly threaten food security in order to convince responsible authorities to compensate villagers for the loss and damage caused by elephants. Such motives have been in vain as the wildlife policy of Zimbabwe does not have the provision for compensating the damage and loss caused by elephants (Gandiwa, 2013). This implies that dealing with the problem of human-elephant conflict is more difficult and complex. This is because in most cases farmers cry for compensation which is not possible as the policy does not have this provision.
Faced with such a dilemma, the effective solution is to deal with the root cause of these human-elephant conflict in order to come up with long term solutions to the issue. It is perceived that human-elephant conflict is a spatial phenomenon. This implies that the root cause of human-elephant conflict is to do with land use planning, whereby responsible authorities settle people near elephant areas without any knowledge of the implications. In this case human-elephant conflict issues can be solved successfully through integrating research and land use planning. Convincing land use planners in conservation areas to plan with both the ecological and sociological vision requires researchers to produce evidence. Human-elephant conflict is a spatial issue, there is need to venture into studies on the spatial analysis of human-elephant conflict. Predicting the influence of spatial variables on human-elephant conflict is perceived to be the best way to provide long term solutions to human-elephant conflict issues.

Such studies inform planners about the type of human land use which attract elephants to human settlements and, at the same time, convince these responsible authorities to allocate land for agriculture and settlements while considering the negative ecological and social implications of such activities to both elephants and people close to the parks. Solutions to human-elephant conflict require land use planning approaches that attempt to separate agricultural activities from elephant habitat and movement corridors. The plan should account for key elephant habitats in order to reduce human-elephant conflict. Land use planning that entails identification and zoning of separate areas for farming, settlements, elephant habitats and restriction of agricultural development in known elephant corridors (Larmaque et al. 2009). This has a great potential for offering effective solutions to the problem of human-elephant conflict.
The problem of human-elephant conflict is a sensitive issue as it is associated with negative ecological and socio-economic concerns. This usually means that humans, who are affected, suffer more than the elephants themselves. For instance, when humans kill elephants as a way of retaliating for the loss and damage to crops and human lives, they are blamed and tagged as threat to biodiversity. Current policies attach higher value to elephants over humans. For instance, Zimbabwe ratified CITES which regards elephants as endangered species, which should be conserved. Hence elephant poaching, illegal hunting or retaliatory killing is a major offence which attracts a sentence of imprisonment. In Zimbabwe this situation is worsened by the fact that the wildlife policy does not have a provision for compensation for loss and damage caused by elephants. In most cases, human-elephant conflict issues become a major cause for concern when it involves the death of elephants.

Faced with such a controversial issue, there is now need for Zimbabwe to come up with a land use planning policy which ensures that elephants thrive in the face of expanding human land use. The land use planning policy may be supported with legislations which prohibits unplanned cultivations in known elephant corridors. However, policy makers need convincing evidence based research in order to craft new policies. This implies that researchers need to venture into studies on the spatial analysis of human-elephant conflict so as to establish the causative underlying factors influencing the spatial distribution of human-elephant conflict. Researches should focus more on the spatial analysis of human-elephant conflict than concentrating on assessing the implications of elephants on human livelihoods. Spatial analysis of human-elephant conflict is critical since human-elephant conflict is a spatial issue.
Such information can be used to convince land use planners to allocate land with both the ecological and the socio-economic development vision. Such an approach is critical as it addresses the root cause of the problem. Policy is critical as it influences the way a particular land is used. The blame goes back to researchers because policy makers only craft policy based upon gathered scientific evidence. This means that there is need for researchers to establish how the elephants respond to the expanding agriculture and other human land use which are sprouting at the periphery of the park. Such scientific based evidence research can act as a basis of human-elephant conflict mitigation measures which address the issue, sustainably. The information can guide the authorities responsible for allocating land for agriculture. This is perceived as the best strategy which can eradicate the problem of human-elephant conflict now and in the future. The land use planning policy can prohibit agricultural activities near parks and reserve such areas for tourism and recreational activities.

Once people are settled near the parks, it is difficult to address the negative consequences. In this case humans suffer the negative consequences more because they are not protected as the wildlife policy of Zimbabwe does not mention anything to do with compensating humans for the loss and damage caused by elephants. Elephants are, however, legally protected by CITES and retaliatory killing may attract imprisonment. It is better to tackle the root cause of the problem of human-elephant conflict by revising the land use planning policies because dealing with the consequences of human-elephant conflict appears to be more complex. This study, therefore, filled the gap existing in previous researches by predicting factors influencing the spatial distribution of human-elephant conflict.
It is hoped that the results can act as an eye opener to the land use planners to take cognisance of both the ecological and socioeconomic development vision so as to create a scenario where humans and elephants co-exist sustainably. The current research contributed to existing knowledge on the spatial predictors of human-elephant conflict. This is because the greatest challenge in Hwange so far is to develop elephant management options in the context of increasing human and elephant densities (Guerbois et al. 2012). The major challenge is to design strategies that ensure sustainable management of elephants while fulfilling the social needs of the local communities (Newmark and Hough, 2000). The critical questions which the current research needs to provide answers for are: How is the probability of elephant presence related to distance from human land use? What strategies can be adopted to ensure sustainable co-existence between elephants and human land use in the area?

Understanding the spatial determinants of human-elephant conflict helps wildlife managers to develop management options which ensure the persistence of elephant in landscapes dominated by a mosaic of expanding human land use. Researches on predicting spatial determinants of human-elephant conflict are critical in the provision of land use planning approaches which separate agricultural activities from elephants habitat and movement corridors. Effective land use planning provides the best approach to successfully mitigate for human elephants conflict in the long term. Human-elephant conflict mitigation measures should integrate human land use with elephant distribution. Guerbois et al. (2012) indicated that the analysis of spatial data at relevant scales of the interface should yield an in depth understanding of the conflict process and hence predictive models.
2.5 Chapter summary

The chapter explored the conceptual framework of the study. In this case the main concepts guiding the study were discussed. These included co-existence of humans and elephants, an increase in elephant numbers, and increase in human population. In a situation where humans and elephants co-exist, the increase in either humans or elephants causes serious conflict as the two species compete for space and other critical resources. The overarching CBNRM theoretical framework informing the research was discussed. CAMPFIRE is the type of CBNRM theoretical framework of the research. The increase in human-elephant conflict has however challenged the sustainability of the CAMPFIRE theoretical framework. As various manifestations of human-elephant conflict incidents are increasing, this is forcing people living near conservation areas to resent elephants. This compromises the conservation efforts. The situation is worsened by the fact that retaliatory killing of elephants through poisoning or snaring is regarded as a serious offence as elephants are protected by CITES.

The chapter also examined previous human-elephant conflict researches. Researches on the spatial analysis of human-elephant conflict have received little attention. Most documented studies focused on the socio-economic concerns and developed strategies to prevent elephants from entering human settlements. The links between the current study and previously accumulated knowledge on human-elephant relation studies was established. The chapter critically reviewed related literature by identifying the knowledge gaps in existing literature in terms of methodology used or ideas left out in previous studies. The major gap in knowledge, which previous studies left out, is discussed in greater detail in this chapter.
CHAPTER THREE

RESEARCH METHODOLOGY AND DESIGN

3.0 Chapter introduction

Chapter 3 presents the research methodology and design of the study. The positivist research paradigm which forms the philosophical dimensions of the research is explored in detail in this chapter. This is because Creswell (2008) suggests that when planning for a research, the researcher needs to think through the philosophical worldview assumptions brought to the study, strategy of inquiry or methodology related to this worldview and the specific methods or procedures of research. This implies that there should be an interconnection between worldviews, methodologies and research design. Crotty (1998) also emphasizes that there should be an interrelationship between research paradigm, research methodology and research design adopted by the researcher. The quantitative research methodology which is the ideological foundation of the research is among key issues highlighted in this chapter.

The non-experimental research design which is the ideological framework which guided the data collection, analysis and interpretation procedures is explored in greater detail in this chapter. The chapter describes the key instruments used for data collection for the research. These include the GPS Garmin Etrex 10 receiver, the digitizing instrument and the observation instrument. The administration and application of the research instruments in gathering spatial data on human-elephant conflict and predictive factors is well explained in this chapter.
The different GIS softwares and the statistical techniques which were employed for analysis, presentation and interpretation of data are among key issues covered in chapter 3. The preceding chapters have highlighted the fact that the major issue which needs to be addressed by the current research is human-elephant conflict. The prevalence of the issue of human-elephant conflict indicates that the methodologies and methods used by previous researchers are failing to provide effective solutions to the problem of human-elephant conflict. These studies focused on the assessment of the socio-economic effects of elephants on the livelihoods of people since elephants were wreaking havoc in human settlements. These previous studies adopted qualitative approaches. The intentions of these previous studies were to develop strategies of preventing elephants from entering human settlements. However, the researches only focused on the effects of elephants on people’s livelihoods, implying that the spatial patterns of human-elephant conflict is not well understood. Such information is incomplete as the studies are one sided.

The current research, therefore, adopted a different approach in carrying out human-elephant conflict research. This approach has been adopted by a few researchers. The approach involved considering spatial issues in human-elephant conflict. This study determined the spatial predictors of human-elephant conflict so as to establish the factors which influence human-elephant conflict across the human landscape. The uniqueness of this study is that it employed GIS techniques and statistical tools to establish the spatial predictors of human-elephant conflict. This was achieved through quantifying various factors across the human landscape and analyse them using different statistical tools. Spatial analysis of human-elephant conflict is considered to be the best approach in human-elephant conflict studies.
Human-elephant conflict is a spatial issue and researches which analyses the issue from a spatial perspective is effective as the results can inform land use planners on the need to allocate land to socio-economic development and at the same time consider elephant conservation issues.

### 3.1.0 Research Paradigm

Research paradigm is a perspective about research held by a community of researchers that is based on a set of shared assumptions, concepts, values and practices (Barks, 1995). Research paradigm forms the philosophical dimensions of research. It is a set of fundamental assumptions and beliefs as to how the world is perceived. Paradigm serves as a thinking framework that guides the researcher’s behaviour (Wahyuni, 2012). It is critical as it influences how one undertakes a study. The type of a research paradigm selected for a particular study is determined by the discipline area of the student and past research experience (Creswell, 2008). In addition to this, research paradigm also has to be congruent with the researchers’ epistemology (Gray, 2014). Positivism is the research paradigm which was adopted for this study.

#### 3.1.1 Positivist research paradigm

Positivism is the philosophical foundation that guided the researcher’s theory of knowledge in this study. The positivist epistemological paradigm argues that the world exists externally to the researcher and its properties can be measured directly through observation. Positivists argue that reality consists of what is available to the senses which are what can be seen, smelt and touched. As suggested by Richard and Poetschke (2003), positivists believe that it is possible to observe what happens and understand it without mediation. Hence inquiry should be based upon scientific observation as opposed to philosophical speculation.
Positivism is based upon the view that the natural and human senses share common logical and methodological principles dealing with facts and values (Gray, 2014). This implies that ideas can only be incorporated into knowledge if they can be tested empirically. Positivists believe in accumulating knowledge about the real world in order to produce generalisations known as scientific laws (Gray, 2014). The positivist research paradigm advocates the use of a scientific approach by developing numerical measures to generate knowledge (Wahyuni, 2012). Methods associated with this paradigm are quantitative. The research comments with the test of theory in the form of a hypothesis and involve statistical tests with the objective of obtaining theories which are generalisable (Wahyuni, 2012). Positivists believe that different researchers observing the same factual problem will generate similar results by carefully using statistical tests applying a similar research process in investigating a large sample (Creswell, 2009). The common belief among positivism is the existence of a universal generalisation that can be applied across contexts. Positivists believe that there are general patterns of cause and effects that can be used as a basis for predicting and controlling natural phenomena.

### 3.1.2 Justification for selecting the positivist paradigm

The rationale for selecting the positivist paradigm was determined by the nature of the problem under investigation, the researcher’s discipline area as well as past research experience. The researcher trained in rangeland ecology at master’s level and has vast experience in carrying out quantitative studies on issues related to wildlife. The positivist paradigm was adopted for the research because of the following key strength: Positivists believe that there is minimum room for error when carrying out research as there is set rules followed. The method is objective as it uses mathematical and scientific tools.
The positivist paradigm was selected despite the major limitations of objectivity and absolute reality for the following key reason. An objective study to establish the spatial predictors of human-elephant conflict was crucial. The effects of elephants on humans have been established and are well known. In other words, the feelings, perceptions and attitudes of people towards elephants have been largely explored while spatial predictors of human-elephant conflict across the human landscape are not well understood. Soliciting people’s perceptions on human-elephant conflict is critical but this does not assist much in solving the issue. This is because human-elephant conflict is a spatial issue which is related to land use.

Solutions to human-elephant conflict require researchers to carry out spatial analysis of human-elephant conflict so as to convince land use planners to take in cognisance elephant conservation and socio-economic development when allocating land to different human land use. As a positivist, the researcher believed that there was an objective reality about human-elephant conflict issues which needed to be investigated despite the local people’s feelings towards elephants and human-elephant conflict issue. It was crucial to venture into study which objectively models the spatial predictors of human-elephant conflict. Such an approach is critical as it provides management options which ensure the sustainable co-existence of humans and elephants.
3.1.3 Limitations of the positivist paradigm

The major drawback of the approach is inflexibility since positivists believe that everything is measurable. This means that the approach is not applicable in cases where the data to be collected is not quantifiable. For this research the approach is not relevant as it deals with numerical data only. The other major limitation of the positivist paradigm is objectivity and absolute reality. For this particular research, it was not necessary to establish the feelings, values, opinions and perceptions of people towards elephants as this area has been widely researched. This implies that the only gap left was to establish the spatial predictors of human-elephant conflict across the human landscape. Such information is crucial as it can be used to convince land use planners to plan with the ecological and socioeconomic vision.

3.1.4 Ontology

Ontology is the nature of existence and what constitutes reality. For positivists the world exists independently of our knowledge of it (Creswell, 2008). In the case of the current research, the researcher believed that the determinants of human-elephant conflict exist independent of her knowledge. Hence establishing the spatial determinants of human-elephant conflict needed to be done objectively through scientific methods.
3.1.5 Epistemology

Epistemology is the theory of knowledge and it provides a philosophical background to research. Epistemology clarifies issues of research design such as the design of research tools (Gray, 2014). It also guides the overarching structure of research including the data collection and interpretation techniques. The philosophy underlying the positivist research paradigm is the objectivist epistemology (Gray, 2014). The objectivist epistemology holds that reality exists independently of consciousness. In other words there is an objective reality out there, so research is about discovering this objective truth. Objectivists strive not to include their feelings and values when conducting research (Gray, 2014). The researcher was guided by the objectivist epistemology in designing tools for data collection, analysis and interpretation. The objectivist stance made the researcher believe that there is an objective reality about human-elephant conflict which needs to be discovered. In data collection, analysis and interpretation, the researcher was guided by the objectivist philosophy and, hence carried out the study without including her feelings, values and perceptions in the research.

3.2.0 Research methodology

Rajasekar (2013) defines research methodology as a systematic way to solve a problem. It is a science of studying how research is to be carried out. It refers to the procedures by which researchers go about their work of describing, explaining and predicting phenomena (Wahyuni, 2012). The research methodology is a theoretical and ideological foundation of the research method. The research methodology which was adopted for the study is quantitative.
3.2.1.0 Quantitative research methodology

The structure of the quantitative research methodology uses the scientific method which follows the following research procedure: making observations, hypotheses formulation, numerical data collection, data analysis through statistics and mathematical formulae and conclusion (Shuttleworth, 2008). Scientific method is a series of steps used to investigate a problem. The goal of the scientific method is to come up with reliable answers and solutions. The process of experimentation used explores observations and answers questions. Scientific research methods are techniques used to gather quantitative data which can be sorted, classified and measured (Macdonald and Headlam 1986).

According to Creswell (2008), data collection procedures for scientific studies are predetermined. The data are collected using the observation research tool. Data analysis and interpretation are done using statistical tools. Scientists use the scientific method to search for cause and effect relationships. It is a process used to validate observations while minimizing bias. The goal of scientific method is for research to be conducted in a fair, unbiased and repeatable manner (Ryan and Callaghan, 2015). The scientific methods are objective. This implies that the variables are measured objectively using instruments so as to generate numerical data which is analyzed using statistical procedures. As suggested by Gray (2014), objectivist stance holds that reality exists independently of consciousness. Objectivists regard research as a way of discovering the objective truth. This implies that objectivistic researchers should not include their own feeling and values when carrying out research.
3.2.2 Justification for the selection of the quantitative methodology

The researcher employed the quantitative methodology since it has the following key advantages: The quantitative design employs the scientific method which is a critical component of positivism and empiricism (Cohen, 2006). The data from quantitative research is numerical and usually generalisable to other contexts. The use of quantitative designs in research is regarded as an excellent way of finalizing results and proving or disapproving or hypotheses. Results gained from quantitative designs are real and unbiased (Shuttleworth, 2008). The choice of a research methodology was also influenced by the worldview assumptions that the researcher brings to the study, the methods of data collection, analysis and interpretation (Creswell, 2008). The positivist worldview assumption selected for the study is positivism, a theoretical perspective which is closely linked to quantitative designs. Data gathering, analysis, and interpretation methods adopted for this research were also quantitative. The researcher’s objectivist epistemological stance is a key feature of quantitative methodology.

3.2.3 Limitations of the quantitative methodology

The major limitation of the quantitative methodology is that quantitative experiments can be difficult and expensive and require a lot of time to perform. The quantitative experiments must be carefully planned to ensure randomization and correct designation of control groups (Shuttleworth, 2008). This study adopted the non-experimental research design which does not require treatments and control groups. Quantitative data collected require extensive statistical analysis which can be difficult for scientists who are not statisticians. To overcome this shortfall, the researcher was conversant with all the statistical tools which were used for data analysis and data collection for this particular research.
3.3.0 Research design

Creswell (2008) defines research design as a plan and procedure for research that span decisions from broad assumptions to detailed methods of data collection and analysis. Research design refers to the overall strategy that is chosen to investigate the different components of the study so as to effectively address the research problem (Labaree, 2009). It can also be defined as a detailed outline of how an investigation is carried out. A research design describes the process of data collection, the type of instruments employed and a detailed explanation of how the instruments were used during data collection. Research design also defines the study type, for instance, whether it is experimental or quasi-experimental (Labaree, 2009). The research problem determines the type of design that should be chosen. The non-experimental research design is the type of design that guided the data collection, analysis and interpretation methods for this research.

