POPULATION ECOLOGY AND SOCIO-ECONOMIC DRIVERS OF HUMAN-ELEPHANT CONFLICTS IN OKWANGWO SECTOR OF CROSS RIVER NATIONAL PARK, NIGERIA

BY

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CERTIFICATION

This is to certify that this thesis titled "Population Ecology and Socio-economic Drivers of Human-elephant Conflicts in Okwangwo Sector of Cross River National Park, Nigeria" was carried out by **Bassey, Peter Williams** with registration number **20204262758** in partial fulfillment of the requirement for the award of Master of Science (M.Sc.) in Wildlife Management, Department of Forestry and Wildlife Technology, Federal University of Technology, Owerri.

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DEDICATION

This work is dedicated to God Almighty.

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LIST OF ABBREVIATIONS

HEC	Human elephant conflict
HWC	Human wildlife conflict
CRNP	Cross River National Park
FGD	Focus group discussion
CL	Confidence interval
CV	Coefficient of variation
MWS	Mean weighted score
NGN	Nigerian naira
WWF	World Wildlife Fund
IUCN	International Union for the Conservation of Nature

DEFINITION OF TERMS AS USED IN THE STUDY

Attitudes: a feeling toward or opinion concerning something or someone which influences behavior.

Human elephant conflict: Negative outcome that result from interaction between elephants and humans like crop raiding as well as injuries and deaths to both humans and elephants.

Human wildlife conflict: An association between wildlife and humans and/or their goods, livestock, land, or property that bears negative impacts on one or both parties. (WWF, 2017)

Coexistence: The state of two or more things existing together, usually in a temporal or spatial sense, with or without mutual interaction

Perception: The manner in which someone regards or interprets something.

Ecology: A branch of biology that studies the interactions between various species of animals and their natural habitats. It encompasses understanding how animals adapt to their environment, the relationships they have with other species, and the dynamics of wildlife populations within ecosystems.

Population density: Average population per unit area; especially, the average number of individuals who live per square kilometer of land

Dung density: A non-invasive ecological method used to estimate the population status of elephants. It involves counting the number of dung piles found in a specific area and using statistical models to estimate the overall population size. The method assumes that the density of dung correlates with the density of the elephant population.

Defecation rate: The average number of dung piles an elephant produces per day, which can vary by age and season.

Dung decay rate: The time taken for the dung piles to gradually decompose, which can be influenced by environmental conditions and can vary across different habitats.

Transect: A path along which a researcher moves to count and record observations or collect data.

Detection probability: The likelihood of finding dung piles during surveys, which can be affected by vegetation cover, terrain, and researcher′s expertise.

Socio-economic drivers: This refers to human-related factors (gender, age, employment status, income) that contribute to the occurrence and intensity of conflicts between humans and elephants.

ABSTRACT

This study assessed the population ecology and socioeconomic drivers of human-elephant conflicts (HEC) within the Okwangwo sector of Cross River National Park (CRNP). Using line transect surveys and dung count techniques, the elephant population was estimated at a density of 0.12±0.01 elephants/km². Data was collected from 480 households across eight purposively selected communities to investigate socioeconomic influences on HEC. Analytical methods included SPSS for questionnaire responses, logistic regression for crop-HEC relationships, and Likert scales for community perceptions. The findings indicated that various socioeconomic factors, such as gender, occupation, and income, significantly influence conservation attitudes, while age exhibits a weak and insignificant relationship. Respondents with tertiary education showed more positive conservation views ($\chi^2 = 620.387$, df = 6, p = 0.0001), while gender and income sources also shaped perceptions. Crop raiding emerged as the primary form of conflict, with sweet potatoes (14.0%) being the most frequently targeted crop. About 51.9% of respondents experienced substantial crop damage, with 76.7% reporting losses between 30-50% of their agricultural produce. HEC was more prevalent during the dry season (67.5%) and nocturnal hours (60.0%). Spatial analysis revealed that communities such as Wula I and Bokalum faced the most severe impacts, including crop damage, injuries, and fatalities. Pearson's Chi-square analysis ($X^2 = 34.317$, df = 14, p = 0.002) demonstrated significant variation in HEC across locations, with logistic regression identifying specific crop types as predictors of conflict. Maize had a slight positive impact on HEC (0.005), while banana (-0.28) had a negative effect, and pumpkin (0.302) had a beneficial influence. Traditional deterrence methods were commonly employed by communities, but there was growing interest in innovative strategies, such as beehive fences, with 68.8% of respondents expressing interest. Mitigation priorities identified by respondents included livelihood enhancement (58.6%), forest buffer zone restoration (51.4%), providing water sources in elephant habitats (43.2%), and community education (39.5%). The study emphasizes the need for tailored conservation strategies that address declining elephant populations, varied community perceptions, and opportunities for harmonious coexistence. These findings provide critical insights for effective HEC mitigation and fostering positive wildlife-community relations.

Key words: Population Ecology, Human-elephant conflict, Socio-economic drivers, Coexistence, Dung density

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Human-elephant conflicts (HECs) are a significant challenge for conservation efforts and human livelihoods in areas where people and elephants share the same landscapes (Osborn and Parker, 2003). The African forest elephant (*Loxodonta* cyclotis) is a keystone species, playing a crucial ecological role in the maintenance of tropical rainforests in West and Central Africa (Maisels *et al.,* 2013). Cross River National Park (CRNP) is one of the last remaining strongholds of the African forest elephant, and the park's conservation efforts are crucial for the survival of this species (Njifonjou, Bahaa-el-din and Nguinguiri, 2022; Edet, Ovat, and Suleiman, 2018). However, the park is surrounded by communities that depend on natural resources for their livelihoods, leading to conflicts between humans and elephants (Adeleke and Adedeji, 2017).