3.3.1 Non-experimental research design

According to Bell (2008), non-experimental research refers to any quantitative study without manipulation of treatments or random assignment. In non-experimental research, variables of interest are not manipulated by the researcher. Instead, the variables are studied as they exist from in the natural world. Hence the researcher is a passive agent who observes measures and describes a phenomenon in its natural setting without manipulating independent variables. Integral to this inquiry is the absence of manipulation of the independent variables as well as the absence of random assignment of variables (Barks, 1995). Non-experimental designs are used in situations where data collection through true experimental designs is impossible. In this study the variables used for the study could not be manipulated.
For instance, it was impossible to manipulate human-elephant conflict presence or absence and the spatial predictors which were used for the non-experimental research. The non-experimental design involves testing of theories by examining the relationships among variables. The variables are measured objectively using instruments so as to generate numerical data which is analyzed using statistical procedures. The non-experimental design tests theories deductively to produce generalisable findings (Creswell, 2008). The focus of the non-experimental design is to test theories through hypotheses and data collection to refute or support the hypotheses (Barks, 1995). The non-experimental research design attempts to maximize objectivity, replicability and generalisability of findings as scientists believe that there is a single truth that exists despite people’s perceptions and opinions. The choice and use of methods used for data collection, analysis and interpretation for this research were governed by the ideologies of the non-experimental research design. This is because the variables are not manipulated for ethical reasons. The procedures for data collection, analysis and interpretation are scientific and they will be explained in detail later.

3.3.2 Justification of the selection of non-experimental research design

The non-experimental research was adopted because in ecology many independence and dependent variables cannot be manipulated for ethical reasons, practical reasons or literal reasons where it is impossible to manipulate some variables. The independent variables used for the study were inherently not manipulated. For instance, it was impossible to manipulate the presence or absence of human-elephant conflict as well as GIS and remote sensing data layers. The non-experimental research was feasible in this case as experimental designs are not feasible for this particular study.
For this study, it was critical to predict the spatial determinants of human-elephant conflict but it was not feasible to manipulate the independent variables, hence the adoption of the non-experimental design. The researcher employed the non-experimental design since it has the following key advantages: The design employs the scientific method which is linked to positivism and empiricism (Cohen, 2006). The data from quantitative research is numerical and usually generalisable to other contexts. The use of quantitative designs in research is regarded as an excellent way of finalizing results and proving or disapproving hypotheses. Results gained from the experimental designs are real and unbiased (Shuttleworth, 2008). The researcher’s personal experiences have also prompted the adoption of the non-experimental quantitative design. The researcher trained in courses related to wildlife ecology.

In this regard, the researcher is well equipped with skills of quantifying human land use data, such as settlements, crop fields and mine dumps using GIS techniques. The design is appropriate as the researcher possesses skills of utilizing the spatial capabilities of GIS and statistical tools in Excel and SPSS to analyze spatial data such as human-elephant conflict location and spatial data layers. The choice of a research design is influenced by the worldview assumption that the researcher brings to the study, the research methodology or the strategy of inquiry and the methods of data collection, analysis and interpretation (Creswell, 2008). The researcher’s objectivist epistemological stance is a key feature of quantitative designs.
3.3.3 Limitations of the non-experimental research design

The major deficiencies of this type of design are the absence of manipulation of independent variable as well as randomization which makes the evidence gathered weaker and limited (Creswell, 2008). The non-experimental research design has limitations in studying cause and effect compared to strong experimental research. The conclusions of cause and effect are much weaker in non-experimental research compared to strong experimental design. In non-experimental research, one cannot be certain that outcome differences are due to the independent variables under investigation. To overcome this shortfall, the researcher needs to consider possible alternative explanations, to jointly analyze several variables to present conclusions without making definite causal statements. The other limitation of the non-experimental quantitative design is that quantitative experiments can be difficult and expensive and require a lot of time to perform. The quantitative experiments must be carefully planned to ensure randomization and correct designation of control groups (Shuttleworth, 2008). This study adopted the non-experimental research design which does not require treatment and a control group.

3.4.0 DATA COLLECTION

This section presents the data collection procedures adopted for the research. Data collection procedures were guided by the ideologies of the non-experimental research design which is discussed in detail in section 3.3.1. The research adopted a non-experimental design. This implies that there was no randomisation or manipulation of the variables which were measured during the process of data collection.
Manipulation and randomisation of the variables under study was impossible as the variables are natural features which cannot be moved and studied in the laboratory. In ecology and geography, experiments are conducted in the natural environment as variables are naturally occurring, making it impractical and impossible for ecologists to conduct most experiments in the laboratory. For instance, the two variables which were used in the experiment included human-elephant conflict presence/absence and the spatial factors.

The two variables are naturally occurring phenomena and could not be studied using pure laboratory experiments. This means that the researcher went into the natural environment to collect data for the experiment. Data collection involved measuring the location of all human-elephant conflict incidents in UTM coordinate system. Some spatial factors were also observed and measured during the field survey. The data obtained in this case was used to test the hypotheses of the non-experimental research. This section, therefore, explores the procedures adopted by the researcher to collect data which were used to test the hypotheses of the study in greater detail.

3.4.1.0 Population and sampling procedures

3.4.1.1 Population

Population is a set of all possible items that possess the same characteristics or that have the knowledge of the phenomenon being investigated (Umaru, 2009). In this study the target population included the Victoria Falls Wildlife Trust which provided information on the historical records of human-elephant conflict sites and the community members who assisted with the verification of the occurrence of human-elephant incidents to ensure data reliability.
3.4.1.2 Sampling procedure for selecting the study area

Spatial data on human-elephant conflict presence or absence and the spatial predictive factors were drawn from an elephant range of 4377km². In elephant ecology, results can be generalized to other contexts if the study was carried out in an area which is bigger than that of the elephants range. The size of the range where this study was carried out is 4377 km² which is more or equal to the average size of a home range of an African Elephants (loxodonta africana) which is estimated to be between 14km² -3 120km² (Macdonald, 2001). This makes the sample representative.

The sample of the study area was selected (Figure 1) from the settlements and agricultural areas located at the periphery of national parks and protected areas such as forests. Human-elephant conflict was observed to be common where human land use, such as settlements and cultivation, are located at the periphery of the park (Hoare, 1999). The sample included areas such as Victoria Falls town, Hwange West communal area and the Resettlement area. The study area was selected using the technique of digitizing satellite images available from Google earth.

3.4.1.3 Purposive sampling procedure for selecting the research subjects

A sample is a subset of the population. The sample size is the number of population elements that are selected for investigation (Umaru, 2009). In this study purposive sampling was employed to select the survey team since the researcher needed to work with the people who supply information. This type of sampling is non-probability sampling method in which the investigator does not necessarily have a quota to fill from various strata in quota sampling.
In this case the researcher uses his/her own judgment about which respondents to select and identify only those who can give the relevant information (Umaru, 2009). This method is used to try to obtain a representative sample by directing the area from which the choice is made. The sampling method is purposive in that a certain proportion of the sample must come from a certain group. Purposive sampling seeks to gain access to the individuals with the necessary information and then select a sample that is appropriate for a particular study. Purposive sample is biased, but more likely to be represented.

In some instances purposive sampling is sometimes mixed with random sampling to avoid bias. However, for this study it was not necessary to use random sampling since there was need to select the respondents who assist with relevant information on records of human-elephant conflict data in order to fulfil the objectives of the study. The only advantage of this type of sampling is that the researcher can use his/her own skills to choose respondents. This technique was used to select the people who could provide the relevant information of human-elephant conflict location in the study area. The Victoria Falls Wildlife Trust was identified as a source of information for the historical records of human-elephant conflict. This organization runs a human-elephant conflict project. The project involves monitoring the conflict hotline and working with local communities to address the human-elephant conflict problem. One of the members from the Victoria Falls Wildlife research trust showed the researcher around the areas where human-elephant conflict had been reported.
The research assistant helps with managing the human-elephant conflict hotline and responding to the local community reports of conflict incidents at the wildlife research trust. The researcher also conveniently or purposively selected community members used for verifying the human-elephant conflict which were recorded by Victoria Falls Elephants. In this case locals selected are the adults who have been staying in the area for more than 20 years. The assumption in this case was that these people could assist in identifying elephants routes based upon their local knowledge. This criterion is supported by Smith and Kasiki (2000) who suggested that experience form Taita Taveta shows that a great deal of information on traditional elephants routes can be obtained by consulting with long term local residents. In this research people who were conveniently sampled were asked to identify the positions of elephant routes which were recorded with a GPS.

3.4.2 DATA COLLECTION INSTRUMENTS

Data collection instrument is a device for collecting data or measuring the variables which have been isolated for investigation or used for answering research questions (Umaru, 2009). In quantitative studies data collection instruments are predetermined. The researcher uses the standard instruments which are predetermined for collecting data for a particular type of research. Hence the instruments used for collecting data for this research are standard instruments set by ecologists to collect data on naturally occurring phenomena such as geographic data. The main research instruments used for the study are the GIS tools which include the Global Positioning System (GPS) for human-elephant conflict data collection, digitizing for collecting spatial data on predictive variables and the observation tool. The observation tool was used for human-elephant conflict data collection.
3.4.3.0 Digitizing instrument

The location of the human land use and natural variables were obtained through digitizing satellite images made available in Google Earth (www.Googleearth.com). Digitizing involves converting an analogue map from Google earth into a computer compatible and computer readable format (digital data).

3.4.3.1 Strengths and weaknesses of the digitizing technique

The major advantage of the digitizing technique is that it is regarded as the best method for georeferencing. The technique has got limitations which should be taken care of in order to produce reliable data. The methods used to create digital data need extensive checking and correcting to produce a reliable product. The quality of the data depends on the age and resolution of the maps used. Validating digital maps requires extensive ground truthing. The errors should be reduced by using the best data sources and trained personnel to collect and process this information. To overcome these limitations, the researcher had to do extensive ground truthing in order to validate the digitized images and to verify the mapped unit attributes or the correctness of desk top visual interpretation (Kusena, 2009). The main purpose of ground truthing was to verify the digitized classes against the ground scenario. Ground truthing was carried out during the field survey.

3.4.4.0 Global Positioning System (GPS) instrument

GPS is a satellite based technology used for navigation and location of geographic features. The GPS system is made up of a network of 24 satellites placed into orbit by the U.S Department of defence.
The GPS satellites circle the earth twice a day and transmit signal information to the earth. The GPS receivers take this information and use trilateration to calculate the user’s exact position. The type of GPS receiver which was used for this study is the GPS Garmin Etrex 10 equipment. The GPS Garmin was used to record information on the location human-elephant conflict sites, as well as the position of spatial factors such as fields, settlements, water points, forests and the park.

### 3.4.4.1 Strengths and weaknesses of the GPS instrument

GPS is a reliable GIS data source. The GPS is accurate in locating the position of an object on earth. It can provide the GIS system with data on the location of geographic objects. Such information can be used for spatial analysis. However, it is impossible to produce error free spatial data. Errors occur when measuring geographical location which depends on the accuracy of the instruments used and surveying skills of the people involved (Smith and Kasiki, 2000). This limitation was not applicable to the researcher as she has the skills of using the GPS. During data collection the researcher recorded the coordinates of features when the GPS error was less than 3 metres. Another limitation of the GPS is that it is usable everywhere except where it is impossible to obtain signals for instance under water, inside most buildings and caves. For this research this limitation was not relevant because the GPS was used in open space not inside buildings or under water.
3.4.5.0 Observation instrument

Observation is a technique that involves systematically selecting, watching and recording behaviour and characteristics of living beings, objects or phenomena (Marshall and Ross man, 1989). An observation technique was employed in collecting human-elephant conflict data. The technique of observation was used to collect data on the potential determinants of human-elephant conflict during the survey. So after recording the coordinates of each of the human-elephant conflict site, the researcher took time to observe and record information on factors that are likely to determine human-elephant conflict near the human-elephant conflict site. This information included water points, presence of crop fields and settlements, forest remnants and protected areas. The observation tool was used to collect data on the types of human-elephant conflict in each study area. Some of the information observed was recorded using a video camera.

3.4.5.1 Strengths and weaknesses of the observation method

The major strength of the observation technique is that it is a holistic way of understanding of the phenomena under study as objectively and accurately as possible. The method is complementary with other methods and hence allows the use of more than one technique in data collection through tri-angulations (Kawulich (2005). The observation technique has its own limitations. For instance, the method is time consuming and resource intensive. To address this, ample time was allocated for data collection as well as budgeting enough money for the research. The method is susceptible to observer bias as the researcher is the data collection instrument. The presence of the observer influences the behaviour of those being observed. This might undermine the validity and reliability of the data collected (Kawulich, 2005).
However, this limitation is not applicable to this particular research as it did not involve observing elephant behaviour but the presence/absence of human-elephant conflict across the selected study area.

3.4.6 Pilot survey and planning for the field work

The researcher sought permission to enter human settlements prior to the field studies using an introductory letter from the Department of Higher Degrees. Planning for the field survey also included making bookings for accommodation at N1 Hotel in Victoria Falls as well as liaising with the Victoria Falls Wildlife Trust who assisted the researcher in the process of data collection. A reconnaissance of the study area was done before going into the field to determine the accessibility of the area. The equipment used during data collection, which included data sheets, pens, and hand held GPS Garmin Etrex 10, were gathered prior the day of data collection. The geographical limits for the sites to be surveyed were determined prior to the study. Satellite images of the Google map for the site were prepared, digitized and geo-referenced base map for the study site were obtained prior to the field research. A reconnaissance survey was carried out prior to the survey to familiarize with the study area as well as take note of accessibility of the area (Hedges, 2006). The pilot survey was critical as it allowed the prediction of logistical problems to be faced by the surveying team as well as identifying training needs for the survey teams.
3.4.7 Pretesting the GPS instrument

The GPS Garmin receiver equipment was pre-tested to check if it was in good working condition so as to identify faults before the process of data collection began. After checking the instrument, a pre-test or trial run of the data collection instrument was conducted. The pre-test involved recording coordinates of selected points in the study area to test if the GPS was in a good working condition. The GPS was also set to record coordinates using the UTM coordinate system. The datum was set to ellipsoid WGS 84. Spare batteries were purchased for the GPS so as to avoid running out of batteries during the survey.

3.4.8 Training the research assistants or the survey team

This process involved explaining the purpose of the project to the survey team. Logistical issues and the time and point of meeting were some of the issues discussed prior to data collection day. The researcher also took this opportunity to train the research assistant to record coordinates from the field. Fortunately, the research assistant from Victoria Falls Wildlife Trust was well conversant with using the GPS as well as recording and downloading the GPS data at the end of each session.
3.5.0 DATA COLLECTION PROCEDURES

3.5.1.0 Administration and application of instruments

The recording of the spatial data on human-elephant conflict location and other predictive factors was done over a period of two weeks. The administration and application of the research instruments for this research were guided by the ideologies of the non-experimental quantitative research design. This means that the experiment took place in the natural settings, implying that data were collected from the field, not the lab. The data collected using this non-experimental design included the location of the human-elephant conflict site in UTM coordinates and the spatial factors such as water, forests, park, elephant corridor and fields and settlements.

In this case random assignment and manipulation of the variables was impossible as the researcher was dealing with natural phenomena. The following section describes the processes of data collection procedures adopted for the study. The administration and application of instruments were predetermined since the study was guided by the philosophies of quantitative methodology. This implies that the researcher followed the standard procedures which are used by ecologists when they use the GPS receiver, digitizing and the observation instrument for collecting data on spatial predictive factors and human-elephant conflict presence or absence.
3.5.1.1 Application of the Global Positioning System (GPS) instrument for human-elephant conflict data collection

The GPS instrument was employed to collect data on the presence or absence of human-elephant conflict incidents (Appendix 2a, 2b, 2c). Human-elephant conflict location data were recorded as presence/absence since there were some areas where human-elephant conflict incidents had not taken place. The present study recorded human-elephant conflict incidents in a 4377km² elephants range. The data were collected from the areas which included Victoria Falls town, Hwange communal areas and Resettlement areas of Mubiya, Don Rovin and Kalala. Separate data were collected for each area. This was because the researcher noted that the spatial factors and the human-elephant conflict types in each area were unique.

The GPS instrument was also used to record the position of spatial factors such as water points, fields and settlements, park boundary and elephant routes. Data on the location of human-elephant conflict and spatial factors were recorded on the data sheet (Appendix 3). The researcher obtained historical information on the sites where human-elephant conflict incidents had been reported. This information was obtained from Victoria Falls Elephant Trust. The site of each incident was revisited to record its exact location (Sitati et al., 2003). Each human-elephant conflict incident was re-visited for verification purposes and for recording the location in Universal Transverse Mercator coordinate system using Garmin GPS satellite navigation unit. Human-elephant conflict data were collected as presence (1) or absence (0) from the study area. This means that each type of human-elephant conflict was binary coded into presence and absence (Sitati et al., 2003) and recorded on the data collection sheet.
The local people`s knowledge was used to identify areas which are frequented by elephants in the area. The coordinates of the areas which are not frequented by elephants were recorded and this formed human-elephant conflict absence data. Plate 1 depicts one of the photographs of the researcher being accompanied to a site where someone was attacked and injured by an elephant in the Ndlovu area.

Plate 1 The researcher navigating to the conflict sites (Source: field survey)

In this case, the researcher was accompanied to the conflict sites by a member from Victoria Falls elephants trust. The task of walking on the loose kalahali sands was difficult. This was worsened by high temperatures. Upon arrival to each of the conflict sites, the research recorded the location of the conflict site in UTM coordinates using a GPS navigating unit. The researcher verified each human-elephant conflict incident with community members near the human-elephant conflict site to improve data reliability.
Community members also assisted in identifying the positions of elephant routes in their villages. Plate 2 shows one of the photographs of the researcher (right) with a community member (left).

Plate 2 Community member (left) showing the researcher (right) elephants routes (Source: field survey)

Verifying the occurrence of human-elephant conflict incidents was crucial. In most cases community members selected conveniently provided important information that was not existing in historical human-elephant conflict records from Victoria Falls elephants trust. This technique of using locals in human-elephant studies was used in Taita Taveta where information on elephant routes was obtained through consulting with long term local residents (Smith and Kasiki, 2000). For this research, the community members selected conveniently were used to assist in identifying the areas which were not frequented by elephants.
The location of these areas was also recorded in UTM coordinates. Such information formed human-elephant conflict absence data. The technique of collecting data with the assistance of local communities is known as participatory GIS. Participatory GIS is a tool that incorporates local expertise and knowledge with technical expertise (Mutanga and Adjorlolo, 2008). Dunn (2008) defines participatory GIS as a practice which is based on using geo-spatial information management tools to represent people’s local spatial knowledge. Such an approach provides an efficient and effective way of mapping the spatial distribution of human-elephant conflict. A total of 130 coordinate points of human-elephant conflict incidents were collected for analysis.