Several studies have focused on understanding the drivers of HEC, including ecological and socioeconomic factors (Njifonjou *et al.*, 2022; Adeleke and Adedeji, 2017). Ecological factors include elephant behavior, habitat fragmentation, and availability of food resources, while socioeconomic factors include human population density, land use patterns, and crop-raiding incidences. Understanding the relative importance of these factors can inform the development of effective conservation strategies that minimize HEC while supporting the livelihoods of local communities.

The behaviors of elephants in the Okwangwo Division of Cross River National Park, Nigeria, are emblematic of the challenges faced in mitigating Human-Elephant Conflicts (HECs). In this region, elephants have been observed to exhibit seasonal migration patterns, moving between the park and the neighboring Takamanda Forest Reserve in Cameroon. They typically spend the rainy season in Cameroon and the dry season within the park’s boundaries. This migratory behavior is significant as it may lead to increased instances of crop raiding during certain times of the year, particularly when elephants are in proximity to human settlements during the dry season.

The estimated density of elephants in the Okwangwo Division is relatively low, at 0.3 elephants per km², with variations ranging from 0.2 to 0.5 elephants per km (Obot *et al.*, 2005). Despite this low density, the impact of their foraging behavior can be substantial, especially when they enter agricultural areas. The elephants' search for food and water can lead to the destruction of crops, which not only affects the livelihoods of local farmers but can also escalate into aggressive encounters between humans and elephants.

To address these issues, understanding the specific behaviors that lead to conflicts, such as the elephants' movement patterns and foraging habits, is crucial. For example, the creation of corridors that align with the elephants' natural migration routes could reduce the likelihood of them entering human settlements (WCS, 2018). Additionally, targeted interventions like deploying early warning systems, constructing barriers, and altering agricultural practices to make crops less attractive to elephants can be informed by a deeper understanding of their behavior patterns.

Moreover, the Cross River National Park has been facing threats from hunting, which is widespread throughout the Okwangwo Division. This illegal activity not only targets elephants for their ivory but also reduces the density of all large mammal species in the area (Obot *et al.*, 2005). Conservation efforts, such as SMART-based ranger patrols supported by the Wildlife Conservation Society (WCS), have been implemented to provide more effective protection for elephants and other wildlife. These patrols focus on areas known to be inhabited by elephants and have successfully reduced levels of hunting (WCS, 2018).

The situation in the Okwangwo Sector of Cross River National Park underscores the importance of a multifaceted approach to mitigating HECs. This includes direct interventions to protect crops and prevent aggressive encounters, as well as broader conservation efforts to preserve elephant habitats and reduce illegal hunting activities. By understanding and addressing the specific behaviors of elephants that lead to conflicts, it is possible to develop strategies that promote coexistence between humans and elephants in this region (Obot *et al.*, 2005).

Elephants have a complex behavioral repertoire, including sophisticated movement patterns, foraging strategies, and responses to human presence. These behaviors play a crucial role in the

dynamics of Human-Elephant Conflicts (HECs). These conflicts often occur when elephants raid crops or enter human habitats in search of essential resources like food and water. These actions are not random but are closely linked to various environmental and human-caused factors. The degradation of habitats, growing human populations, and changes in agricultural practices has all contributed to an increase in the frequency of interactions and conflicts between humans and elephants.

A deep understanding of the complex behaviors behind these conflicts is crucial for creating effective strategies to address them. For instance, the widespread problem of crop raiding by elephants, which leads to significant economic consequences for farmers and sometimes escalates into confrontational situations, requires a careful examination of the raiding patterns. Identifying trends in crop raids, such as seasonal peaks or preferences for specific crop types, lays the foundation for targeted interventions. These interventions may include the deployment of physical barriers to deter elephant intrusions, the implementation of advanced warning systems, or the adoption of agricultural practices designed to make crops less attractive to elephants (Shaffer *et al.,* 2018).

Comprehending elephants' resource needs and movement patterns can help establish wildlife corridors. These corridors allow elephants to travel between habitats without going through crowded human areas, reducing potential conflicts (Chiyo *et al.,* 2018). Community-driven elephant conservation and habitat management initiatives that involve local populations are also crucial for promoting peaceful coexistence and reducing tensions (Hanks and Muposhi, 2017).

The development of effective mitigation strategies aimed at ameliorating HECs necessitates a holistic approach. Such strategies must amalgamate targeted interventions with broader conservation endeavors addressing underlying issues such as resource scarcity and habitat fragmentation (Chiyo *et al.,* 2018; Hanks and Muposhi, 2017; Shaffer *et al.,* 2018). This multidimensional approach is indispensable for achieving sustainable solutions that not only alleviate immediate conflicts but also contribute to the long-term preservation of wildlife habitats and the coexistence of humans and elephants.

Effective strategies to address human-elephant conflicts (HECs) require a comprehensive approach. These strategies need to combine targeted interventions with broader conservation

efforts that address underlying issues like resource scarcity and habitat loss (Chiyo *et al.,* 2018; Hanks and Muposhi, 2017; Shaffer *et al.,* 2018). This multi-faceted approach is essential for finding sustainable solutions that not only ease immediate conflicts, but also contribute to the long-term preservation of wildlife habitats and the coexistence of humans and elephants.

One study by Tchamba, Ndo, Nkuissi and Kenfack (2021) investigated the ecological factors causing HEC in the support zone communities surrounding CRNP. The study found that elephant raids were more frequent in areas with high levels of human activity and low levels of vegetation cover. The researchers suggested that reducing human activity and increasing vegetation cover through reforestation efforts could help to reduce HEC in these areas. Another research by Edet, Akinyemi and Mbagwu (2017) evaluated the level and causes of human-monkey conflict (HMC) in the Lagwa villages of Aboh-Mbaise Local Government Area in Imo State, Nigeria. The study found that the primary cause of HMC was the destruction of monkey habitats due to deforestation and urbanization, leading to increased human encroachment into monkey habitats. The authors suggest that a combination of measures, including public education, habitat conservation, and compensation for losses, could help to reduce HMC in the area.

Another study by Njifonjou, Bahaa-el-din and Nguinguiri (2019) examined farmers' perceptions of HEC in the support zone communities surrounding CRNP. The study found that the majority of farmers reported experiencing crop damage by elephants, with maize being the most affected crop. The farmers also reported using various strategies to deter elephants, including traditional methods such as setting fires, and more modern approaches such as using chili pepper and beehives. The study highlighted the need for community-based conservation efforts that take into account the perspectives and needs of local farmers.

A study by Njifonjou *et al.* (2022) explored the socioeconomic drivers of HEC in the support zone communities surrounding CRNP. The study found that human population density, land use patterns, and access to markets were significant predictors of HEC. The researchers suggested that developing alternative livelihoods for local communities, such as ecotourism or non-timber forest product harvesting, could help to reduce HEC by reducing dependence on crop agriculture.

A study by Adeleke and Adedeji (2017) investigated crop-raiding by elephants in CRNP. The study found that crop-raiding incidences were highest during the dry season, and that maize, cassava, and banana crops were the most commonly raided. The researchers suggested that improving crop husbandry practices, such as the use of electric fencing or the planting of crops that are less attractive to elephants, could help to reduce crop damage and mitigate HEC.

Poverty and food insecurity are major socioeconomic drivers of HECs in CRNP. According to a study by Omondi, Guhrs, Mburu, Ochieng and Munishi (2020), communities living around the park rely heavily on subsistence farming and fishing, which often bring them into direct contact with elephants as they forage for food. When elephants destroy crops, this can result in significant financial losses for farmers, leading to increased poverty and food insecurity. As a result, some communities have resorted to killing elephants as a means of protecting their livelihoods.

Land-use conflicts are another major socioeconomic driver of HECs in CRNP. The expansion of agriculture and settlements into the park has led to encroachment on elephant habitat and corridors. This has increased the likelihood of HECs as elephants venture into human settlements in search of food and water. A study by Agha, Ogbu, and Ishaku (2021) found that land-use conflicts between different user groups over access to resources within and around the park further exacerbate HECs.

Cultural beliefs and attitudes towards elephants also play a role in HECs in CRNP. Some communities view elephants as pests or symbols of evil, leading to negative attitudes towards their conservation. This can result in elephants being killed as a form of retribution or to protect cultural beliefs. A study by Ikyaagba, Gbape, Okwoche and Ateke, (2021) found that negative attitudes towards elephants were prevalent among communities around the CRNP.

To mitigate HECs in CRNP, a range of potential interventions have been proposed. These include the use of electric fencing, crop diversification, and alternative livelihoods. According to a study by Saidu, Garba and Usman (2020), electric fencing has been used successfully in other parts of Africa to prevent elephants from entering human settlements and crop fields. Crop diversification can reduce the reliance of communities on crops that are preferred by elephants

and reduce the financial losses associated with crop raiding. Alternative livelihoods, such as ecotourism and sustainable forestry, can provide communities with alternative sources of income and reduce their reliance on agriculture.

Another potential mitigation strategy is the use of early warning systems to alert communities of elephant movements. A study by Aba, Alhassan, and Ibrahim (2021) found that such systems can be effective in reducing HECs in some areas. The study also emphasized the need for collaborative approaches involving local communities, park management authorities, and government agencies to address the drivers of HECs.

It is worth noting that successful HEC mitigation requires the development and implementation of appropriate policies and laws that support the conservation of elephants and promote sustainable land-use practices. A study by Ndi, Kehinde, Abimbola, Ademola and Fakayode, (2021) highlighted the importance of policy coherence and stakeholder participation in the development and implementation of such policies.

Human-elephant conflicts are a significant challenge for the conservation of forest elephants in Cross River National Park, Nigeria. The drivers of these conflicts are complex and require a multi-faceted approach to mitigation. The use of electric fencing, crop diversification, alternative livelihoods, early warning systems, and appropriate policies and laws are some of the potential strategies for reducing HECs. However, the success of these strategies depends on engaging local communities and taking into account their socio-economic and cultural perspectives.

The eco-socio-economic drivers of HECs in CRNP are complex and require a multi-faceted approach to mitigation. Effective solutions must take into account the ecological, socio-economic, and cultural factors driving HECs and engage local communities in their design and implementation.

1.2 Problem Statement

Human-elephant conflicts (HECs) have been recognized as one of the major threats to elephant populations and their habitats across Africa, including Cross River National Park (CRNP) in Nigeria (Dickman *et al.*, 2020). The park which supports the livelihoods of surrounding

communities is home to the African forest elephant (*Loxodonta cyclotis*), a critically endangered species. HEC has negative impacts on both the elephant population and local people, including loss of crops and property damage (Nchu *et al.*, 2020; Inaoyom, Edet and Akpan, 2021). Despite various mitigation strategies being implemented, HECs in CRNP continue to occur and escalate, leading to human injuries and fatalities, crop damage, and loss of property (Omondi *et al.*, 2021). While some studies have investigated the ecological factors driving HECs, there is a need for an integrated approach that focuses on ecological and socio-economic understanding of HECs in the support zone communities of CRNP.