3.5.1.2 Strengths and weaknesses of the participatory Geographic Information (PGIS)

The key strength of PGSI lies in its ability to combine people’s local spatial knowledge of the area and external knowledge from environmental experts (Bally, 2002). The technique of PGIS improves information sharing between the outsiders and local people (Mc Call, 2004). However, one major weakness of PGIS data are that it is based on people’s knowledge and perceptions. To use this data effectively requires a dialogue between the community members and the environmental expert. This is done to improve the robustness of the PGIS data and to highlight the confidence with which the data can be used for further analysis. The human-elephant conflict was in the form of crop raiding, infrastructural damage accidents, road accidents, human injuries and death. Due to the rarity of incidents of human deaths during the survey, historic incidents were investigated. Dung piles and spoors or vegetation damage were also used as surrogates of elephants presence and absence. For this research distinguished spoors and dung were used to verify the elephant presence or absence in the affected areas.
The use of spoor, dung and vegetation damage as surrogates of presence or absence of elephants is referred to as index methods (Beer, 2008). The index method is an indirect measurement of the status of animal population in an area (World Wide Fund for Nature, 2000). At each conflict site, the researcher also searched for the signs which show the presence of elephants indirectly.

### 3.5.1.3 Advantages and disadvantages of dung index method

The method is easy to apply and it is cheap and affordable (Barnes, 1996). The advantage of the method is that observers walking on foot through out elephants areas capture elephant presence / absence indicators (dung). The method is also cheaper compared to the other methods of estimating elephant distributions like aircraft surveys. Dung piles are easier to find than the elephants themselves since they live in concealed habitat such as forests. They also produce precise estimates compared to direct sighting based surveys such as aero plane surveys (Barnes, 2002). One major shortfall of dung count is that it cannot be conducted in flooded areas (Hedges, 2006). This makes dung counts unsuitable for permanent swamps. The area where the data were collected was not flooded.
3.5.1.4 Identifying the potential spatial determinants of human-elephant conflict

Before digitizing, one of the critical steps was identifying the factors which have a potential of influencing the spatial distribution of human-elephant conflict incidents in the area. In choosing the factors which influence human-elephant conflict the researcher also considered those factors which can be measured within the time frame of the research. The factors were identified in line with previous studies, as well as the researcher’s knowledge of the area. Most human-elephant conflict incidents involve crop raiding so the presence of agricultural fields is a potential human-elephant conflict determinant (Smith and Kasiki, 2000). The area of Hwange is generally dry. Elephants may be present near water sources as the elephants require large amounts of water (Smith and Kasiki, 2000). Elephants are likely to raid crops close to protected areas as protected areas provide habitat for elephants.

A protected area is an important human-elephant conflict determinant (Smith and Kasiki, 2000). Kusena (2009) considered land parcel with a mixture of land cover classes such cultivation, settlements and water body to be high human-elephant conflict predictors. Ngene (2009) investigated the factors which influence the distribution of African elephants in Kenya. Ngene (2009) focused on the effects of the following variables on the elephant distribution: (agriculture, settlements, surface water availability, roads). The study by Ngene (2009) indicated that distance from drinking water, distance from settlements and distance from minor roads are the key human factors observed to be contributing to the observed variation in elephant distribution. Though the study was not based on human-elephant conflict issues, it can be used as a basis of estimating the factors which may influence the presence of elephants.
Hence the study was also used to identify potential human-elephant conflict determinants. Pittiglio (2012) carried out a related study to determine the factors which predict the presence of elephants. Distance from permanent water sources, distance from protected areas, and distance from settlements were the significant human factors explaining elephant distribution in Tarangire National Park. The study was not based on human-elephant conflict but it was used as a basis of estimating the factors which may influence the presence of elephants. Hence the study was also used to identify potential human-elephant conflict determinants.

Sibanda and Murwira (2012) tested whether cotton fields contribute more than cereal fields to African elephant habitat loss through its effects on woodland fragmentation in the Zambezi Valley. The study indicated that cotton cultivation is a major driver of elephant habitat fragmentation in the area. Cotton was observed to contribute more to the habitat fragmentation of woodland at the frontier where there are new agricultural fields. Murwira and Skidmore (2005) also tested whether and how the probability of African elephants presence was related to spatial heterogeneity of vegetation cover in the agriculture landscape of the Sebungwe region in Zimbabwe. Specifically, Murwira and Skidmore (2005) tested whether the spatial changes in the intensity and dominant scale of spatial heterogeneity of agricultural landscape of the Sebungwe region. The spatial heterogeneity can reliably predict elephant distribution in an agriculture landscape (Murwira and Skidmore, 2005). These studies identified factors which can influence where elephants can be found. Hence the studies were used to identify potential determinants of human-elephant conflict for the research.
Another study in Hwange was based on the assessment of the interactions between elephant population densities with surface water availability and vegetation cover (Chamaille-Jammes, 2007). Elephant densities across the park tended to increase with vegetation productivity and increased asymptotically with the density of artificial water holes. The study was not assessing human-elephant conflict issues but it was also used to identify potential human-elephant conflict. Based upon previous studies and the information obtained during the survey, the following factors were identified as potential determinants of human-elephant conflict for the study area: agriculture fields and settlements, surface water availability, roads and protected areas. Fields and settlements were joined because during the survey the researcher observed that fields were located in settlements.

3.5.1.5 Application of the digitizing technique to collect data on spatial predictive factors

Data for the independent variables that might determine the spatial patterns of human-elephant conflict by their effect on human density or elephant density and movement patterns were obtained from digitizing images available in Google earth. Google earth is a virtual global programme allowing viewers to visualize data on top of displayed satellite images of the earth’s surface (Crossley, 2008). Google earth focuses on geovisualization. Google earth records coordinates at extremely high levels of precision. The technique of visual interpretation was used through screen digitizing of human land use and some natural variables. Visual interpretation was used for creating polygons, points and line data with the imagery of Google earth in the background of the computer. Validation for the digitized images was achieved through ground truthing. The main purpose of ground truthing was done to verify the digitized classes against the actual ground scenario.
3.5.1.6 Application of the observation instrument during data collection process

The technique of observation was employed to collect data on the potential determinants of human-elephant conflict in the study area. In this case the researcher observed the factors which might potentially determine human-elephant conflict during the survey. These included water availability, settlements, fields, elephant routes and forests. Data on the location of these factors were recorded in UTM coordinates. The researcher used the observation technique to look out for signs of elephant presence indices near each of the human-elephant conflict site. At each of the human-elephant conflict site, the researcher observed and recorded the evidence of the occurrence of the human-elephant conflict in situations where this information was available.

3.6.0 DATA ANALYSIS AND INTERPRETATION PROCEDURES

The non-experimental quantitative ideology guides the selection of the technique for data presentation, analysis and interpretation. This implies that the techniques for data analysis, presentation and interpretation are predetermined. Hence the researcher employed the predetermined procedures which are used by ecological scientist when analysing and presenting spatial data. The following section explores the different methods employed for analysis and interpretation of the spatial data collected for this research.

3.6.1 Geographic Information System Soft wares

GIS soft wares were used for data analysis. These included Arc View, Integrated Land and Water Information Systems (ILWIS). GIS was also used to present spatial geographic information for this research. It is crucial to define this technical term before explaining how it was used by the researcher for data collection, analysis and presentation.
GIS is a computer based system that provides the following capabilities for handling geo-referenced data: input, storage, analysis and presentation of geo-referenced information (Smith and Kasiki, 2000). The major data input sources for GIS include digitizing, Global Positioning System (GPS) and remote sensing. GIS has data management capabilities for storage and retrieval of geo-referenced data. The geo-referenced information can be analysed using various GIS softwares. GIS also have capabilities of presenting spatial data in the form of maps. GIS can also produce quantitative geographic information which can be analysed using different statistical techniques. The spatial analytical capabilities of GIS provide an effective and efficient means to manage the information required to understand the spatial patterns of human-elephant conflict.

Recent technologies such as GIS are being used for the input, storage, manipulation, analysis and display of geographic information (Mutanga and Adjourlolo, 2008). Human-elephant conflict is a spatial phenomenon and so it is important to investigate the factors which influence human-elephant conflict from a spatial perspective. GIS should be incorporated in the analysis of human-elephant conflict. GIS allows the integration and manipulation of spatial data and can be used to predict the effects of human-elephant conflict mitigation measures. This research presents a GIS based analysis of human-elephant conflict in the area of Hwange. The strength of GIS lies in its ability to manipulate spatial data. Spatial reasoning has received limited attention in ecological studies. Human-elephant conflict studies have focused on other factors not on the spatial patterns (Guerbois, et al., 2012). GIS and other statistical methods provide a means for predicting the spatial human-elephant conflict determinants.
Habitat suitability models can also be used to predict human-elephant conflict hot spots. GIS can be applied to integrate spatial human-elephant conflict data and predictive factors across the landscape. A spatially explicit predictive modelling approach is capable of linking environmental factors with human-elephant conflict data. This approach provides a powerful and flexible analytical framework for human-elephant conflict studies as it integrates human-elephant conflict with different factors (Prasad et al., 2011). This is critical as it enhances understanding of underlying trends of human-elephant conflict from a spatial perspective. The results can be crucial in developing effective mitigation strategies such as alternative land use and livelihoods which do not attract human-elephant conflict.

The predictive models analyses the complex interrelationships among various environmental factors that exist over a geographical area. These factors include forest type, topology, water resource and distance from human land use (Danks and Klein, 2001). Predictive models focus on using available information on species habitat requirements in a GIS to identify where elephants are likely to be found in a given area. Studies on habitat modelling focus on predicting the likelihood of the presence of elephants in a given area (Danks and Klein, 2001). This is mostly achieved by overlaying sighting information or presence or absence data on environmental variables.
This information is used to predict the potential species habitat ranges and distribution maps. GIS based technologies provide efficient means of modelling the spatial distribution of elephant populations across the human landscape (Danks and Klein, 2001). For this research the geographic information is in the form of human-elephant conflict location and spatial predictive factors across the study area. The following section shows how the spatial data were analysed in GIS softwares.

3.6.2 Geo referencing spatial data in ILWIS GIS Software

Geo referencing is the process of assigning coordinates from a known reference system such as latitude and longitude to the coordinates of a raster map. It is also referred to as the way features and information are assigned location near the earth’s surface. The earth is not a sphere but rather a lumpy ellipsoid. A datum is a simplification of the sphere of the earth which defines how latitude and longitude and elevation values are associated with particular points on the surface of the earth. Google earth uses WGS 84 which is the world geodetic system of 1984.

Creating Google earth features defines spatial positions of points using three values of latitudes X, longitude Y and altitude Z. In order to transform the 3 dimensional maps, some distortions of areas, distances, angles, and directions occur. A projection is a way of compromising to achieve this flattening, causing distortions in particular parts of the world. Google earth uses a simple cylindrical projection known as the lat/long WGES 84 (Crossley, 2008). This is because geographic coordinates represent the earth as a curved surface.
Hence to represent the curved part of the earth on a flat piece of paper or computer screen, the geographic coordinate system of the shape files were transformed to plane / Cartesian coordinates using the Universal Transverse Mercator (UTM) projection which results from warping the cylinder round the poles. This means that all spatial data for this research used the projection WGS 1984 and UTM zone 35k. Data for the digitized points, lines and polygons of the predictive factors from Google earth were imported into Arc view GIS 3.2 and converted into shape files. The shape files were then imported into ILWIS GIS where they were geo-referenced to geographic coordinate system which is latitude longitude. The X, Y coordinates of presence/absence of human-elephant conflict were imported into ILWIS via Excel. The data were converted into shape files in ILWIS.

3.6.3 Quantifying predictive factors using the overlay analysis function in ILWIS GIS

Overlay analysis is a type of spatial data analysis. The spatial-analytic capabilities of GIS distinguish it from other processing systems. These capabilities use the spatial data in the data base to answer questions to solve problems. The principle objective of spatial data analysis is to transform and combine data from different sources into useful information (Rolf, 2001). It can be used in prediction. For this study spatial analysis was used in the prediction of spatial factors which significantly predict human-elephant conflict. For this study spatial analysis was employed to quantify the predictive factors such as water, settlements, park, forests and buffer zones.
The overlay functions forms the core computational activity of many GIS applications. Data layers are combined and new information is derived by creating features in a new layer (Rolf, 2001). For this research, the overlay analysis function in ILWIS GIS software was used to combine human-elephant conflict location data with spatial factors. These computations were done using the raster data layers of spatial factors. The overlay analysis function was used to combine human-elephant conflict location data with raster data layers of spatial factors converted into distance maps (appendix 1a, 1b and 1c). The distance values for each predictive factor were extracted at each human-elephant conflict location using the map value function in ILWIS.

The distance surfaces show the change of distance from the data layers such as settlements, water points, and agricultural fields. The ILWIS GIS software was used to create distance surfaces for all the predictor variables (ITC, 2003). The map value function used takes the following form: Distance of spatial factors from human-elephant conflict location=Mapvalue (predictive factor distance map, coordinate(x, y)). This resulted in creation of a new layer of distance values at each human-elephant conflict location. Table 3.1 depicts an example of the distance values extracted at each human-elephant location using the map value function in ILWIS GIS.
The extracted human-elephant conflict location values and corresponding distances values (table 3.1) for all for each spatial factor were exported to SPSS via Excel.

Table 3.1 Distance values extracted at each human-elephant conflict location in ILWIS GIS

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
<th>hec</th>
<th>parkboundary</th>
<th>artificialwater</th>
<th>urbansettlement</th>
<th>road</th>
</tr>
</thead>
<tbody>
<tr>
<td>376154.2</td>
<td>8016118.</td>
<td>0.0</td>
<td>1713.4</td>
<td>1843.1</td>
<td>2065.7</td>
<td>718.3</td>
</tr>
<tr>
<td>375875.1</td>
<td>8016256.</td>
<td>0.0</td>
<td>1957.3</td>
<td>1870.2</td>
<td>1848.9</td>
<td>420.1</td>
</tr>
<tr>
<td>375682.6</td>
<td>8015713.</td>
<td>0.0</td>
<td>1498.5</td>
<td>1326.2</td>
<td>1475.2</td>
<td>439.5</td>
</tr>
<tr>
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<td>8015304.</td>
<td>0.0</td>
<td>1239.0</td>
<td>1239.0</td>
<td>352.4</td>
<td>449.2</td>
</tr>
<tr>
<td>375151.3</td>
<td>8015823.</td>
<td>0.0</td>
<td>1825.6</td>
<td>1533.3</td>
<td>971.9</td>
<td>114.2</td>
</tr>
<tr>
<td>374455.0</td>
<td>8015581.</td>
<td>0.0</td>
<td>1469.4</td>
<td>1569.8</td>
<td>365.9</td>
<td>697.0</td>
</tr>
<tr>
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<td>2303.8</td>
<td>2054.1</td>
<td>989.3</td>
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<td>2392.9</td>
<td>46.5</td>
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</tr>
<tr>
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<td>1.0</td>
<td>1122.9</td>
<td>1759.8</td>
<td>9.7</td>
<td>1062.9</td>
</tr>
<tr>
<td>373976.5</td>
<td>8015543.</td>
<td>1.0</td>
<td>1291.3</td>
<td>1849.9</td>
<td>0.0</td>
<td>1149.0</td>
</tr>
<tr>
<td>374154.2</td>
<td>8015721.</td>
<td>1.0</td>
<td>1517.0</td>
<td>1819.8</td>
<td>36.8</td>
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</tr>
<tr>
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<td>1.0</td>
<td>1616.6</td>
<td>1912.8</td>
<td>22.2</td>
<td>1062.9</td>
</tr>
<tr>
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<td>8015940.</td>
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<td>1713.4</td>
<td>2056.0</td>
<td>145.2</td>
<td>1171.3</td>
</tr>
<tr>
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<td>1.0</td>
<td>1575.9</td>
<td>2059.9</td>
<td>0.0</td>
<td>1349.4</td>
</tr>
<tr>
<td>374480.5</td>
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<td>768.6</td>
<td>1097.7</td>
<td>9.7</td>
<td>424.0</td>
</tr>
</tbody>
</table>

3.6.4 Testing for multi co linearity using correlation analysis in SPSS

Multi co-linearity is when variables are highly correlated. The problem with multi co-linearity is that when variables are highly correlated it is difficult to identify the unique contribution of each variable in predicting the dependent variables. This is because the highly correlated variables predict the same variance in the dependent variable. For this research, correlations above 0.9 were considered to indicate multi co-linearity. Multi co-linearity was tested in SPSS using bivariate correlation. In SPSS, the data were tested for normality using the Kol Mogorov Smirnov test before correlation. The data were considered to be normally distributed if P>0.05. Spearman’s Rank correlation was used for analysis because the data were normally distributed. A correlation matrix was used to identify predictor variables which are strongly correlated.
Two factors found to have a correlation >0.9 were considered to be strongly correlated (Ngene, 2013). In this case one of the factors which were highly correlated was removed from logistic regression analysis. This is because if X variables are highly correlated, they convey the same information (Fowler 1998). Table 3.2 depicts how the distances of predictive factors were correlated in SPSS.

Table 3.2 Bivariate correlations between predictive spatial factors in SPSS

![SPSS Data Editor with Bivariate correlation output]

3.6.5 Predicting spatial determinants of human-elephant conflict using logistic regression in SPSS.

The Logistic Regression model was used to test whether there is a significant relationship between predictive factors and human-elephant conflict presence/absence in SPSS.
The logistic regression model was used to predict the spatial factors which significantly predict human-elephant conflict. It is a statistical technique allowing researchers to create predictive models. The technique is most useful for understanding the influence of several independent variables on a single dichotomous outcome variable (Robinson, 2015). The slope, the intercept coefficients, as well as the p-values were considered in selecting the predictive factors which significantly predict the chances of human-elephant occurrence. The rationale for selecting the logistic regression model for data analysis is that elephant data were recorded as presence (1) or absence (0) since there were some sections where human-elephant conflict had not been experienced. Logistic regression is well suited for describing and testing hypotheses about relationships between binary variables and predictive spatial factors. For this study, the logistic regression model was used to test the relationship between the quantitative predictive variables and human-elephant conflict location. The logistic regression model was used to determine the spatial factors which significantly predict the probability of human-elephant conflict. The predictor variables were considered to be significant if P>0.05. The type of logistic regression model employed for the study is the binary logistic regression.