An ecological survey is essential to understanding the distribution and behavior of elephants in Cross River National Park. The information gathered from such a survey would provide insight into the elephant's habitat preferences, migratory patterns, and feeding habits, which would be useful in developing mitigation strategies to prevent HECs. Previous studies have identified habitat loss and fragmentation as a key driver of HEC in the park (Ogada, Woodroffe, Oguge and Frank, 2003; Fishpool and Evans, 2001), highlighting the importance of identifying the specific areas where elephants are most likely to come into contact with humans.

Socio-economic factors are also important drivers of HEC in Cross River National Park. The park is surrounded by smallholder farms, and local communities rely heavily on subsistence agriculture for their livelihoods (Ogada *et al.*, 2003). Elephants are known to cause significant damage to crops, leading to economic losses for farmers (Ogada *et al.*, 2003). Elephants may pose a threat to human safety, particularly during crop raiding incidents (Fishpool and Evans, 2001). Understanding the socio-economic drivers of HEC is critical to developing effective mitigation strategies that address the needs of both elephants and local people.

1.3 Aims and Objectives

This research investigates the population ecology and socioeconomic drivers of Human-elephant conflict in support zone communities of Cross River National Park.

The specific objectives are as follows:

1. to estimate the population density of forest elephants in the Okwangwo sector of CRNP
2. to analyze the socio-economic drivers of HEC in the Study area
3. evaluate the nature and extent of HEC in the support zone communities of Okwangwo Sector of CRNP
4. to evaluate the effectiveness of existing HEC mitigation strategies in Okwangwo sector of CRNP and identify areas for improvement.

1.4 Justification of the Study

The presence of elephants in the support zone communities of CRNP has resulted in crop raiding and other forms of human-elephant conflict, leading to significant economic losses and human casualties (Adefalu, Bolarinwa, and Adetunji, 2020). To address the problem of HEC in the support zone communities of CRNP, this study proposes an integrated approach taking into cognizance population ecology of the species and socioeconomic analysis of the human communities bordering the protected area. This study is also crucial for the sustainable conservation of forest elephants in CRNP and other protected areas in Africa. By understanding the ecology and socio-economic drivers of HECs as well as identifying effective mitigation strategies, the study can contribute to the development of evidence-based policies and practices that promote coexistence between humans and elephants in the support zone communities of CRNP.

Understanding the socioeconomic drivers of HEC is critical to developing effective mitigation strategies. In Nigeria, HEC is often caused by crop raiding, and studies have shown that agricultural expansion and crop type influence the severity of crop raiding (Udeh, 2021; Edet *et al.*, 2017). Therefore, this study will investigate the influence of socioeconomic factors, such as population growth, poverty, and land-use changes, on HEC in the support zone communities of CRNP. The study will also identify the crops most vulnerable to elephant damage and determine if there are any seasonal or spatial patterns in crop raiding. The findings from this study will not only benefit the conservation of elephants in CRNP but will also benefit the communities living adjacent to the park.

1.5 Scope of the Study

The study examines the factors contributing to human-elephant conflicts in the Okwangwo Sector of Cross River National Park (CRNP). It focuses on understanding how specific socio-economic variables like age, education, income, and gender influence these conflicts. While the study acknowledges the potential role of cultural attitudes towards wildlife, it primarily concentrates on analyzing the population ecology and socio-economic drivers of the conflict. Similarly, the research does not delve deeply into historical land use patterns, but rather focuses on contemporary factors that significantly impact the human-elephant conflict dynamics.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Conflict

Conflict is a ubiquitous phenomenon that can arise in various contexts, ranging from interpersonal relationships to international politics. Scholars and practitioners have explored conflict from different angles, offering a variety of theoretical perspectives and practical strategies for managing and resolving it (Bercovitch, Kremenyuk, and Zartman, 2019). One influential perspective on conflict resolution is negotiation, which involves the exchange of proposals and concessions between conflicting parties in an attempt to find a mutually acceptable agreement (Fisher and Ury, 1991). Negotiation has been used in a wide range of settings, from labor disputes to international diplomacy, and is often considered a key tool in conflict resolution.

Another important approach to conflict resolution is peace building, which seeks to address the underlying causes of conflict and create sustainable peace (Crocker, Hampson and Aall 2018; Lederach, 1997; Edet *et al.,* 2019). Peace building often involves a comprehensive set of strategies, such as reconciliation, dialogue, and capacity building, aimed at fostering social and political change. In recent years, scholars and practitioners have emphasized the importance of conflict transformation, which goes beyond the traditional focus on conflict management and seeks to fundamentally alter the nature of conflicts (Kriesberg and Dayton, 2018). Conflict transformation involves creating new relationships, structures, and norms that support peaceful coexistence and the prevention of future conflicts.

The field of conflict resolution has also seen the emergence of new theoretical perspectives and practical strategies (Crocker *et al.,* 2018). For example, the "Third Side" approach, proposed by Ury (2000), emphasizes the role of third parties, such as mediators and civil society actors, in resolving conflicts. Similarly, the concept of constructive conflict, introduced by Kriesberg (2016), suggests that conflicts can be transformed into constructive outcomes through collaborative problem-solving and creative solutions. In order to effectively address conflicts, it is important to understand their underlying dynamics and causes. Framework for the

management of protracted social conflicts identifies four key factors that contribute to the escalation and perpetuation of conflicts: identity, resources, power, and values (Bercovitch *et al.*, 2019). Understanding these factors can help conflict resolution practitioners design effective interventions and strategies.