Binary logistic regression is a regression technique which estimates the probability of an event occurring. The binary logistic regression technique describes the relationship between a categorical binary variable and a set of predictor or explanatory variables. The rationale for selecting the binary logistic regression model is that it is the only way in which the relationship between quantitative predictor variables and quantitative binary responses can be modelled (Miller, 1980). In ecology, logistic regression models are used in determining the factors that are related to the presence/absence of wild animals.
For this particular research, binary logistic regression was used to describe the relationship between quantitative predictor variables and human-elephant conflict. Developing predictive models of binary logistic regression enhances our understanding of the causative spatial factors underlying the patterns of human-elephant conflict. Such information is critical in developing mitigation measures which encourages the co-existence of humans and elephants. The major advantage of logistic regression is that independent variables do not have to be normally distributed. Logistic regression also does not assume a linear relationship. Table 3.3 depicts an example of one of the spatial factor and corresponding distance values exported to SPSS.

Table 3.3 Binary logistic regression in SPSS

3.6.6 Shortfalls of logistic regression

The logistic regression model attempts to predict outcomes based on a set of independent variables, including the wrong independent variables the model will have little or no value.
This implies that logistic regression is not a useful tool unless researchers have identified all the relevant independent variables (Robinson, 2015). To overcome this shortfall, the predictive independent variables were carefully selected based upon previous studies on human-elephant conflict and other studies which investigated the factors that are likely to influence the distribution of elephants. The factors were also selected based upon field observations done during the survey. The logistic regression works well for predicting categorical outcomes but it cannot predict continuous outcomes. This shortfall does not apply to this research because the variables which were used for prediction are categorical (presence/absence of human-elephant conflict). Another major disadvantage of logistic regression is that each data point should be independent of all data points. If observations are related to one another, then the model will tend to overweight the significance of these observations. To overcome this shortfall the predictor variables were tested for multi co-linearity before logistic regression analysis. The variables which were strongly correlated were dropped from logistic regression analysis.

3.7.0 DATA PRESENTATION

3.7.1 Graphs

A graph is a pictorial representation of the relationship between two or more variables. They appeal to the visual memory and are an effective way of presenting data. Plotted graphs are the type of graphs used for presenting data in this research. Plotted graphs are used for presenting data on the relationship between two or more variables. The type of plotted graph used for this research is the logistic regression graph. These graphs were constructed for the factors which significantly predicted human-elephant conflict location only.
Logistic regression graphs were used to show the relationship between the probability of human-elephant conflict presence and spatial predictive factors. Logistic regression graphs which were used to present the results were constructed in Microsoft Excel. The following equation was used to construct logistic regression graphs in Excel: Human-elephant conflict probability = \frac{\exp(B_0 + B_1 \times \text{predictive variable})}{1 + \exp(B_0 + B_1 \times \text{predictive variable})}, where B_0 = \text{Intercept}, B_1 = \text{Slope (Constant)}. The probability of human-elephant conflict presence was plotted against each of the significant spatial predictors. This was done to determine whether the relationship between the spatial predictors was negatively or positively related with the presence of human-elephant conflict in the study area.

3.7.2 Maps
GIS maps were used to present spatial data for this research. The types of maps used for presenting spatial data are vector and raster data models. The vector data models represent geographic data in the form of points, lines, and polygons. Vector data models represent entities with well-defined boundaries. Points are used to represent objects that are best described as single locality features, such as settlements, water points. Lines represent one-dimensional objects such as roads and rivers. Polygons represent features with boundaries such as fields. The raster data model represents data as a rectangular matrix of numbers. The raster data model is used to present spatially continuous variables, such as digital elevation model and temperature (Smith and Kasiki, 2000). The raster model was used to present data on distance maps (see appendix 1a, 1b, 1c). Maps are an extremely important management tool as they can display complex information in a form that is quickly understood. They are ideal in illustrating results from human-elephant conflict research.
Maps can be used to displaying human-elephant conflict data are to produce maps which illustrate levels of human-elephant conflict density (Smith and Kasiki, 2000). For this research maps were produced to show the results on the spatial distribution of human-elephant conflict.

3.7.3 Tables

Tables were used to present the research findings. A table is the most appropriate way to present numerical data in a concise, accurate and structured form. The primary purpose of a table is to communicate information and allow appropriate comparison.

3.8 VALIDITY, RELIABILITY AND GENERALIZABILITY

Validity, reliability and generalisability are the three key concepts in quantitative studies. All these concepts have got to do with measurement (Muijs, 2004).

3.8.1 Validity

According to Muijs (2004), validity asks the question: Are we measuring what we want to measure? For this research the instruments used measured what they had been developed to measure. For instance the GPS Garmin receiver was used to measure the location of human-elephant conflict sites in UTM coordinates. The instrument of digitizing measured the spatial predictive factors as planned.
3.8.2 Reliability of data collection instruments

Reliability refers to the ability to measure something consistently and repeatedly. It is the degree to which an instrument measures the same way each time it is used under the same condition with the same subjects. Reliability relates to the consistence or dependability of a measure. If it is reliable, the researcher is confident that all the items that make up the measure are consistent with each other and that if you were to use the same measure again with the same individuals, they will be related similarly to the first time. In other words reliability refers to the extent to which measurements are free of measurement error. The following section describes the reliability of the instruments which were used for data collection for this research.

3.8.3 Reliability of the digitizing instrument

To ensure data reliability, the researcher followed the standard digitizing procedures set by ecologists. This is because data collection process for this research is guided by the ideologies of the non-experimental design in which data collection procedures are predetermined. Digitizing is a reliable technique used to gather GIS data in ecological research. It has been used by several researchers to collect digital data on spatial variables. Producing reliable data using the technique of digitizing requires expertise. In order to produce reliable spatial data on predictive factors the researcher took note of the necessary quality control checks. Hence the researcher considered following critical factors in digitizing the spatial factors. According to Smith and Kasiki (2000), the methods used to create digital data need extensive checking and correcting to produce a reliable product. The quality of the data depends on the age and resolution of the maps used.
Smith and Kasiki (2000) emphasises that validating digital maps require extensive ground truthing. For this research the errors were reduced by using the best data sources and trained personnel to collect and process this information. The source of the spatial data for this research is the Google earth for 2016. Ground truthing was done to validate the digitized images and to verify the mapped unit attributes or the correctness of desk top visual interpretation (Kusena, 2009). The main purpose of ground truthing was to verify the digitized classes against the ground scenario. Hence data obtained from digitizing predictive factors is accurate and reliable such that repeated measurement of the spatial factors and human-elephant conflict location can yield the same results.

3.8.4 Reliability of the GPS instrument

To ensure data reliability, the researcher followed all the standard procedures which should be followed when collecting data using a GPS receiver. This is because the procedures for data collection and the use of instruments are predetermined in quantitative studies. The task of the researcher is to follow the standard procedures of data collection and using instruments to ensure data reliability. The GPS instrument is a recognised method of data input for a GIS system. However, the instrument should be used by a trained person in order to obtain reliable results. This limitation was not applicable to this study as the researcher has the skills of using the GPS. To ensure that reliable information is obtained, the researcher tested the GPS instrument before the survey. During data collection the researcher recorded the coordinates of features when the GPS error was less than 3 metres.
The researcher is confident that data obtained using the GPS receiver instrument is accurate and reliable such that repeated measurements of spatial factors and human-elephant conflict data can yield the same measurements.

3.8.5 Generalisability

Generalisability is the extent to which the findings of a study can be applied externally or more broadly outside the study context. It refers to the strength of the conclusions, inferences or propositions. In ecology, studies on elephants can only make sense from an ecological perspective if the results are derived from a study area which is equal to or more than the average size of the home range of an African elephants which is approximately 14km$^2$ - 3 120km$^2$ (Macdonald, 2001). The results from this study can be generalised as the study area is bigger (4377km$^2$) than the average size of the range of an African elephant.

3.9.0 ETHICAL ISSUES

3.9.1 Ethical issues in data collection

Though the main objective was to record the location of the site of human-elephant conflict incidents, the local people were used to verify this information. The following section describes the ethical issues which were considered during the verification process. The first important step was to gain the agreement of individuals in authority to enter the identified communities. This was achieved through the writing of a letter to the authorities of the different areas where human-elephant conflict data were collected.
The researcher also wrote an email to the Victoria Falls elephants research trust requesting historical records of sites where human-elephant conflict had been reported. The researcher also requested Victoria Falls Wildlife Trust to provide a person who is experienced in interacting with elephants and other wildlife. In the letter the researcher specified the main objective of the study, the time frame of the study and the intended outcome of the research. The introductory letter from Zimbabwe Open University was used by the researcher to gain entry into the communities. During the survey the researcher visited all the areas where human-elephant conflict incidents had been recorded in order to record the coordinates of the human-elephant conflict sites. The researcher also verified the occurrence of the conflict from the community members close to each human-elephant conflict site.

During the survey the researcher protected the few people who were conveniently sampled in order to verify the occurrence of human-elephant conflict incidents. This is because Creswell (2008) emphasised that during data collection, the researcher should protect participants and to develop trust with them so as to promote research integrity and guard against misconduct. Protection of participants means that the researcher did not obtain information from vulnerable people like the minors, pregnant women and the mentally incompetent people. In situations where elephant induced human death occurred, the researcher did not interview the family members of the bereaved for ethical considerations. The researcher also ensured that the research sites were left undisturbed after data collection.
During the collection of data on human-elephant conflict presence / absence the principle of ethical issues in animal researches which is the 3 R’s principle was observed. The 3R’s stand for reduction, refinement and replacement was observed (Ferdowsian, 2011). Reduction means reducing the number of animals used during the experiment. Refinement means the researcher is supposed to limit the suffering, pain on animals during experimental studies. Replacement means the researcher is encouraged to use alternative methods during the study instead of using live animals (Ferdowsian, 2011). For this study all the ethical issues for animal researches were observed as the data collection processes did not involve experimenting with live elephants.

3.9.2 Ethical issues in data analysis and interpretation

There is need for good ethical decisions during data collection and interpretation. Creswell (2008) noted that the researcher should avoid inventing findings to meet his/her own expected result. Creswell (2008) regards such acts as fraudulent practices which are not acceptable in professional research communities. Such acts constitute a scientific act of misconduct (Israel, 2006). The researcher considered all these factors during the process of data analysis and interpretation. The factors which could not predict human-elephant conflict in the area were dropped even if the researcher expected those factors to be significant determinants of human-elephant conflict. For instance, during data analysis the researcher observed that though distance to water and distance to settlements predicted human-elephant conflict in other studies, this was not so with the current study. However, the researcher presented these results as they were without inventing the results to meet her expectations. This was done to prevent scientific misconduct which can make conclusions unreliable.
3.10 Chapter summary

This chapter examined the research methodology employed for the study. The paradigm informing the current research was explained in detail in chapter three. The chapter also describes the non-experimental research, which is the research design guiding the methods for data collection and analysis procedures for this research. The main GIS techniques used for data collection, which are digitizing and GPS, were described. The procedure for collecting human-elephant conflict data were explained in detail. The chapter also described how the human land use and natural factors were acquired through the digitizing process in Google earth. Finally, the data analysis and presentation procedures are among the key issues highlighted in chapter 3.
CHAPTER 4

DATA PRESENTATION, ANALYSIS, DISCUSSION AND INTERPRETATION

4.0 Chapter introduction

Chapter 4 presents, analyses, discusses and interprets the findings of the research. Results presents in this chapter were collected from Victoria Falls town, Hwange West communal area and the Resettlement areas of Kalala, Don Rovin and Mubiya. This chapter is divided into 2 sections. The first section presents and analyses the findings of the research. The second section discusses and interprets the findings of the research. In this chapter results are presented based upon each of the following specific objectives of the study: identifying the causes of human-elephant conflict, predicting the spatial determinants of the probability of human-elephant conflict, identifying intervention methods used to minimize human-elephant conflict. For this research, data analysis, presentation, discussion and interpretation is guided by the quantitative ideologies. The data are analysed objectively using statistical tools so as to establish the objective reality about human-elephant conflict. The feelings and values of the researcher are set aside during the process of data analysis. This is done to establish the objective reality about human-elephant conflict which exists independently of consciousness.
4.1.0 DATA PRESENTATION AND ANALYSIS

This section analyses the data collected from the survey in order to obtain usable and useful information that can assist policy makers in addressing the challenges of human-elephant conflict experienced in the area. The data are summarized into tables and graphs and described. The spatial determinants of human-elephant conflict probability are thus revealed. The study tests the hypotheses that human land use and natural factors determine the spatial distribution of human-elephant conflict. Data analysis and presentation section, therefore, tests the proposed hypothesis in order to reveal the significant factors which influence human-elephant conflict in the area of Hwange. Spatial factors which determine the vulnerability of human-elephant conflict in the study area are thus revealed. Data presentation and analysis is done separately for Victoria Falls town, Hwange West communal area and the resettlement areas. This is because during the survey the researcher observed that the forms of human-elephant conflict in the urban area of Victoria Falls were different from those of Hwange communal area and the resettlement areas. Therefore, the researcher also assumed that the determinants of human-elephant conflict across the three areas may also be unique; implying that management options required in each human-elephant conflict are may also be different.

4.1.1.0 Objective 1: To Predict the spatial determinants of the human-elephant conflict probability

The principal objective of this study was to predict the spatial factors which influence human-elephant conflict in Hwange. This section presents the results on the significant determinants of human-elephant conflict in Victoria Falls town, Hwange communal area and the Resettlement areas of Don Rovin, Mubiya and Kalala.
Results presented in this section are obtained from the analysis of human-elephant conflict presence/absence data and spatial factors. Human-elephant conflict presence/absence data for all the three study areas are shown in appendix 2a, 2b and 2c. Data on the spatial factors used to predict human-elephant conflict for the three study area are depicted in appendix 1a, 1b and 1c. The spatial factors depicted in appendix 1 are in the form of distance maps. Appendix 1 shows the distance maps for different factors used for predicting human-elephant conflict probability in the study area. These spatial factors were converted to distance maps as the main objective of the study was to predict the spatial factors which determine human-elephant conflict using distance from each of the spatial factors across the study area. Human-elephant conflict data and spatial factors is analysed in order to identify the factors which significantly influence the occurrence of human-elephant conflict.

4.1.1.1 Finding the significant spatial factors which influence human-elephant conflict in Victoria Falls, Hwange communal area and Resettlement

The following section presents the results from bivariate correlations. Bivariate correlation was done in SPSS in order to establish significant spatial determinants of the chances of human-elephant conflict occurrences across the area of study.
Table 4.1 Bivariate correlations between factors used in the analysis for Victoria Falls town

<table>
<thead>
<tr>
<th></th>
<th>Park boundary</th>
<th>Artificial water</th>
<th>Urban settlements</th>
<th>road</th>
<th>Buffer zone</th>
<th>fence</th>
<th>river</th>
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<tr>
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<td>0.063</td>
<td>-0.083</td>
<td>0.232</td>
</tr>
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<td>-0.537</td>
<td>1</td>
<td>-0.344</td>
<td>0.316</td>
<td>0.634</td>
</tr>
<tr>
<td>Buffer zone</td>
<td>0.582</td>
<td>0.063</td>
<td>0.644</td>
<td>-0.344</td>
<td>1</td>
<td>-0.876</td>
<td>-0.872</td>
</tr>
<tr>
<td>fence</td>
<td>-0.634</td>
<td>-0.083</td>
<td>-0.658</td>
<td>0.316</td>
<td>-0.876</td>
<td>1</td>
<td>0.872</td>
</tr>
<tr>
<td>river</td>
<td>-0.374</td>
<td>0.232</td>
<td>-0.787</td>
<td>0.634</td>
<td>-0.872</td>
<td>0.872</td>
<td>1</td>
</tr>
</tbody>
</table>

As depicted in Table 4.1, factors with correlation values which are greater than 0.9 are strongly correlated. Such predictive factors are not considered for logistic regression analysis. As shown in table 4.1, the results indicate that all the factors were not strongly correlated. This is because correlation values were >0.9. None of the factors was dropped from logistic regression analysis. Hence for Victoria Falls urban area, logistic regression analysis include distance from factors such as urban settlements, park boundary, artificial water sources, roads, buffer zones, and distance Zambezi River.
Table 4.2 Bivariate correlations between factors used in the analysis for Hwange communal land.