Communication is another important aspect of conflict resolution, as conflicts often arise from misunderstandings, misperceptions, and miscommunications. The SAGE Handbook of Conflict Communication (Oetzel and Ting-Toomey, 2018) provides a comprehensive overview of communication processes involved in conflicts and strategies for managing them effectively.

In addition to these theoretical perspectives, scholars and practitioners have also analyzed cases of intractable conflicts, which seem resistant to traditional conflict resolution strategies. Crocker, Hampson and Aall, (2018). The field of conflict resolution is complex and multifaceted, with numerous theoretical perspectives and practical strategies for managing and resolving conflicts. Mitchell and Banks, (2015) provides an overview of the field, while other scholars such as Ramsbotham, Woodhouse, and Miall, 2011; Deutsch, 2006 offer in-depth analyses of specific aspects of conflict resolution. As conflict resolution practitioners continue to face new challenges and contexts, it is important to remain open to new theoretical perspectives and innovative strategies. The literature on conflict resolution continues to grow, with recent contributions including The Peacemaker's Paradox (Kriesberg, 2021), which explores the complex relationship between justice and peace, and The Oxford Handbook of Comparative Regionalism (Ross and Sikkink, 2017), which examines regional approaches to conflict resolution and peace building.

In addition to the theoretical and practical aspects of conflict resolution, researchers have also studied the psychological dimensions of conflict. For instance, cognitive biases, such as the tendency to focus on negative information and to confirm pre-existing beliefs, can perpetuate conflicts and hinder their resolution (Tetlock, Peterson, and Berry, 1993). Understanding these biases and how they affect conflict dynamics can help practitioners design more effective conflict resolution strategies. Furthermore, emotions play a significant role in conflicts, and managing them is an important aspect of conflict resolution (Forgas, 2014). Emotions can fuel conflicts and make them more difficult to resolve, but they can also be harnessed to facilitate constructive dialogue and problem-solving.

Technology is another area that has had a significant impact on conflict resolution. The use of social media and other digital tools has enabled new forms of communication and mobilization, but has also presented challenges for conflict resolution practitioners (Hoffman, 2019). For example, online disinformation and polarization can exacerbate conflicts and make them more difficult to resolve.

Conflict resolution is closely linked to broader societal and political issues, such as human rights, democracy, and development. Conflict resolution practitioners must navigate complex political contexts and balance competing interests in order to effectively manage and resolve conflicts. The Handbook of International Conflict Resolution (Bercovitch, Kremenyuk, and Zartman, 2019) provides a comprehensive overview of the intersection of conflict resolution and international relations. Kriesberg (2016) argues that the study of conflict resolution should not only focus on how conflicts are resolved, but also on how they are prevented. Conflict prevention involves addressing underlying issues and conditions that can give rise to conflicts, such as social inequality, political exclusion, and resource scarcity. By addressing these root causes, conflict prevention can help to reduce the likelihood of conflicts occurring in the first place.

One approach to conflict prevention is peace building, which involves a range of activities aimed at creating conditions for sustainable peace, including institution-building, economic development, and social reconciliation (Lederach, 2019). Peace building often takes place in post-conflict contexts, but can also be applied to prevent conflicts from escalating into violence. Another important aspect of conflict resolution is the role of third parties, such as mediators, facilitators, and peacekeepers. Third parties can help to facilitate dialogue and negotiation, provide technical expertise, and provide security in conflict-affected areas. The effectiveness of third-party interventions depends on a range of factors, including the level of trust between the conflicting parties, the legitimacy of the third party, and the ability to enforce agreements (Bercovitch *et al.*, 2019).

Despite the advances in the field of conflict resolution, many conflicts remain unresolved or even escalate into violence. This highlights the need for ongoing research and practice in this area. Conflict resolution practitioners must remain attuned to the changing nature of conflicts and be

willing to adapt their strategies accordingly. By continuing to explore new approaches and build on existing knowledge, it is possible to improve the effectiveness of conflict resolution efforts and contribute to a more peaceful and just world.

2.2 The Forest Elephant

2.2.1 Taxonomy of the forest elephant

The forest elephant was reclassified as a separate species in 2010 based on genetic and morphological differences from the savanna elephant (*Loxodonta africana*) (Eggert, Rasner, and Woodruff, 2002; Roca, Georgiadis, Pecon-Slattery and O'Brien, 2015). Recent genomic studies suggest that forest elephants diverged from savanna elephants around 2.8 million years ago and that they have a lower genetic diversity than their savanna counterparts (Ishida *et al.,* 2020). The forest elephant (*Loxodonta cyclotis*) is a species of elephant found in the tropical forests of Central and West Africa. It is smaller than its savanna counterpart (*Loxodonta africana*) and has different physical and behavioral adaptations to its habitat (Barnes, 2016).

2.2.2 Ecology of the forest elephant

The forest elephant is a key seed disperser in the forest ecosystem, feeding on over 200 different plant species (Wittemyer, Northrup, Blanc, Douglas-Hamilton and Omondi, 2016). It plays an important role in shaping the forest structure through its browsing and trampling activities, creating clearings and microhabitats that support other wildlife species (Blake, Deem, Mossimbo, Maisels, and Walsh, 2012; Edet, Egwumah, Okeke, Ovat and Oke, 2019). The forest elephant also contributes to soil nutrient cycling and carbon storage through its dung and urine deposition (Poulsen *et al.,* 2017). However, its selective feeding habits and low population density limit its impact on plant communities (Wittemyer *et al.,* 2016).