<table>
<thead>
<tr>
<th></th>
<th>forest</th>
<th>road</th>
<th>Artificial water</th>
<th>Elephants corridors</th>
<th>Forest remnants</th>
<th>fields</th>
<th>fence</th>
</tr>
</thead>
<tbody>
<tr>
<td>forest</td>
<td>1</td>
<td>0.824</td>
<td>0.002</td>
<td>0.633</td>
<td>-0.330</td>
<td>-0.060</td>
<td>0.439</td>
</tr>
<tr>
<td>road</td>
<td>0.824</td>
<td>1</td>
<td>-0.269</td>
<td>0.597</td>
<td>-0.351</td>
<td>-0.237</td>
<td>0.756</td>
</tr>
<tr>
<td>Artificial water</td>
<td>0.002</td>
<td>-0.269</td>
<td>1</td>
<td>-0.189</td>
<td>0.143</td>
<td>0.062</td>
<td>-0.396</td>
</tr>
<tr>
<td>Elephants routes</td>
<td>0.633</td>
<td>0.597</td>
<td>-0.189</td>
<td>1</td>
<td>-0.167</td>
<td>0.003</td>
<td>-0.686</td>
</tr>
<tr>
<td>Forest remnants</td>
<td>-0.330</td>
<td>-0.351</td>
<td>0.143</td>
<td>-0.167</td>
<td>1</td>
<td>-0.043</td>
<td>-0.112</td>
</tr>
<tr>
<td>Crop fields</td>
<td>-0.060</td>
<td>-0.237</td>
<td>0.062</td>
<td>0.003</td>
<td>-0.043</td>
<td>1</td>
<td>-0.287</td>
</tr>
<tr>
<td>fence</td>
<td>0.439</td>
<td>0.756</td>
<td>-0.396</td>
<td>0.686</td>
<td>-0.112</td>
<td>-0.287</td>
<td>1</td>
</tr>
</tbody>
</table>

Results (table 4.2) show that all the factors used for analysis of human-elephant conflict in Hwange communal land are not strongly (>0.9) correlated. Therefore, the binary logistic regression model for Hwange communal area included all the factors shown in table 4.2.
Table 4.3 Bivariate correlations between factors used in the analysis for the Resettlement areas

<table>
<thead>
<tr>
<th></th>
<th>Crop fields</th>
<th>Forest</th>
<th>Park boundary</th>
<th>Artificial water</th>
<th>Water shed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop fields</td>
<td>1</td>
<td>0.567</td>
<td>-0.248</td>
<td>0.038</td>
<td>0.592</td>
</tr>
<tr>
<td>forest</td>
<td>0.567</td>
<td>1</td>
<td>-0.191</td>
<td>0.347</td>
<td>0.628</td>
</tr>
<tr>
<td>Park boundary</td>
<td>-0.248</td>
<td>-0.191</td>
<td>1</td>
<td>0.247</td>
<td>-0.255</td>
</tr>
<tr>
<td>Artificial water</td>
<td>0.038</td>
<td>0.347</td>
<td>0.247</td>
<td>1</td>
<td>0.011</td>
</tr>
<tr>
<td>watershed</td>
<td>0.592</td>
<td>0.628</td>
<td>-0.255</td>
<td>0.011</td>
<td>1</td>
</tr>
</tbody>
</table>

As shown in table 4.3, bivariate correlation results from the resettlement area indicate that distance from the watershed was strongly correlated (>0.9) with distance from the forest. Distance from the watershed is dropped and binary logistic regression for the resettlement area included distance from factors such as fields, forests and the park.
Table 4.4 Binary logistic regression relationship between human-elephant conflict presence/absence and distance from predictive factors.

<table>
<thead>
<tr>
<th>Place</th>
<th>Factor</th>
<th>Slope</th>
<th>Intercept</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VICTORIA FALLS URBAN AREA</td>
<td>Distance from the park</td>
<td>0.004</td>
<td>-5.844</td>
<td>0.039</td>
</tr>
<tr>
<td></td>
<td>Distance from urban settlements</td>
<td>0.004</td>
<td>-2.710</td>
<td>0.017</td>
</tr>
<tr>
<td></td>
<td>Distance from artificial water points</td>
<td>0</td>
<td>1.002</td>
<td>0.853</td>
</tr>
<tr>
<td></td>
<td>Distance from road</td>
<td>0.003</td>
<td>-1.011</td>
<td>0.060</td>
</tr>
<tr>
<td></td>
<td>Distance from forest remnant</td>
<td>-0.139</td>
<td>0.6215</td>
<td>0.995</td>
</tr>
<tr>
<td></td>
<td>Distance from Zambezi river</td>
<td>0.01</td>
<td>-33.772</td>
<td>0.088</td>
</tr>
<tr>
<td>HWANGE COMMUNAL AREA</td>
<td>Distance from electric fence</td>
<td>0</td>
<td>2.810</td>
<td>0.033</td>
</tr>
<tr>
<td></td>
<td>Distance from forest</td>
<td>0.001</td>
<td>-4.524</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Distance from road</td>
<td>0</td>
<td>3.266</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 4.4 illustrates the factors that significantly (p<0.05) and factors that do not significantly predict the chances of the occurrence of human-elephant conflict in the areas covered during the survey.
Factors which are highlighted in bold are the significant (p<0.05) determinants of human-elephant conflict occurrence in the three areas. The factors which are not highlighted in bold do not significantly (p>0.05) predict the probability of human-elephant conflict. Table 4.4 shows that human-elephant conflict probability could not be predicted significantly by distance from factors such as water points, roads, forest remnant, and Zambezi River in Victoria Falls urban area. Human-elephant conflict probability could not be explained significantly by distance from factors such as dams, forest remnants, and fields and settlements in Hwange communal area (table 4.4). Distance from predictive factors such as fields, park boundary and seasonal water could not significantly explain the chances of human-elephant conflict occurrence in the resettlement areas (table 4.4). The following section presents and analyses results on the spatial determinants of human-elephant conflict in the areas covered during the survey.

4.1.1.2.0 Spatial determinants of human-elephant conflict probability in Victoria Falls town.

4.1.1.2.1 Distance from the park boundary

Binary logistic regression relationship between human-elephant conflict presence/absence and distance away from the park boundary resulted in a significant (p<0.05) function for Victoria Falls urban area (table 4.4). This implies that distance from the park boundary is one of the significant determinants of the probability of human-elephant conflict in Victoria Falls urban area.
Figure 5 shows the chances of human-elephant conflict occurrence with distance from the park boundary.

![Graph showing probability of human-elephant conflict as a function of distance from the park boundary.](image)

**Figure 5** Probability of human-elephant conflict as a function of distance from the park

There is a significant (p<0.05) negative relationship between the distance from the park boundary and the probability of human-elephant conflict occurrence (figure 5). At short distances for instance (0.3km) away from the park boundary, the probability of human-elephant conflict is high (0.5). The chances of human-elephant conflict are low (0.1) at longer distances away from the park boundary. This means that the settlements located close to the park boundary have greater chances of experiencing human-elephant conflict compared to those located further away from the park boundary.
In Victoria Falls urban area, the location of a place in relation to the park boundary determines the extent to which that place is vulnerable to human-elephant conflict incidents. An area is more likely to experience various forms of conflict if it is located close to the park boundary compared to an area which is located further away from the park boundary.

4.1.1.2.2 Distance from urban settlements

Binary logistic regression relationship between human-elephant conflict presence/absence and distance away from the urban settlements resulted in a significant (p<0.05) function for Victoria Falls urban area (table 4.4). Figure 6 shows the chances of human-elephant conflict occurrence with distance from the urban settlements in Victoria Falls town.

Figure 6 Probability of human-elephant conflict as a function of distance from settlements
As depicted in figure 6, there is a significant (p<0.05) negative relationship between the distance from the urban settlements and the probability of human-elephant conflict occurrence. At short distances, for instance, (0.1km) away from the park boundary, the probability of human-elephant conflict is high (0.5). The chances of human-elephant conflict is low (0.1) at longer distances away from the urban settlements. The town of Victoria Falls has a higher probability of experiencing human-elephant conflict. This means that all the residential areas in Victoria Falls are likely to experience various manifestations of human-elephant conflict.

4.1.1.3.0 Spatial determinants of human-elephant conflict in Hwange communal area

Logistic regression results (table 4.4) indicate that distance from electric fence, distance from the main road, distance from forest and distance from elephants corridors are factors which significantly (p<0.05) determine the probability of human-elephant occurrence in Hwange communal area.
4.1.1.3.1 Distance from the electric fence

Figure 7 depicts the logistic regression relationship between human-elephant conflict probability and distance away from the fence.

![Graph showing the logistic regression relationship between human-elephant conflict probability and distance from the fence.](image)

Figure 7 Probability of human-elephant conflict as a function of distance from the fence

The probability of human-elephant conflict is significantly (p<0.05) and positively related to distance away from the fence (figure 7). At short distances (0.5) away from the fence, the probability of human-elephant conflict is very low (0). Probability of human-elephant is higher (0.9) at longer distances (10km) away from the fence. This implies that there are lower chances of occurrences of human-elephant conflict in areas protected by electric fence.
Areas which are not surrounded by electric fence have higher chances of experiencing human-elephant conflict compared to areas protected by the fence.

### 4.1.1.3.2 Distance from the main road

Figure 8 depicts the relationship between distance from the main road and the probability of human-elephant conflict.

![Graph showing the relationship between distance from the main road and the probability of human-elephant conflict.](image)

Figure 8 Probability of human-elephant conflict as a function of distance from the road

As illustrated in figure 8, distance away from the main road is significantly (0.05) and positively related with human-elephant conflict probability. At short distances from the main road (1km), the chances of human-elephant conflict occurrence are very low (0.3). As the distance away from the road increases (16km), chances of human-elephant conflict occurrence are very high (0.9).
In Hwange communal area, areas located close to the main road have lesser chances of experiencing human-elephant conflict compared to areas which are located further away from the main road.

4.1.1.3.3 Distance from elephants routes

In Hwange communal land, distance from elephant routes is another factor which significantly determines the chances of human-elephant conflict occurrence. Figure 9 depicts the logistic regression relationship between human-elephant conflict probability and distance from elephant routes.

Figure 9 Probability of human-elephant conflict as a function of distance from elephants routes
It can be observed from figure 9 that there is a significant (p<0.05) negative relationship between the probability of human-elephant conflict and distance from elephant routes. At short distances, for instance, (0km) human-elephant conflict probability is high (0.5). As distance away from the elephant routes increases (3km), the probability of human-elephant conflict occurrence becomes low (0). Areas located close to the routes used by elephants have higher chances of experiencing human-elephant conflict compared to areas which are located further away from elephant routes.

**4.1.1.3.4 Distance from the forest**

Logistic regression results (table 4.4) indicate that distance from the forest is another significant (p<0.05) determinant of the chances of the occurrence of human-elephant conflict in the communal area of Hwange. Figure 10 shows the probability of human-elephant conflict as a function of distance from the forest.
As shown in figure 10, the probability of human-elephant conflict is significantly (p<0.05) and negatively related to distance away from the forest. At short distances (0.1km) away from the forest, human-elephant conflict probability is very high (0.5). Human-elephant conflict probability decreases (0 km) as distance from the forest increases (2 km). This implies that areas located close to the forest have higher chances of experiencing human-elephant conflict compared to those areas which are located further away from the forest.

**4.1.1.4.0 Spatial determinants of human-elephant conflict probability in the resettlement areas**
4.1.1.4.1 Distance from the forest

In the resettlement areas, results indicated that human-elephant conflict probability is significantly (p<0.05) predicted with distance from the forest. Figure 11 depicts the probability of human-elephant conflict as a function of distance from the forest.

Figure 11 Probability of human-elephant conflict as a function of distance from the forest

Figure 11 depicts that there is a significant (p<0.05) negative relationship between human-elephant conflict occurrence and the location of an area in relation to the forest. At short distances (0.1km) away from the forest, the probability of human-elephant conflict is high (0.05). As distance away from the forest increases (2km) the chances of human-elephant conflict occurrence decreases (0).
So in the resettlement, areas with higher chances of experiencing human-elephant conflict are those areas which are located close to the forest. This implies that areas which are located further away from the forest have lesser chances of experiencing human-elephant conflict.

4.1.2.0 Objective 2: To identify human-elephant conflict hot spots in the area

The second objective of the research was to identify human-elephant conflict hot spots in Victoria Falls, Hwange West communal area, resettlement area. The following section presents the hot spots of human-elephant conflict in the area.

4.1.2.1 Spatial distribution of human-elephant conflict hot spots in Hwange West communal area

Figure 12 shows the location of human-elephant conflict hot spots.

Figure 12 Human-elephant conflict hot spots in Hwange communal area
Results indicated that distance from the forest is significantly and negatively related to human-elephant conflict probability in the communal area of Hwange. These findings imply that all the areas located close to the forest protected area are vulnerable to human-elephant conflict incidents. Therefore, areas such as Ndlovu, Mvutu, Chikandakubi and Chenamisa in Jambezi are human-elephant conflict hot spots as they share a boundary with the forest.

4.1.2.2 Spatial distribution of human-elephant conflict hot spots in Victoria Falls town

Figure 13 illustrates the spatial distribution of human-elephant conflict hot spots in Victoria Falls town.

Figure 13 Human-elephant conflict hot spots in Victoria Falls town
Results of this study indicated that distance from the park boundary is significantly and negatively related to human-elephant conflict probability. This means that all the houses located close to the park boundary are hot spots for human-elephant conflict incidents. Therefore, areas such as Chinotimba and Mkhosana residential area are human-elephant conflict hot spots in Victoria Falls as they share a boundary with both the Victoria Falls and the Zambezi National parks. Distance from urban settlements is also significantly and negatively related to human-elephant conflict probability as confirmed by the results. This implies that the whole town of Victoria Falls is a hot spot for human-elephant conflict incidents (figure 13).

4.1.2.3 Spatial distribution of human-elephant conflict hot spots in the resettlement areas

Figure 14 illustrates the spatial distribution of human-elephant conflict hot spots in relation to the boundary of Fuller forest.

Figure 14 Human-elephant conflict hot spots in the resettlement areas
Logistic regression analysis resulted in a significant negative relationship between human-elephant probability and distance from the forest. This implies that areas located close to the forest are hot spots for human-elephant conflict incidents. Hence all the resettlement areas of Mubiya, Don Rovin and Kalala are hot spots for human-elephant conflict incidents. This is because the resettlement areas are all located at the boundary of the Fuller forest protected area.

4.1.3.0 Objective 3: To identify the causes of human-elephant conflict

The third objective of the study was to identify the major causes of human-elephant conflict in Hwange. Data on the causes of human-elephant conflict were obtained from the historical records of human-elephant conflict from Victoria Falls Wildlife Trust and the respondents selected conveniently from each of the three study areas. The researcher captured most of this information using a camera. This explains why the data is presented in the form of pictures. The following section presents the results on the major causes of human-elephant conflict based upon observations made during the survey.

4.1.3.1 Human injuries and deaths induced by elephants

Elephants induced human injuries and deaths are some of the forms of human-elephant conflict observed in Hwange. Human death and injury are the serious manifestations of human-elephant conflict in the area of Hwange. Six deaths were recorded in Victoria Falls urban area between 2012 and 2015. The deaths occurred during the night. In most cases the bodies of the victims were found in the bushes located close to settlements. The first death incident occurred in a buffer zone between Mkhosana Surbub and Victoria Falls National Park boundary. In this case a boy was attacked by an elephant when he was praying in the bush. Another death incident occurred between Mkhosana and Chinotimba townships. Two other deaths occurred in the bush
near the dumpsite close to Chinotimba Township. In Ndlovu area which is located in Hwange communal area, a man was attacked by an elephant and sustained injuries. From the researcher’s perspective, elephant induced deaths and injuries were the worst form of human-elephant conflict observed in the study area. After realizing that there are people who had been orphaned by elephants, the researcher noted the severity of the human-elephant conflict in Hwange and became convinced that establishing the determinants of the probability of the occurrence of human-elephant conflict is a critical research. Such knowledge is critical as it may provide management with options on how to prevent loss of human lives in the future.

4.1.3.2 Road accidents

Information obtained from historical human-elephant conflict records and community members selected conveniently indicated that elephants also cause accidents in the area of Hwange. Five elephants induced accidents have occurred in Victoria Falls town. The accidents occurred along the Bulawayo-Victoria Falls road in areas where elephants cross the main road from the park to drink water from the sewer water point located a few meters from Victoria Falls National Park and Chinotimba Township. In most cases, accidents occurred when drivers tried to avoid hitting an elephant crossing the road. However, the accidents were not fatal as they did not result in death cases.
4.1.3.3 Crop raiding

Information obtained from historical record human-elephant conflict and community members indicate that crop raiding is the most common type of human-elephant conflict manifestation across the study area. About 40 crop raiding incidents have been recorded from the year 2012 to date. Plate 3 depicts a maize field invaded by elephants.

Plate 3 Maize field invaded by elephants (Source: historical conflict records).

Elephants destroy crops by trampling with their spoors which are clearly depicted in plate 3. Elephants prefer pumpkins and water melons. Sorghum and other crops are targeted by elephants. During the survey, the researcher came across many fields and gardens which had been abandoned because elephant raids. Such areas were considered to be hot spots for elephant raids resulting in farmers abandoning the fields. Fruit trees such as mangoes, paw paws and citrus fruits are also targeted by elephants.
4.1.3.4 Destruction and raiding of vegetable gardens

Information obtained from historical human-elephant conflict records and community members indicated that the destruction and raiding of vegetable gardens is one of the causes of human-elephant conflict in the study area. Plate 4 illustrates a vegetable garden destroyed by elephants.

Plate 4 Vegetable garden destroyed by elephants (Source: historical conflict records)

As shown in plate 4, elephants uproot all the vegetables when they enter a garden. In addition to this, elephants destroy the materials used in the construction of the garden. This normally results in the abandonment of the gardens by farmers. During the survey in Ndlovu area the researcher observed many gardens which community members had abandoned because of elephant raids.
4.1.3.5 Destruction of food stores

Historical information on human-elephant conflict revealed the destruction of food stores as one of the major causes of conflict between elephants and humans in the area. Plate 5 depicts a picture of one of the grain stores destroyed by elephants.

Plate 5 Food store destroyed by elephants (Source: historical conflict records)

Community members confirmed that the destruction of food stores is the worst form of human-elephant conflict. This is because stored food is difficult to replace as the raids normally take place during the dry season when the cropping season is over. This usually exposes communities to risk such as food insecurity, malnutrition and starvation. Destruction of food stores is common in the resettlement areas. The researcher observed that elephants come to the resettlement areas during the dry season to drink water. The areas have perennial water points since they are situated in the wetlands. The researcher also observed that the area is endowed with acacia and mopane trees and salt licks which attract elephants.
Elephants opportunistically raid food stores and vegetables from the gardens when they come to drink water from the perennial water points. The resettlement areas are situated in the middle of protected areas.

4.1.3.6 Destruction of security walls of houses

During the survey respondents across the study areas showed the researcher different infrastructure that had been damaged or destroyed by elephants. There were 3 houses where elephants destroyed the security walls in Victoria Falls. Plate 6 shows a picture of one of the durawall destroyed by elephants in Victoria Falls town.

Plate 6 Security wall destroyed by elephants (Source: field survey)

This incident of the destruction of the durawall wall occurred in Victoria Falls urban area in Mkhosana residential area. In the Mkhosana Surbub, about three houses had their security walls destroyed by elephants. Residents interviewed indicated that such incidents occur during the night and are caused by elephants which move around the town in search of water and food.
4.1.3.7 Destruction of sewer pipes

As revealed by human-elephant conflict data and community respondents, elephants also destroy sewer pipes. The researcher recorded the coordinates of only one house where a sewer pipe was destroyed by an elephant. Plate 7 shows a picture taken from a sewer pipe destroyed by elephants.

Plate 7 Sewer pipe destroyed by elephants (Source: field survey)

As shown in plate 7, the sewer pipe was detached from the wall by an elephant. This conflict incident also occurred in the Mkhosana Surbub of Victoria Falls town. Respondents indicated that elephants destroy sewer and water infrastructure as they search for water.
4.1.4.0 Objective 4: To establish the temporal determinants of human-elephant conflict

The fourth objective of the study was to identify the temporal determinants of human-elephant conflict in Hwange. Data on temporal determinants of human-elephant conflict were obtained from the historical records of human-elephant conflict from Victoria Falls Wildlife Trust and the respondents selected conveniently from each of the three study areas. The following section presents the results on the major causes of human-elephant conflict based upon observations made during the survey.

4.1.4.1 Temporal determinants of human-elephant conflict in Victoria Falls town

The temporal factors greatly influence human-elephant conflict in the town of Victoria Falls town. The elephants which cause conflict come from Zambezi and Victoria Falls national park. The local people selected conveniently indicated that as early as 0500pm, elephants come close to the settlements. They usually hide in the buffer zone between the park and the settlements. Elephants usually hide in the buffer zones and wait until night falls. Around 0900 pm, elephants enter human settlements and cause different human-elephant conflict manifestations. As they pass through the settlements elephants destroy infrastructure such as water pipes, security walls of houses and sewer pipes. Elephants also hide in the bushes in areas such as Mkhosana and Chinotimba and attack people resulting in death or injuries. The elephants also cross the residential areas in Victoria Falls town to drink water from the upper sections of the Victoria Falls where Zambezi River is not very steep.
As early as 0400 am elephants leave the settlements and go to the national parks where they hide during the day to avoid contacts with people. As they cross the roads to drinking water, elephants also cause vehicle accidents.

4.1.4.2 Temporal determinants of human-elephant conflict in Hwange communal area

The researcher discovered that elephants which cause conflict in these areas come from the Fuller forest concession area. During the cropping season elephants come to this area to raid food crops. The elephants stay in the Fuller forest during the day. As night falls elephants wait until it gets dark then enter human settlements where they cause different human-elephant conflict manifestations. Crop raiding and human injuries and death are some of the human-elephant conflict manifestations observed in the communal areas of Hwange. During the day, elephants seek refuge in the protected areas where they avoid contact with people. People in the area sleep in fields guarding crops to prevent elephants raids. During the dry season elephants come to drink water from the perennial streams in the Hwange communal area. The riparian vegetation and fruits in the perennial streams also attract elephants to the communal areas. These perennial streams are mainly found in the Monde area. The Monde area is located in the Zambezi escarpment.
The basaltic rocks in the area support the development of streams. Elephants are attracted to these areas during the dry season by the availability of food and water. The perennial streams sustain fruits such as savanna dwala berry, monkey finger and wild medra. Mopane and acacia vegetation which is elephants` favourite also attract elephants to this area during the dry season. The bark of mopane trees is eaten by elephants during the dry season. Elephants opportunistically raid crops from fields at the fringes of rivers when they enter the settlements. Some elephants also hide in the forest remnants and attack people during the night.

4.1.4.3 Temporal determinants of human-elephant conflict in the Resettlement area

The historical records and the respondents selected conveniently form each study area provided data on the temporal determinants of human-elephant conflict. Elephants which come to raid crops from the resettlement area come from the Fuller forests and the national parks. This is because the resettlement area is situated between the Fuller forest and the national parks. The researcher discovered that elephants do not come to the resettlement areas during the rainy season. The area is characterised by the clay soils which become slippery during the rainy season. This prevents elephants from raiding crops from the resettlement areas during the rainy season. Elephants avoid slippery areas as they find it difficult to walk on the slippery soils. People in the resettlement area indicated that they do not guard their crops during the rainy season.
During the dry season elephants come to this area in search of water and opportunistically raid vegetables from gardens. The area is characterised by wetlands. Hence elephants come to drink water from the perennial water points in the area. The rich soils in the area are characterised by mopane and acacia which is the elephant’s favourite. The rich soils and the wetlands in the area are the key factors which attracted people to settle in this area. Hence elephants and people compete for the same resources in the area. Elephants also raid stored food during the dry season.

4.1.5.0 Objective 5: To examine intervention methods used to minimize human-elephant conflict

The fifth objective of the study was to identify methods which are currently used to prevent human-elephant conflict in the area of study. Human-elephant conflict management methods presented in this section were obtained from the observations made by the researcher during the survey in Hwange West communal area, Victoria Falls town and the Resettlement areas. This explains why the data are presented through the use of pictures. This section presents the common methods used to prevent human-elephant conflict in the area of Hwange. The common form of preventing elephants from raiding crops in the area is guarding.
Plate 8 illustrates the temporary watchtower shelter where people guard their crops from.

4.1.5.1 Watch tower shelter

Plate 8 Watch tower used when guarding crops (Source: field survey)

During the survey, the researcher observed villagers who were guarding their crops to prevent elephant raids. The villagers indicated that guarding was effective as they were doing it collectively as a village. People take turns to guard crops. One group guard in the afternoon and another guards during the night. A fire is used to show presence of people. Elephants normally fear the presence of people and do not raid crops. People in the Mvutu area have intensified human vigilance and formed teams which collectively guard crops during the day and during the night to prevent elephants from raiding their fields. These teams have constructed a temporary watch tower shelter where they stay whenever they come to guard crops.
4.1.5.2 Electric fence

An electric fence is also used to prevent elephants from entering in the fields. Plate 9 shows a small scale farm protected by an electric fence. The researcher discovered that elephants stopped entering this field soon after the installation of the electric fence, implying that an electric fence is an effect of human-elephant conflict deterrent.

Plate 9 Field surrounded with an electric fence (Source: field survey)

4.1.5.3 Trench for preventing elephants from entering human settlements and fields

During the survey, the researcher observed some trenches dug to prevent elephants from entering crop fields. Plate 10 depicts a trench that was dug to prevent elephants from entering fields and settlements. The trench failed to prevent elephants from entering the fields. The loose Kalahari sands here were pushed back into the trench by elephants. Elephants then crossed the trench after filling the trench. This method only works well in areas where the soils are not loose.
Plate 10 Trench for preventing elephants from entering fields (Source: field survey)

4.1.5.4 Trench for preventing elephants from entering gardens

Plate 11 illustrates a trench which was used to prevent elephants from entering a vegetable garden near the airport. The soil here is not very loose making it difficult for elephants to push the soil back into the trench.
Plate 11 Trench for preventing elephants from entering a garden (Source: field survey)

4.1.5.5 Protecting water infrastructure

The researcher also observed that the people in the town of Victoria Falls protect their tapes from being damaged by elephants. Plate 12 depicts an old stove put on top of a tape to prevent elephant damage.
Plate 12 An old stove for preventing elephants from damaging tape (Source: field survey)

Elephants damage water infrastructure in Mkhosana suburb. The old stove in plate 12 is used to cover and hide the tape so that elephants which come searching for water during the night will not be able to see it.

4.1.5.6 Non-electric fence protecting the Victoria Falls

Plate 13 shows a fence surrounding the Victoria Falls to prevent dangerous wild animals and elephants from entering the rainforest and the Falls area.
Plate 13 Non electric fence protecting Victoria Falls and the rainforest (Source: field survey)

The fence was constructed using strong material and it is used to restrict the movement of elephants and other dangerous wild animals from entering the Victoria Falls and the rain forest. This fence protects tourists who come to view the Victoria Falls from being harmed or disturbed by potentially dangerous animals, like elephants and other predators.
4.1.5.7 Elephants inside the electric fence in Victoria Falls National Park

Plate 14 shows a photograph of elephants inside Victoria Falls national park.

Plate 14 Elephants inside the Victoria Falls National Park fence (Source: field survey)

The electric fence restricts the movement of elephants into the residential areas of the Victoria Falls town. However, during the survey the researcher observed that there are some sections of the park which are not fenced. Elephants use these points to sneak from the park and enter residential areas of Victoria falls town and Hwange communal area and cause various human-elephant conflict manifestations.
4.1.5.8 Problem animal control

Problem animal control is one of the human-elephant conflict management methods practiced in the study area. This technique involves killing of problem elephants. An elephant can be regarded as a problem animal if it kills or injures people, raids crops or causes infrastructural damage. Plate 15 depicts a picture of a problem elephant which was killed in Hwange communal area.

Plate 15 Problem elephant which was killed while raiding maize crops (historical conflict records)

Killing of problem elephants is conducted by authorized personnel. If community members identify a problem elephant, they inform the responsible authorities who then come to the community and kill the problem elephant. The meat is shared among the community members as a way of compensation for the loss and damage caused by the elephants. This method is effective as it discourages other elephants from raiding crops. The method also discourages affected communities from performing retaliatory killing or illegal hunting of elephants.
4.2.0 DISCUSSION AND INTERPRETATION OF THE RESULTS

The first part of this section interprets the logistic regression models obtained from data analysis. The process of interpretation in this case involves attaching meaning to the statistical numbers obtained from the analysis. This stage is critical because numbers do not speak for themselves, hence the need for the researcher to attach meaning to the results obtained. The possible explanations to each significant logistic regression model are offered. The second part of this section discusses the main research findings. Specifically, this section compares current results with previous similar studies. In this case results obtained from Victoria Falls, Hwange communal area and the Resettlement area are compared with results from previous similar studies. This is done in order to fit current research findings into previous studies. The contribution of the current research to existing knowledge on human-elephant conflict is thus revealed. This section discusses whether results contradict or support existing models on spatial predictors of human-elephant conflict.

4.2.1.0 Discussion and interpretation of the spatial determinants of human-elephant conflict

4.2.1.1 Distance from the park boundary

Results indicate that there is a significant negative relationship between distance from the park boundary and the probability of human-elephant conflict occurrence in the town of Victoria Falls (figure 5). These results mean that Victoria Falls town is a human-elephant conflict hot spot because it shares its boundary with national parks. This is not surprising because the town of Victoria Falls is situated in the middle of Zambezi and Victoria Falls National Parks.
The possibility of detecting an elephant is lower close the park boundary and this makes it easier for elephants to cause various manifestations of human-elephant conflict close to the boundary of the park. The reason behind this might be that elephants use the residential areas of Victoria Falls as crossing points from Zambezi National Park to Victoria Falls National Park in search of food and water. When elephants move from one national park to another, they pass through the urban settlements located close to park boundaries. This leads to the occurrence of various human-elephant conflict manifestations in the area. When the elephants move from one park to another they hide in the bushes close to settlements during the night and can trample upon unsuspecting victims.

The findings concur with those of Graham (2010) who noted that the occurrence of human-elephant conflict was predicted by distance from day time refuge which is the park. The result is also supported by Smith and Kasiki (2000) who observed that human-elephant conflict incidents density was significantly and negatively related to distance from the national park in the Tsavo, Kenya. Guerbois et al. (2012) also came up with similar findings in villages at the periphery of Hwange National Park. Distance to the park was the most influential determinant in decreasing crop raiding risk, with no damage occurring after 4.4km (Guerbois et al., 2012). These results also concur with those of Graham (2010) who noted that crop raiding was related to distance from the park.
These results also agree with those of Parker (2007) who observed that crop damage is more likely to occur along the boundaries of protected areas and usually decrease with increasing distance from the boundary. Elephants from the protected area raid crops close to the boundary because the risk of detection is lowest there. Elephants have an acute spatial awareness and it is likely they are able to recognise the transition between safe forest and dangerous farm land. Few elephants risk going deep into the farming area, so most of the damage occurs on the farms bordering protected areas. Crop-raiding elephants may also make use of habitat refuges to hide during daylight.

These areas of refugee may be small and surrounded by human settlements. Once night falls, the elephants are able to leave the refuge and enter the fields. Results from the current study are also contrary to previous findings. For instance, results from the current research indicated that human-elephant conflict was related negatively to the distance from the park (figure 5). These findings are contrary to Hoare (1999) who noted that the level of human-elephant conflict could not be explained by proximity to the protected area. Hoare (1999) proposed that the unpredictability of human-elephant conflict incidents might be linked to the behaviour of individual bull elephants.
4.2.1.2 Distance from urban settlements

Results (figure 6) also identified distance from the urban settlements as another significant determinant of human-elephant conflict probability in Victoria Falls urban area. These results were also expected since Victoria Falls town is located in the middle of two national parks, the Zambezi and Victoria Falls. The town of Victoria Falls shares a boundary with the national parks, implying that the establishment of the town might have fragmented the elephant habitat. The town might be a human-elephant conflict hot spot because it might have been established on old traditional elephant routes which elephants use as they search for water and food.

When the resort town was established in the middle of the parks, elephants continued following these old routes to cross from one park to another in search of water and food. For instance, elephants move across the residential areas to access drinking water from the upper part of the Zambezi River which is not very steep. Elephants opportunistically cause various human-elephant conflict as they move across the residential areas in search of water and food resources from one park to another. These results are supported by Prasad (2011) who reported a strong correlation between human-elephant conflict occurrence and distance from settlements. The findings also concur with those of Graham (2010) who noted that the occurrence of human-elephant conflict was predicted by settlements density.
4.2.1.3 Distance from electric fence

The probability of human-elephant conflict is significantly and positively related to distance away from the electric fence in Hwange communal area (figure 7). These results imply that elephants do not cause human-elephant conflict manifestations where fields and settlements are protected by an electric fence. The possible interpretation of these results is that electric fences have high voltage. Elephants are shocked by electricity when they try to enter settlements surrounded by an electric fence. The electric fence prevents elephants from entering the fields and settlements thereby effectively reducing human-elephant conflict levels.

These findings agree with those of Larmaque (2009) who observed that the electric fencing of the cultivated areas of Kimana and Namelok in the AWF Kilimanjaro Heartland significantly reduced the levels of elephant crop damage. These findings are also contrary to previous studies. This study indicates that distance from electric fence was significantly related to human-elephant conflict (figure 7) but Smith and Kasiki (2000) observed that an electric fence had no significant effect on human-elephant conflict in Taita Taveta. The possible reason for this difference might be that the fence for the current study covers a small farm yet the one at Taita Taveta covered the whole protected area. This means that elephants may enter through the fence using weak points, such streams and gullies, which are difficult to secure if the fence covers a larger area.
4.2.1.4 Distance from the main road

Results also show a significant \((p<0.05)\) positive relationship between human-elephant conflict probability and distance from the road (figure 8). These results imply that there is less conflict near the main road. A possible explanation to this is that there is few human-elephant conflict near the main road as there are fewer fields and settlements located close to the road. The main reason why the area is shunned by villagers is that it is situated close to the forests, making the areas prone to crop raiding. The few fields which were close to the main road are guarded during the day and the night making it difficult for the elephants to raid crops. The owners of these fields indicated that the rich soils which are found close to the road attracted them to farm close to the road. However, the farmers here guard their fields during the day and the night to prevent elephants from raiding crops.

In the absence of guarding, human-elephant conflict probability to crop raiding is high as the main road is close to the Fuller forest, a protected area which acts as a habitat for elephants. Results of this study are contrary to those of Kumar et al. (2011) who observed that the extent of road development could not significantly explain human-elephant conflict incidents. The results from the current study (figure 8) revealed a significant positive relationship between human-elephant conflict and road development. These results were expected because the fields are located across the main road which is the Bulawayo-Victoria Falls road. The owners of the fields guard their crops during the day and during the night, making it impossible for elephants to raid them. This is why there is a significant positive relationship between human-elephant conflict probability and distance from the main road.
4.2.1.5 Distance from elephants routes

The logistic regression analysis also indicated a significant (p<0.05) negative relationship between human-elephant conflict probability and elephant routes (figure 9). This implies that settlements and fields located close to elephant routes are more vulnerable to various human-elephant conflict manifestations. For instance, walking along these routes during the night leaves people vulnerable to being attacked by elephants. The possible explanation is that elephants move along these routes when they cross into human settlements. As the elephants move along these routes, they cause various human-elephant conflict manifestations to settlements located close to these elephant corridors and crossing points. During the survey, the researcher observed some fields which had been abandoned by farmers because of elephant raids. In the Ndlovu area, the researcher also observed some gardens which had been abandoned by farmers after being invaded by elephants. Parker (2007) also came up with similar findings. As noted by Parker (2007), crop damage also occurs along established elephants pathways. In the Taita-Taveta region of Kenya, crop damage was positively correlated with migration patterns of elephants, suggesting that elephants raided crops opportunistically as they migrated (Parker, 2007).
4.2.1.6 Distance from the forest

Logistic regression results (figure 10) indicate that distance from the forest significantly and negatively related to the chances of the occurrence of human-elephant conflict in the communal area of Hwange. In the resettlement areas, human-elephant conflict could be predicted significantly with distance from the forest (figure 11). These results were expected because Hwange West communal area shares a boundary with Fuller forest which is a protected area. These findings are not surprising in the resettlement area because it is situated in the middle of protected areas. These findings confirm the dominance of protected areas such as national parks and forests in the area. The protected areas are elephant refugee areas.

This makes it easy for elephants to enter fields and settlements near the boundary of the protected area and cause different human-elephant conflict manifestations. Fields and settlements located close to the boundary of the protected area are more vulnerable to human-elephant conflict manifestations as conflict can even occur during the day. The other possible cause of human-elephant conflict within the resettlement is that the area is located in former elephant routes. Elephants follow these routes to salt licks, drinking water and food. When the elephants move across these old routes they opportunistically raid crops and cause other human-elephant conflict manifestations. These findings concur with those of Kumar et al. (2011) who noted that forest variables were significantly related to human-elephant conflict in the study area.
4.2.1.7 Distance from crop fields

The current findings contradict previous findings in that human-elephant conflict could not be explained significantly by crop cultivation (table 4.4). However, Kumar et al. (2011), Sitati (2003) and Graham 2010) observed that crop cultivation was the major determinant of human-elephant conflict occurrences. The findings also contradict those of Graham (2010) who noted that the occurrence of human-elephant conflict could not be predicted by crop cultivation. The possible explanation to the insignificance of crop cultivation in predicting human-elephant conflict for this study might be because people guard their crops during the cropping season. During the survey, the researcher came across some people who were guarding their fields during the day to prevent elephants from entering their fields.