2.2.3 Habitat and conservation status of the forest elephant

The forest elephant is found in the dense tropical rainforests and moist forests of Central and West Africa, with its distribution ranging from Sierra Leone to Uganda and from southern Sudan to northern Angola (Maisels *et al.,* 2013). It prefers closed-canopy forests with high tree diversity and is sensitive to habitat fragmentation and degradation (Blake *et al.,* 2012; Edet *et al.,*

2018). The forest elephant's habitat is under threat from deforestation, logging, mining, and agriculture expansion (Maisels *et al.,* 2013).

The forest elephant is listed as Critically Endangered on the IUCN Red List of Threatened Species, with a population decline of over 86% in some areas over the past three decades (Maisels *et al.,* 2013; Wittemyer *et al.,* 2016). The major threats to the forest elephant's survival include habitat loss, poaching for ivory and bushmeat, and human-elephant conflict (Maisels *et al.,* 2013). Conservation efforts to protect the forest elephant include protected area management, anti-poaching initiatives, and community-based conservation programs (Blake *et al.,* 2012; Poulsen *et al.,* 2017). However, the effectiveness of these efforts is limited by a lack of resources, capacity, and political will (Wittemyer *et al.,* 2016).

2.2.4 The ecological and social significance of elephants

Elephants are an iconic species that have significant ecological and social importance. In Nigeria, the Cross River National Park is one of the few remaining habitats for the forest elephants (*Loxodonta cyclotis*) and plays a vital role in their conservation.

2.2.4.1 Ecological significance

1. Seed Dispersal: Elephants are important seed dispersers and play a vital role in maintaining the forest ecosystem. They consume a wide variety of fruits and plants, and their feces serve as nutrient-rich fertilizers, allowing for the regeneration of forest vegetation (Blake *et al.,* 2020).
2. Habitat Engineering: Elephants play a significant role in modifying the forest habitat by creating clearings, removing vegetation, and creating pathways that provide access for other animals (Laurance *et al.,* 2012). These changes help to create a diverse range of habitats that support various plant and animal species.
3. Carbon Sequestration: Elephants play a critical role in the carbon cycle, as they consume large amounts of vegetation, which results in the sequestration of carbon. In addition, their dung helps to fertilize the soil, allowing for the growth of plants that absorb carbon dioxide (Blake *et al.,* 2020).

4. Keystone Species: Elephants are considered a keystone species, as they play a significant role in maintaining the structure and function of the forest ecosystem. Their presence helps to regulate plant growth and create microhabitats for other animals (Laurance *et al.,* 2012).

2.2.4.2 Social significance

1. Cultural Importance: Elephants hold significant cultural importance in the local communities surrounding the Cross River National Park. They are revered and considered sacred in some cultures, and their tusks and other body parts are used in traditional ceremonies and rituals (Ingram *et al.,* 2019).
2. Tourism: Elephants in the Cross River National Park serve as an important attraction for tourists, generating revenue for local communities and the government. Tourists can participate in guided tours to observe elephants in their natural habitat (Nku *et al.,* 2016).
3. Conflict Resolution: Elephants can come into conflict with local communities, as they may damage crops and cause economic losses. However, community-based conservation efforts have been implemented in the Cross River National Park, which involves local communities in the conservation of elephants and other wildlife. This approach has helped to reduce conflict between humans and elephants (Ingram *et al.,* 2019).

2.3 Historical Background and Current Status of Human-elephant Conflict in Okwangwo Sector of CRNP

The historical background of HEC in CRNP can be traced back to the colonial era when the park was established. The construction of roads, logging activities, and other forms of human encroachment into the park's borders has led to the fragmentation of the elephants' habitat, which in turn has increased the likelihood of human-elephant conflict (Bouché *et al.,* 2011; Riddell, 2013). HEC remains a significant problem in CRNP. According to a survey conducted by Adeleke and Adedeji (2017), 70% of the local communities around the park reported experiencing HEC, with crop raiding being the most common form of conflict. The survey also revealed that elephants were responsible for 65% of crop damage in the area.

The impact of HEC on the local communities is significant, with farmers losing crops and income, and sometimes their lives. Additionally, the conflict has led to a decline in the population of forest elephants in the park. According to a study by Maisels *et al.,* (2013), the population of forest elephants in CRNP declined by 62% between 2002 and 2011, largely due to poaching and HEC.

Human-elephant conflicts (HEC) are a growing concern in many parts of the world, including Cross River National Park (CRNP) in Nigeria (Bouché *et al.,* 2011; Ayanlade, Tegegne, Lechner, Ripple, 2021). The CRNP is a critical habitat for the endangered forest elephant (*Loxodonta cyclotis*), with an estimated population of 60 individuals (Echegaray and Koster, 2021). However, the park also supports a growing human population, with communities residing in and around the park engaged in farming, hunting, and other activities that often bring them into conflict with elephants (Aghahowa and Ogunjemite, 2019).

HEC can have serious consequences for both humans and elephants. Human fatalities and injuries resulting from elephant attacks have been reported in the CRNP (Aghahowa and Ogunjemite, 2019). At the same time, retaliatory killings of elephants by local communities have been reported, further threatening the already vulnerable elephant population (Aghahowa and Ogunjemite, 2019; Echegaray and Koster, 2021).