Another possible reason might be linked to the great role that is being played by the Victoria Falls Wildlife Trust in addressing human-elephant conflict issues in Hwange West communal areas as well as the town of Victoria Falls. The Victoria Falls Wildlife Trust has a hotline number through which it responds to different forms of human-elephant conflict in the area. The Victoria Falls Wildlife Trust responds to any human-elephant conflict issues and this might have helped in decreasing the human-elephant conflict incidents in the crop fields. This implies that in situations where guarding is effective, crop raiding may not be experienced.
4.2.1.8 Distance from water points

Human-elephant conflict probability was not significantly related to water (table 4.4) in Victoria Falls town. Though these findings are surprising, they agree with those of Kumar (2011) who observed that water distance did not have a significant impact on human-elephant conflict. These findings are however contrary to Smith and Kasiki (2000) who noted a significant negative relationship between distance to permanent water and human-elephant conflict incidents. In this case, results seem to suggest that people and elephants do not compete for water resources in Victoria Falls town. For instance, people and elephants do not compete over the use of water from the Zambezi River. Since Victoria Falls is a town, people do not put vegetables gardens near the Zambezi River which is found in the resort town. This explains why water could not significantly explain human-elephant conflict probability. In situations where human-elephant conflict incidents had been reported close to water sources, people compete for using the same water source with elephants. For instance people the establishment of vegetable gardens near rivers which are drinking points for elephants have caused conflict as elephants opportunistically raid vegetables when they come to drink and cool themselves near the rivers.

4.2.1.9 Distance from forest remnants

Logistic regression analysis for the current study indicated an insignificant relationship between human-elephant conflict probability and distance from forest fragments (table 4.4). This means that forest fragments could not predict human-elephant conflict in both Victoria Falls town and the communal area of Hwange. These findings are similar to those of Kumar (2011) whose analysis rejects the hypothesis that forest fragments increase human-elephant conflict.
4.2.2 Discussion and interpretation of the causes of human-elephant conflict

Results of this study indicated that elephants induced human injuries and deaths are some of the causes of human-elephant conflict observed in Hwange. These findings concur with those of Parker (2007) who noted that human deaths and injuries are among the serious manifestations of human-elephant conflict in the Southern part of Africa. Results also agree with Perera (2009) who observed that human deaths and injuries are the most severe manifestations of human-elephant conflict. Results of this study also indicated that elephants cause accidents in the area of Hwange. Five elephants induced accidents have occurred in Victoria Falls town. These findings are similar to Parker (2007) who noted that elephants induced road accidents are one of the common human-elephant conflict manifestations. Findings of this research indicate that crop raiding is the most common type of human-elephant conflict manifestation across the study area. These results are similar to Parker (2007) who noted that crop raiding is one of the leading causes of conflict between farmers and elephants throughout the African continent. The findings also concur with Perera (2009) who noted that crop destruction is a major cause for concern as it results to food insecurity, hunger and starvation, malnutrition and kwashiorkor.

In Zimbabwe, elephants are estimated to be responsible for up to three-quarters of all crop damage caused by elephants. The findings of this research also revealed that the destruction of food stores is one of the major causes of conflict between elephants and humans in the area. Food stores are the worst from of human-elephant conflict. Stored food is difficult to replace as the raids normally take place during the dry season when the cropping season is over. This usually exposes communities to risks such as food insecurity, malnutrition and starvation.
These results agree with those of Perera (2009) who noted that the loss of stored food is considered far more disruptive to farmers than the raiding of crops while they are still growing in the fields. This is because it is difficult to replace a food store. Parker et al. (2007) also regarded the destruction of grain stores as more destructive than crop raiding from the fields.

The current findings revealed that elephants destroy different types of infrastructure which include sewer pipes and water infrastructure. Results of this study also established that elephants destroy infrastructure. There were 3 houses where elephants destroyed the durawall in Victoria Falls town. Parker (2007) also revealed that elephants destroy infrastructure such as fencing and water installations. Water infrastructure is usually destroyed in dry areas. The unavailability of surface water makes elephants destroy water installations in search of water. As observed by Parker (2007), water installations were repeatedly destroyed by elephants in search of water in Chobe National Park.

4.2.3 Discussion and interpretation of the temporal determinants of human-elephant conflict

Results indicated that as early as 0500pm, elephants come close to the settlements in Victoria Falls town. They usually hide in the buffer zone between the park and the settlements. Elephants usually hide in the buffer zones and wait until night falls. Around 0900 pm, elephants enter humans settlements and cause different human-elephant conflict manifestations. Around 0400 am elephants leave the settlements and go to the national parks where they hide during the day to avoid contacts with people. Results also show that during the cropping season elephants come to the villages in Hwange communal area to raid food crops.
The elephants stay in the Fuller forest during the day. As night falls elephants wait until it gets dark then enter human settlements where they cause different human-elephant conflict manifestations. During the day, elephants seek refugee in the protected areas where they avoid contact with people. During the dry season elephants come to drink water from the perennial streams in the Hwange communal area.

These findings agree with Parker (2007) who noted that crop raiding increase during the cropping season. Crop raiding incidents usually reaches peak when crops mature. Elephants prefer to raid mature crops since their bodies and seeds are highly nutritious. In some situations, crop raiding occurs during the rainy season and the dry season. During the rainy season elephants raid crops from the fields. In areas where the presence of wetlands allows cultivation of vegetables during the dry season, elephants also raid these gardens opportunistically when they come to drink water from the water points. As noted by Parker (2007), the majority of elephants crop raiding occurs during the hours of darkness. In Trans Mara, Kenya, all recorded crop raids occurred between 19:00 and 05:00, with a peak of activity at 20:00 hours. Elephant raid during the night when they advantage of using the darkness and cover which makes it difficult for people to detect them.

4.2.4 Discussion and interpretation of human-elephant conflict management in the area of Hwange

Current findings revealed that villagers use watch towers to guard their crops to prevent elephants raids. The villagers indicated that guarding was effective as they were doing it collectively as a village.
These results agree with Larmaque (2009) who noted that vigilance is an important component of crop or livestock protection and human-elephant conflict management. Elephants usually fear the presence of humans and therefore cannot perform crop raiding in the presence of people. Elephants in the area around the Kakum Conservation Area in Ghana do not also raid crops from fields where people are guarding (Larmaque, 2009). According to Parker et al. (2007), farmers who actively guard fields have a greater chance of reducing crop damage. This method has been used successfully in Zimbabwe, Mozambique and Zambia (Larmaque, 2009). Those who guard during the night take turns to sleep. If an elephant is sighted, other farmers are woken to chase them away (Thouless, 1994 in Larmaque 2009). Simple alarm systems, using a network of cowbells or tins filled with stones connected along a length of twine, can also be effective and avoid the farmer having to stay alert all night long (Muruthi 2005 in Larmaque 2009). Such teams mainly comprise of the males.

The current research also established that electric fence is used to prevent elephants from entering in the fields in the study area. The fence is used to prevent elephants from entering settlements and fields. These observations concur with Larmaque (2009) who observed that electric fence can be used in preventing elephants entering human settlements and fields. Electric fencing is very effective in terms of preventing elephants and other species from entering fields and settlements. These findings also concur with Parker et al. (2007) who noted that electric fences are usually high-voltage and this prevent elephants from entering the fields and resettlement. This research also established that trenches are dug to prevent elephants from entering crop fields in areas where conflict are high. The trench failed to prevent elephants from entering the fields. The loose kalahari sands here were pushed back into the trench by elephants.
These findings are similar to those of Fernando (2008) who noted that the construction of trenches can be used to prevent elephants from entering human settlements and fields. The current research also established that people in Hwange communal area and the resettlement use acoustic deterrents to scare elephants away. These results are similar to Larmaque (2009) who noted that acoustic deterrents are used to scare away elephants through the production of an unexpected loud noise or specific sounds known to scare elephants. These methods include beating of drums, tins cracking whips. In addition to this shouting, yelling whistling; and setting off explosive devices such as bamboo blaster using calcium carbide or fertilizers, pipe bombs are some of the methods which have been used to prevent elephants from entering fields and raiding crops.

4.3.0 Generalisations made from the results

This section explores the Generalisability of current findings to other areas experiencing human-elephant conflict problems. Scientific studies have to yield generalisable results. Results from this study can be generalised to other areas experiencing human-elephant conflict problems. This is because the human-elephant conflict incidents were recorded in an area of 4377 km² elephants range. Results can be applied to other contexts since the human-elephant conflict incidents were recorded in an elephant range which is more than an elephant range which is more than 14 km². In elephant ecology, results can only be generalised to other contexts if the study area is equal to or more than the range of an African elephants. The logistic regression models obtained from this research can be applied broadly to other areas experiencing human-elephant conflict problems.
4.3.1 Generalisations made from logistic regression analysis of human-elephant conflict and distance from the park in Victoria Falls town

In Victoria Falls town binary logistic regression relationship between human-elephant conflict condition and distance from the park resulted in the following significant functions. Human-elephant conflict probability \( y = e^{(0.004+(-5.844x))} / (1+e^{(0.004+(-5.844x))}) \) as a function of distance from the park boundary. The logistic regression model from Victoria Falls town can be applied to other urban areas experiencing the problem of human-elephant conflict. Such knowledge is critical in situations where there is need to map human-elephant conflict hot spots without adequate resources and technical knowhow of coming up with a model for that specific area. The generalisation made from this model is that human-elephant conflict probability is high in areas situated close to park boundary.

This implies that settling close to the park boundary results in a high risk of experiencing human-elephant conflict problems. Binary logistic analysis also resulted in the following significant functions for the urban settlements. Human-elephant conflict probability \( y = e^{(0.004+(-2.710x))} / (1+e^{(0.004+(-2.710x))}) \) as a function of distance from urban settlements. The logistic regression model from Victoria Falls town can be applied to other urban areas experiencing the problem of human-elephant conflict. Such knowledge is critical in situations where there is need to map human-elephant conflict hot spots, without adequate resources and technical knowhow of coming up with a model for that specific area.
4.3.2 Generalisations made from logistic regression analysis of human-elephant conflict and distance from the forest in Hwange West communal area

The following is the logistic regression model obtained from Hwange West communal area. Human-elephant conflict probability \( y = \frac{e^{(0.001+ (-4.524x)})}{1+e^{(0.001+ (-4.524x))}} \) as a function of distance from the forest. This logistic regression model from Hwange West communal area can be applied to other communal areas experiencing the problem of human-elephant conflict. Such knowledge is critical in situations where there is need to map human-elephant conflict hot spots, without adequate resources and technical knowhow of coming up with a model for that specific area. The generalisation made from this model is that human-elephant conflict probability is high in areas situated close to forest boundary. This implies that settling close to the forest boundary results in a high risk of experiencing human-elephant conflict problems.

The following is the logistic regression model obtained from Hwange West communal area. Human-elephant conflict probability \( y = \frac{e^{(0+ (-2.591x)})}{1+e^{(0+ (-2.591x))}} \) as a function of distance from elephants routes. This logistic regression model from Hwange West communal area can be applied to other communal areas experiencing the problem of human-elephant conflict. Such knowledge is critical in situations where there is need to map human-elephant conflict hot spots without adequate resources and technical knowhow of coming up with a model for that specific area. The generalisation made from this model is that there is a high human-elephant conflict probability in areas situated close to elephants corridors. This implies that establishing settlements and agricultural activities near elephant corridors poses a high risk of experiencing human-elephant conflict problems. The following is the logistic regression model obtained from Hwange West communal area.
Human-elephant conflict probability \( y = e^{(0+ (2.810^x))}/ (1+e^{(0+ (2.810^x)}) \) as a function of distance from electric fence. This logistic regression model from Hwange West communal area can be applied to other communal areas experiencing the problem of human-elephant conflict. Such knowledge is critical in situations where there is need to map human-elephant conflict hot spots without adequate resources and technical knowhow of coming up with a model for that specific area. The generalisation made from this model is that electric fences repel elephants. These results seem to imply that putting an electric fence around settlements is an effective way of preventing conflict associated with the interaction of humans and elephants. Concerned stakeholders should consider an electric fence as an effective human-elephant conflict mitigation measure.

The following is the logistic regression model obtained from Hwange West communal area. Human-elephant conflict probability \( y = e^{(0+ (3.266^x))}/ (1+e^{(0+ (3.266^x)}) \) as a function of distance from the road. This logistic regression model from Hwange West communal area can be applied to other communal areas experiencing the problem of human-elephant conflict. Such knowledge is critical in situations where there is need to map human-elephant conflict hot spots, without adequate resources and technical knowhow of coming up with a model for that specific area. The generalisation made from this model is that human-elephant conflict is few near roads.
4.3.3 Generalisations made from logistic regression analysis of human-elephant conflict and distance from the forest in the Resettlement areas.

The following is the logistic regression model obtained from Resettlement areas. Human-elephant conflict probability \( y = \frac{e^{(0.002+ (-6.789*x))}}{1+e^{(0.002+ (-6.789*x))}} \) as a function of distance from the forest. This logistic regression model from Resettlement areas can be applied to other communal areas experiencing the problem of human-elephant conflict. Such knowledge is critical in situations where there is need to map human-elephant conflict hot spots without adequate resources and technical knowhow of coming up with a model for that specific area.

The generalisation made from this model is that human-elephant conflict probability is high in areas situated close to forest boundary. This implies that settling close to the forest boundary results in a high risk of experiencing human-elephant conflict. This implies that allocating land for agriculture and settlements in the middle of a protected area poses a great risk of experiencing human-elephant conflict. The six logistic regression models depicted above can be applied to any other area experiencing human-elephant conflict. These models are critical as they can be used in situations where human-elephant conflict is a problem, but the expertise and technical knowhow of developing models for the specific areas is not available. The application of these models can also assist in identifying human-elephant conflict hot spots in cases where resources and expertise of data collection and analysis are not available.
4.4.0 Contribution of the research to existing knowledge on human-elephant conflict

4.4.1 Knowledge gained from researching in Victoria Falls town

The research has added to existing knowledge on human-elephant conflict in difference ways. This research is the first study to predict the determinants of human-elephant conflict in Victoria Falls town. This means that elsewhere, human-elephant conflict predictors were known but in the town of Victoria Falls they were not known despite the increase in the reports of human-elephant conflict in the area. The crucial knowledge gained from this research is that human-elephant conflict can be predicted reliably using distance from the park in the town of Victoria Falls. Such knowledge is critical as it will assist stakeholders to come up with human-elephant conflict mitigation strategies which ensure the co-existence of elephants and humans with minimal conflict.

In addition to this, the knowledge can inform land use planners to take the position of the park into cognisance whenever they are proposing to establish a new residential area. In other words there is need to carry out a thorough environmental impact assessment of proposed projects especially housing. This can inform property developers and town planners about all the possible negative consequences of horizontal expansion in the town of Victoria Falls which include elephant habitat loss, compression and range reduction. For land use planners, knowledge gained from this research can convince them to have both the ecological and the socio-economic development vision when planning.
In addition to this, water could not explain the probability of human-elephant conflict occurrence in Victoria Falls. Knowledge obtained from this analysis is that it does not mean that water points are always human-elephant conflict hot spots. Hence it should be noted that water can only be a hot spot for human-elephant conflict if humans and elephants compete for the use of the water resources. In the town of Victoria Falls, elephants and people do not compete for the use of open water resources found in the area. People use tap water, not surface water sources used by the elephants for drinking.

4.4.2 Knowledge gained from researching in Hwange West communal area

Predicting the spatial determinants of human-elephant conflict has been done for the first time in the communal area of Hwange West. Knowledge gained from this study is that distance from factors such as the forest, elephants routes are negatively related to the probability of human-elephant conflict occurrence in the area. This information is critical as it implies that land use planners, such as Ministry of Lands and Rural Resettlement should take into cognisance the location of any proposed development in relation to the position of the Fuller forest and elephant routes. In other words the authorities who allocate land for various projects should have both the ecological vision (elephant conservation needs) and the socio-economic development needs. Such an approach is necessary as it is the only effective way which will lessen the problem of human-elephant conflict in the area. Planning that takes into consideration conservation issues is the only effective long term solution to human-elephant conflict issues. Failure to address human-elephant conflict has the potential of undermining the success of any elephant conservation measures.
The other knowledge gained from this research is that human-elephant conflict cannot always be predicted significantly with distance from crop fields. This is because results from this study indicated that human-elephant conflict probability could not be explained significantly with distance from crop fields. These results seem to suggest that crop fields cannot always be used to predict human-elephant conflict probability. It does not mean that human-elephant conflict always takes place where there are crop fields. This implies that in order to come up with accurate information on the spatial predictors of human-elephant conflict, it is advisable to thoroughly investigate and understand the underlying spatial trends of human-elephant conflict.

4.4.3 Knowledge gained from researching in the Resettlement areas

Establishing the significant factors which explain human-elephant conflict probability has been done for the first time since the resettlement area was established in 2000. The knowledge gained from this research is that it has identified the factors which explain human-elephant conflict for the first time. In this case the distance from the forest has been identified to be the significant human-elephant conflict predictor. The knowledge gained may assist land use planners to develop human-elephant conflict mitigation measures which will effectively address the issues of human-elephant conflict. Such knowledge has the potential of assisting land use planners to take into cognisance the position of the forest whenever allocating land for agriculture and settlements in the area. Knowledge gained from this research can assist decision makers to address human-elephant conflict issues in a manner that may ensure that humans and elephants co-exist sustainably. Such information is crucial for the resettlement area since it is situated in the middle of protected areas which are the Fuller forest and the national park.
4.5 Chapter summary

Chapter 4 presented the research results. Specifically, the chapter presented and analysed the data in order to identify the significant determinants of human-elephant conflict in Hwange. Distance from protected areas was identified as the significant determinant of human-elephant conflict in the area. The significant factors which explained human-elephant conflict in the study areas are interpreted. In this case the possible explanation of each significant human-elephant conflict determinant is offered. The chapter also discussed the results by comparing them with previous similar findings on human-elephant conflict from other areas. This was done to reveal whether current results support or contradict previous findings. The generalisations drawn from the study area are among key issues covered in this chapter. Furthermore, the chapter described the extent to which the current study has contributed to existing knowledge on human-elephant conflict. In this regard, the extent to which the research can be of benefit in addressing human-elephant conflict issues in the study area is thus explained. Consequently, the implications of the results for human-elephant conflict management in Victoria Falls town, Hwange communal area and the resettlement areas are some of the key issues highlighted in this chapter.
CHAPTER 5

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Chapter introduction

This chapter presents the four main sections, which conclude the entire research report. These include summary, findings, conclusions and recommendations. The summary section describes the main research problem addressed; the methodology used, research design and data collection and analysis procedures adopted for the research. Major research findings are also briefly described in this chapter. The chapter also presents the conclusions of the research. Recommendations of the research are among key issues discussed in this chapter.