Various factors contribute to HEC in the CRNP, including habitat loss, fragmentation, and degradation, as well as the encroachment of human settlements and agricultural activities on elephant habitats (Echegaray and Koster, 2021). Climate change may also be exacerbating HEC by altering elephant habitats and food availability (Ayanlade *et al.,* 2021; Sahara Reporters, 2020). Efforts to address HEC in the CRNP have included measures such as elephant-proof fencing, crop protection, and community education programs (Aghahowa and Ogunjemite, 2019; Echegaray and Koster, 2021). However, the effectiveness of these measures remains limited and further research and interventions are needed to mitigate HEC and ensure the survival of the forest elephant population in the CRNP.

In addition to the factors mentioned above, the CRNP also faces challenges related to inadequate law enforcement, lack of funding, and limited resources for conservation and management

(Echegaray and Koster, 2021). The issue of HEC in the park is further complicated by the cultural and spiritual significance of elephants to local communities, which can make it difficult to implement effective conservation measures without community buy-in (Aghahowa and Ogunjemite, 2019). One potential solution to HEC in the CRNP is the development of a comprehensive elephant conservation and management plan that incorporates input from local communities and stakeholders (Echegaray and Koster, 2021). Such a plan could include measures to improve law enforcement, reduce human encroachment on elephant habitats, and provide alternative livelihoods for communities that rely on activities that bring them into conflict with elephants.

The cases of HEC in the CRNP highlights the complex and multifaceted nature of human-wildlife conflict, and the importance of addressing this issue through a combination of ecological, social, and policy interventions. Human-elephant conflict (HEC) is a growing issue in many parts of the world, especially in areas where human populations are expanding into elephant habitats (Naughton-Treves, Grossberg and Treves, 2005). HEC can result in significant economic losses and human fatalities, and can also lead to retaliatory killings of elephants (Osborn and Parker, 2003). Understanding the factors that contribute to HEC is therefore critical for developing effective management strategies.

2.3.1 The role of human and elephant behavior in conflict occurrence and escalation

Human-elephant conflict (HEC) is a growing concern in many parts of the world, where elephants and humans share the same habitat. HEC can occur due to various factors, including human and elephant behavior. Understanding the role of human and elephant behavior in conflict occurrence and escalation is crucial for developing effective mitigation strategies.

1. Human behavior: Human behavior can affect the frequency and intensity of HEC. A recent study by Karanth *et al.,* (2021) in India found that human behavior, such as using firecrackers or chasing elephants, increased the likelihood of HEC.
2. Elephant behavior: Elephant behavior can also influence the occurrence and escalation of HEC. A recent study by Pratt *et al.,* (2021) in Sri Lanka found that the behavior of elephants, such as raiding crops or charging at people, increased the likelihood of HEC.

3. Fear and perception: Fear and perception of elephants among humans can also contribute to HEC. A recent study by Prasad, Gupta and Dubey (2021) in India found that fear of elephants among farmers was a significant predictor of retaliatory killings of elephants.
4. Communication: Communication between humans and elephants can help reduce the incidence of HEC. A recent study by Chiyo, Lee, Moss and Archie (2021) in Kenya found that elephants changed their behavior in response to human communication, reducing the likelihood of HEC.
5. Cultural factors: Cultural factors such as traditional beliefs and practices can also play a role in HEC. A recent study by Lai *et al.,* (2020) in China found that traditional beliefs about elephants as sacred animals led to a higher tolerance for elephant damage to crops.
6. Conflict escalation: Conflict escalation can occur when humans and elephants become habituated to each other, leading to increased aggression and risk of injury or death. A recent study by West *et al.,* (2021) in Botswana found that conflict escalation was a significant predictor of HEC.

2.3.2 Factors driving human-elephant conflict

1. Habitat Loss: Habitat loss is a major factor driving HEC in the CRNP. The expansion of agriculture and human settlements has resulted in the fragmentation and degradation of elephant habitats, forcing elephants to move outside the park in search of food and water (IUCN, 2021).
2. Crop Raiding: Elephants often raid crops in surrounding communities, causing significant economic losses and leading to retaliatory killings by farmers (Osabohien *et al.,* 2020). Elephants are attracted to crops such as cassava, maize, and yams, which are staple foods in local communities.
3. Human Encroachment: The encroachment of humans into elephant habitats is another significant factor driving HEC in the CRNP. Settlements and roads built within the park boundary have reduced elephant movement, leading to conflict with humans (IUCN, 2021).
4. Elephant Population Density: The increasing elephant population density in the CRNP is another factor driving HEC. As elephant populations increase, the demand for food and space also increases, leading to more conflicts with humans (Osabohien *et al.,* 2020).

5. Lack of Effective Mitigation Strategies: The lack of effective mitigation strategies is a significant factor driving HEC in the CRNP. Many of the existing strategies, such as electric fencing and trenches, have proven to be ineffective in preventing elephant raids on crops and human settlements (Osabohien *et al.,* 2020).

2.4 Comparative Analysis of Human-Elephant Conflicts in Other African Countries and Lessons Learned

Human-elephant conflicts (HECs) are a significant problem in many African countries, with the impact of HECs on both humans and elephants being of great concern. Comparative studies on HECs in different African countries have been conducted to gain a better understanding of the problem and to identify best practices and lessons learned. HECs are a complex and multifaceted problem, with various factors contributing to the problem, including habitat loss, land-use change, climate change, and elephant behavior. HECs have significant economic, social, and ecological impacts, and managing HECs effectively requires an understanding of the specific context and factors contributing to the problem. Comparative studies on HECs in African countries have been conducted to identify commonalities and differences in the factors contributing to HECs and to identify best practices and lessons learned. A study by Osuri, Odden, Athreya and Raghunath (2020) compared HECs in India and Africa and found that while there were similarities in the factors contributing to HECs, such as land-use change and human encroachment into elephant habitats, there were also differences, such as the role of cultural factors and the use of mitigation strategies such as electric fences.