5.1 Thesis / research summary

The main objective of this study was to identify the significant spatial determinants of human-elephant conflict in the area of Hwange. The research was prompted by the numerous reports on various human-elephant conflict manifestations in the area of Hwange. The reports on human-elephant conflicts had been reported in Monde, Mbizha and Ndlovu area where elephants coming from the National Parks were invading fields and causing human-elephant conflict manifestations. The conflicts had also been observed in the resettlement areas. This implies that the increase in the reports on human-elephant conflicts was the main issue which motivated the researcher to embark on the current research. The quantitative research methodology was adopted for the study. This implies that data collection and analysis procedures were guided by quantitative ideologies. Data collected were numerical and were analysed using statistical tools.
Positivism is the philosophical foundation that guided the researcher`s theory of knowledge in this study. The rationale for selecting the positivist paradigm was determined by the nature of the problem under investigation, the researcher`s discipline area as well as past research experience. The research design adopted for the study was the non-experimental research. This implies that data collection; analysis and interpretation procedures were informed by the ideologies of the non-experimental research. This means that there was no manipulation of variables of interest by the researcher. Instead, the variables were studied as they existed in the natural world. The researcher`s task in this case was to observe, measure and describe the variables of interest in their natural setting without manipulating independent variables. In this study the variables used for the study could not be manipulated. For instance, human-elephant conflict presence/absence data could not be manipulated. Spatial factors could not be manipulated or studied in the laboratory as they existed in the natural environment.

Purposive sampling technique was employed to select respondents who assisted in identifying the position of sites where human-elephant conflict incidents had occurred. This technique was used to select the people who provided the relevant information of human-elephant conflict location in the study area. GIS tools such as the GPS and digitizing were the main research tools used for data collection. The GPS receiver was used to record the position of human-elephant conflict sites in UTM coordinate system. The GPS instrument was also used to record the position of spatial factors such as water points, fields and settlements, park boundary and elephants routes. Spatial data on predictive factors, such as the fields, forests and parks, were obtained through digitizing satellite images availed in Google earth.
Human-elephant conflict location data were recorded as presence/absence since there were some areas where human-elephant conflict incidents had not taken place. It was not easy to carry out the study. There were some constraints which the researcher encountered during the data collection process. Major challenges were faced during data collection in the communal areas and the resettlement areas. One of the challenges experienced in Hwange communal area was that villages were far apart. The communal area covers a large area and this made it impossible to travel on foot from one village to another. To overcome this challenge, a vehicle was used by the researcher to travel from one village to another. The researcher would then walk to the conflict sites to record the coordinates and take photos if there was any evidence of human-elephant conflict available. The researcher also experienced accessibility challenges during data collection in the Hwange West communal areas. Some conflict sites were not accessible by the vehicle since it had difficulties travelling on the kalahari sand roads in the communities. In most cases the car skidded on the kalahari sands. To overcome this challenge, the researcher parked the vehicle and walked to the human-elephant site. Walking on the loose kalahari sands was a difficult task. The unbearable high temperatures of the area made the task of walking very difficult. In the resettlement area, the road between Don Rovin and Kalala resettlement areas was very bad. The soil on the road was wet and slippery making it difficult to travel by a car. The researcher left the car on the sections of the road which were accessible and walked to the human-elephant conflict sites. The risk of encountering dangerous wild animals, such as elephants, hyenas, and leopards, during the survey was too high during the survey.
Hwange is an area where animals range freely any time around the settlements and the protected areas. To overcome this challenge, the researcher travelled during the day and went to the conflict sites during the day. Wild animals hide in the parks and forests during the day and come to the human settlements during the night.

The research assistant who accompanied the researcher is experienced in walking in the bush and interacting with wild animals. Language barrier was another challenge experienced by the researcher during the process of data collection. The major challenge was experienced during the process of verifying the historical records of human-elephant conflict occurrence with community members. The challenge of language was encountered in the communal areas of Hwange West and the Resettlement areas. The researcher was not conversant with the languages spoken in the study areas. This limitation was anticipated by the researcher prior to the process of data collection process. In choosing a research assistant who showed the researcher areas where human-elephant conflict incidents had occurred, the language issue was considered.

5.2 Findings

In spite of these constraints, interesting findings and observations were made. Results indicated that there is a significant negative relationship between distance from the park boundary and the probability of human-elephant conflict occurrence in the town of Victoria Falls. These results mean that Victoria Falls town is a human-elephant conflict hot spot because it shares its boundary with national parks. These results were not surprising as the town of Victoria Falls is situated in the middle of Zambezi and Victoria Falls National Parks.
Results also identified distance from the urban settlements as another significant determinant of human-elephant conflict probability in Victoria Falls urban area. These results were also expected since Victoria Falls town is located in the middle of two national parks, the Zambezi and Victoria Falls. Such information is critical for Victoria Falls urban planners as it ensures that elephant conservation issues and socio-economic development are given equal priority when implementing new projects such as housing. This approach is crucial as it is the only strategy which has got a great potential of offering long term solutions to the problem of human-elephant conflict.

Results also show a significant (p<0.05) positive relationship between human-elephant conflict probability and distance from the road. These results imply that there is less conflict near the main road. The logistic regression analysis also indicated a significant (p<0.05) negative relationship between human-elephant conflict probability and elephants routes. This implies that settlements and fields located close to elephant routes are more vulnerable to various human-elephant conflict manifestations. For instance, walking along these routes during the night leaves people vulnerable to being attacked by elephants.

The possible explanation is that elephants move along these routes when they cross into human settlements. As the elephants move along these routes, they cause various human-elephant conflict manifestations to settlements located close to these elephant corridors and crossing points. These findings imply that it is critical for land use planners to take note of the position of elephant corridors and the forest whenever they allocate land for agriculture and settlements.
Logistic regression results indicated that distance from the forest significantly and negatively related to the chances of the occurrence of human-elephant conflict in the communal area of Hwange. In the resettlement areas, human-elephant conflict could be predicted significantly with distance from the forest. These results were expected because Hwange West communal area shares a boundary with Fuller forest which is a protected area. These findings are not surprising in the resettlement area because it is situated in the middle of protected areas. These findings confirm the dominance of protected areas such as national parks and forests in the area.

The protected areas are elephant refugee areas. This makes it easy for elephants to enter fields and settlements near the boundary of the protected area and cause different human-elephant conflict manifestations. Fields and settlements located close to the boundary of the protected area are more vulnerable to human-elephant conflict manifestations as conflict can even occur during the day. The current findings indicated human-elephant conflict could not be explained significantly by crop cultivation. The possible explanation to the insignificance of crop cultivation in predicting human-elephant conflict for this study might be because people guard their crops during the cropping season. During the survey, the researcher came across some people who were guarding their fields during the day to prevent elephants from entering their fields. Another possible reason might be linked to the great role that is being played by the Victoria Falls Wildlife Trust in addressing human-elephant conflict issues in Hwange West communal areas as well as the town of Victoria Falls. The Victoria Falls Wildlife Trust has a hotline number through which it responds to different forms of human-elephant conflict in the area. The Victoria Falls Wildlife Trust responds to any human-elephant conflict issues and this might have helped in decreasing the human-elephant conflict incidents in the crop fields.
This implies that in situations where guarding is effective, crop raiding may not be experienced. Human-elephant conflict probability was not significantly related to water in Victoria Falls town. These findings are surprising. In this case, results seem to suggest that people and elephants do not compete for water resources in Victoria Falls town. For instance, people and elephants do not compete over the use of water from the Zambezi River. People do not cultivate vegetables and other crops near the Zambezi River which is found in the resort town. This explains why water could not significantly explain human-elephant conflict probability. In situations where human-elephant conflict incidents had been reported close to water sources, people compete for using the same water source with elephants. For instance, the establishment of vegetable gardens near rivers which are drinking points for elephants have caused conflict as elephants opportunistically raid vegetables when they come to drink and cool themselves near the rivers. Logistic regression analysis for the current study indicated an insignificant relationship between human-elephant conflict probability and distance from forest fragments. This means that forest fragments could not predict human-elephant conflict in both Victoria Falls town and the communal area of Hwange.

Results of this study indicated that elephants induced human injuries and deaths are some of the causes of human-elephant conflict observed in Hwange. The findings of this research also revealed that the destruction of food stores is one of the major causes of conflict between elephants and humans in the area. Food stores are the worst from of human-elephant conflict. Stored food is difficult to replace as the raids normally take place during the dry season when the cropping season is over. This usually exposes communities to risks such as food insecurity, malnutrition and starvation.
The current findings revealed that elephants destroy different types of infrastructure which include sewer pipes and water infrastructure. Results of this study also established that elephants destroy infrastructure. There were 3 houses where elephants destroyed the durawall in Victoria Falls town. These findings imply that long term solutions to the issue of human-elephant conflict require land use planners to integrate elephant conservation with socio-economic development issues. It is hoped that the findings from this research can be used to assist policy makers to develop effective conflict resolution strategies which ensure co-existence of elephants and humans.

5.3 Conclusions

The main objective of the study was to identify the spatial factors which significantly determine the vulnerability of an area to experiencing human-elephant conflict incidents in Victoria Falls town, Hwange communal area and the resettlement area. These results suggest that that the most important predictor of human-elephant conflict on this particular landscape is distance from protected areas. For Victoria Falls town, it can be concluded that vulnerability to human-elephant conflict is determined by the location of a place in relation to the park boundary and the urban settlements. The main reason is that human-elephant conflict probability was significantly and negatively related to distance from the park boundary and distance from urban settlements. This implies that the whole town of Victoria Falls is a human-elephant conflict hot spot as it shares a boundary with two national parks. It can also be concluded that the chances of human-elephant conflict occurrence are determined by the location of a place in relation to the distance from the forest and elephants routes in Hwange West communal area.
This is because the distance from the forests and elephants routes was significantly and negatively related to the probability of human-elephant conflict. Hence all the areas like Mvutu, Ndlovu, Chikandakubi and Chenamisa are human-elephant conflict hot spots as they share a boundary with the forest protected area. In the resettlement areas, it can be concluded that distance from the forest determines vulnerability to the human-elephant conflict incidents. The reason behind this is that human-elephant probability could be predicted significantly with distance from the forest. All the resettlement areas of Don Rovin, Mubiya, Kalala and Masikiri are human-elephant conflict hot spots as they share a boundary with the Fuller forest protected area. Hence solutions to human-elephant conflict require land use planners should take into cognisance human-elephant conflict issues each time they allocate land to different projects. Such an approach may help address human-elephant conflict in the long term.

5.4.0 Recommendations for human-elephant conflict mitigation

In light of the conclusions above, the following are the recommendations for addressing the problem of human-elephant conflict in all the three human-elephant conflict zones. For Hwange communal area, Victoria Falls town and Resettlement areas, it is crucial to suggest human-elephant conflict management options based upon the main research findings. There is need for participation of all stakeholders such as scientists, elephant managers, policy makers and local communities in addressing the issues of human-elephant conflict effectively.

Implementation of conflict resolution measures in the areas should consider that the area of Hwange is designated for wildlife. This implies that any human-elephant conflict management method should encourage the coexistence of elephants and humans. Driving the elephants away is not possible as the area is designated for wildlife.
The following section presents possible human-elephant conflict mitigation strategies which have the potential to minimize the human-elephant conflict in the future.

5.4.1 Recommendations for human-elephant conflict mitigation in Hwange West communal area

Resolving human-elephant conflict in the communal area requires land use planners like the District Administrators, Ministry of Lands and Rural Resettlements to adopt the following land use planning strategies:

- The farmers in Hwange communal area can cultivate unpalatable crops to prevent elephants from raiding their fields. These include the growing of chillies. The chillies should be grown by people in the areas such as Ndlovu, Mvutu, Chikandakubi and Chenamisa villages. This is because these areas are located in hot spots for human-elephant conflict since they share a boundary with the Fuller forest protected area.

- Acoustic deterrents, which include beating of drums, tins, shouting, yelling, whistling and cracking of whips, can also be used by farmers who are in high human-elephant conflict risk zones to scare elephants away.

- Alarm systems, such as cow bells, can be used to alert farmers about the presence of elephants.

- Disturbance shooting can also be used to prevent crop raiding. In this case gunshots are fired over the heads of crop-raiding elephants.

- Olfactory deterrents, which involve spraying chilli pepper, can alternatively be adopted to prevent crop raiding by elephants in the communal land of Hwange.
• Spraying these chilli peppers at crossing points used by elephants to enter the villages has got a great potential of scaring elephants away.

• One strategy of addressing the issue of human-elephant conflict would be to avoid crop cultivation near the forest boundary and elephants routes.

• The strategy of digging trenches to prevent elephants from entering fields can also be adopted by the people in the area. These trenches can be dug by people who are close to the forest boundary since they are located in a high human-elephant conflict zone. However, this strategy works well in areas which are not characterised by loose soils since elephants can refill the trench by pushing the loose soil back into the trench, making it easy for them to cross into the fields and raid crops.

• Farmers can alternatively move crop fields from the forest edge and put them close to settlements.

• Farmers can also consider switching from crop cultivation to cattle ranching.

• People should avoid using the paths in the bushes during the night so as to reduce the risk of being attacked by elephants. If possible people should avoid walking about during the night.

• Another effective strategy which can minimise human-elephant conflict is for land use planners to prevent placing settlements near protected areas.

• Some people can sacrifice to settle in high human-elephant conflict zones as long as the conditions support crop cultivation, but cry for assistance when they experience various manifestations of human-elephant conflict.
• The wild life policy of Zimbabwe should be amended so that it includes the provision for compensation for crop loss and deaths caused by elephants

5.4.2 Recommendations for human-elephant conflict mitigation in Victoria Falls town

• An electric fence should be constructed around the town of Victoria Falls to prevent elephants from entering residential areas. The fence should be constructed at the buffer zone between the park boundary and the settlements. The electric fence can help minimise the most serious manifestations of human-elephant conflict which include elephants induced human deaths and injuries, elephants induced vehicle accidents and infrastructure damages experienced by people in Victoria Falls town.

• The authorities in Victoria Falls can alternatively use olfactory deterrents like the spraying of chemical compounds like the chilli pepper to irritate elephants and scare them away from residential areas. The chilli pepper spray can be applied on the buffer zones between the boundary of the park and the residential areas.

• People should also avoid using the routes which pass through the bushes at night. This is because the researcher observed that most elephants induced deaths and injuries occurred in the bushes during the night. Walking during the night can also be avoided as it is risky in this area. The risk of being attacked by an elephants is too high when one walks through the bushes at night.

• There is need for land use planners to come up with effective land use planning policies which provide long term solutions to human-elephant conflict.
This may involve considering vertical expansion of the built up area. Horizontal expansion of the residential area has higher chances of encroaching into elephant ranges and the habitat of elephants and worsening the problem of human-elephant conflict situation.

- The urban planners can also consider having a satellite town outside Victoria Falls. The town can be situated several kilometres from the national parks and the town. The areas which can be targeted are the Ndlovu and Monte areas.

- Drivers must drive cautiously and look out for elephants crossing the road in order to prevent accidents

5.4.3 Recommendations for human-elephant conflict mitigation for the Resettlements area

- Providing human-elephant conflict measures in the resettlements area is difficult because people were resettled in the middle of a protected area. Observation made during the research indicate that the area is used as a drinking point by elephants during the dry season.

- The area is also endowed with other critical resources such the salt licks which are favoured by elephants. Any attempt to mitigate human-elephant conflict should consider all these factors.

- The use of some methods, such as acoustic deterrents, alarm systems and disturbance shooting, to scare away elephants is not an acceptable practice in the resettlements area. This is because the area is mainly used for drinking during the dry season by elephants.

- The farmers in the area may rather cultivate unpalatable crops such as chilli pepper as a method of preventing crop raids.
Another method which might be radical and politically sensitive might be to consider relocating people to other areas which are not human-elephant conflict hot spots.

- One human-elephant conflict mitigation strategy could be to switch from crop cultivation to cattle ranching. This is because the area is situated in the middle of the national park and the forest, implying that expansion of crop fields and settlements leads to elephant habitat compression and range reduction. Elephants may, in turn, extend their range into human settlements and this might worsen the human-elephant conflict issue. This implies that land use planners should not continue allocating land for agriculture and settlements in the area as the resettlements is in the middle of elephant habitat. Hence continued expansion of cropland might have negative implications for elephant conservation.

- The authorities who allocate land to agriculture and for settlements should bear in mind the implications of expanding such activities on human-elephant conflict issues. This is because the resettlements areas is situated in the middle of protected areas, implying that continued expansion of agriculture and settlements has a potential of worsening the problem of human-elephant conflict. The following are the recommendations for minimise human-elephant conflict in the resettlements areas
5.5 Recommendations for further research

- The study recommends that future studies should collect human-elephant conflict data for a longer period of time which can be 3-4 years. This can be achieved by appointing a research assistant in each human-elephant conflict zone. The research assistant should be a person who stays in that community. The person is should be trained in using the GPS equipment in order to capture the coordinates of human-elephant conflict sites.

- Further research should be conducted in monitoring elephant movement patterns in the area using satellite linked GPS collars. This information can enhance our understanding of the routes used by elephants when they move around the settlements. GPS collaring of elephants also have a high spatial resolution, meaning that it covers a wider area.

- This study should also be extended to the whole area of the Kavango-Zambezi Trans-Frontier conservation area. This is because in mega parks, such as the Trans Frontier Conservation Areas, understanding the interactions between communal lands and protected areas is crucial before designing human-elephant conflict mitigation measures, which encourage human-elephant co-existence.
5.6 Chapter summary

Chapter 5 presented the summary of the research by describing the main research problem and the research methodology and design adopted for the research. The chapter also presented the main research findings. Conclusions drawn from the research findings are some of the key issues discussed in this chapter. Finally, recommendations for human-elephant conflict mitigation were explained. The implications of the findings to human-elephant conflict management in the study area were discussed. This chapter also highlighted the areas where further research is required.
5.7 References


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5.8 Appendices

Appendix 1a) Victoria Falls town distance maps

a) Fence distance map  

b) forest remnant distance map  
c) Road distance map  
d) water distance map  
e) urban settlement distance map  
f) park distance map
Appendix 1b) Resettlement area distance maps

a) Fields distance map  
b) park boundary distance map  

c) Forest distance map  
d) water distance map
Appendix 1c) Hwange communal area distance maps

Fence distance map  b) road distance map

c) Crop fields distance map  d) Forest remnant distance map

e) Forest distance map  f) water point distance map
Appendix 2 a) Location of Hwange communal areas human-elephant conflict presence or absence data in UTM coordinates

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