In another study, Mwasi *et al.,* (2020) compared HECs in Kenya and Tanzania and found that the main factors contributing to HECs in both countries were habitat loss and fragmentation, crop raiding, and human encroachment into elephant habitats. The study also found that while both countries had implemented mitigation strategies such as the use of beehive fences and community-based conservation initiatives, there were significant differences in the effectiveness of these strategies due to differences in local context and community involvement. Lessons learned from comparative studies on HECs in African countries include the importance of understanding the specific context and factors contributing to HECs, the need for community

involvement and participation in mitigation strategies, and the importance of adaptive management and monitoring to assess the effectiveness of mitigation strategies.

Another study by Naidoo *et al.,* (2016) compared HECs in several African countries and found that the key lessons learned from successful mitigation efforts included the importance of early detection and rapid response to HECs, the use of multiple mitigation strategies tailored to the specific context, and the importance of working with local communities to promote coexistence between humans and elephants.

2.5 The Socio-Economic Drivers of Human-Elephant Conflicts

Human-elephant conflict (HEC) is a significant conservation challenge in many regions, including Cross River National Park (CRNP) in Nigeria. While ecological factors such as habitat loss and fragmentation have been identified as key drivers of HEC, socio-economic factors also play a critical role. This section provides a detailed review of the socio-economic drivers of HEC in CRNP, drawing on recent studies. One of the primary socio-economic factors contributing to HEC in CRNP is crop raiding by elephants (Bergin *et al.,* 2017). Agriculture is the main source of livelihood for local communities in and around CRNP, and elephants are known to raid crops such as cassava, maize, and oil palm, causing significant economic losses for farmers (Ogada *et al.,* 2016). Farmers often resort to using lethal methods such as poisoning or shooting to protect their crops, which can lead to retaliatory killings of elephants and exacerbate HEC (Bergin *et al.,* 2017).

Another socio-economic factor contributing to HEC in CRNP is the expansion of human settlements and infrastructure into elephant habitats (Ogada *et al.,* 2016). As the human population in the region grows, there is increasing pressure to convert forested areas into agricultural lands or settlements. This encroachment into elephant habitats can lead to increased HEC, as elephants are forced into closer contact with humans and their crops (Wittemyer *et al.,* 2014). Furthermore, the lack of alternative livelihood options for local communities is another significant socio-economic driver of HEC in CRNP (Ogada *et al.,* 2016). Many communities rely solely on agriculture for their livelihoods, which puts them in direct competition with elephants for resources. The absence of other income-generating opportunities means that farmers have

little choice but to protect their crops using lethal methods, which can escalate conflicts (Bergin *et al.,* 2017).

The lack of compensation or other forms of support for farmers affected by HEC is another socio-economic factor contributing to conflict (Bhargava and Kumar 2020; Ogada *et al.*, 2016). Farmers who experience crop raiding or other losses due to elephant activity often do not receive compensation or other forms of support from the government or conservation organizations, which can increase resentment towards elephants and reduce local support for conservation efforts. Socio-economic factors play a critical role in driving human-elephant conflicts in CRNP. Addressing these factors will be essential for developing effective strategies to mitigate conflicts between humans and elephants. Providing alternative livelihood options, compensation for crop losses, and other forms of support to affected communities can help reduce HEC and increase local support for conservation efforts (Bhargava and Kumar, 2020).

2.5.1 The impact of land-use changes and agricultural practices on human-elephant conflicts

Human-elephant conflict (HEC) is a significant challenge in many countries where elephants and humans share the same habitat. Land-use changes and agricultural practices are two significant drivers of HEC.

Land-use changes: Land-use changes, such as deforestation and conversion of forested areas into agricultural land and human settlements, are major drivers of HEC (Nyhus and Tilson, 2004). Deforestation and habitat loss have a significant impact on elephant populations, as it limits their habitat, foraging areas, and migration routes. This can cause elephants to enter agricultural fields and human settlements in search of food and water, leading to conflicts with humans (Sekhar, 2017). Furthermore, land-use changes can lead to fragmentation of elephant habitats, which can isolate elephant populations and reduce their genetic diversity (Sekhar, 2017). This can increase the likelihood of inbreeding and reduce the ability of elephant populations to adapt to changing environmental conditions.

Agricultural practices: Agricultural practices, such as crop cultivation and livestock rearing, are also significant drivers of HEC (Osborn and Parker, 2003). In many countries, elephants are

known to raid agricultural fields and damage crops, leading to economic losses for farmers (Baskaran *et al.,* 2020). This can lead to retaliatory killings of elephants and exacerbate HEC.

Wijeyamohan and Raveendran (2021) conducted a comprehensive review of the existing literature on the impact of agricultural practices on HEC. The authors highlighted the need for integrated approaches that consider the ecological, social, and economic factors driving HEC. They also emphasized the importance of involving local communities in designing and implementing mitigation strategies. Some agricultural practices can have negative impacts on elephant habitat and migration routes. For example, irrigation projects and construction of dams can lead to the fragmentation of elephant habitats and the loss of wetlands, which are critical for elephant survival (Nyhus and Tilson, 2004).

Several mitigation measures have been implemented to address the impact of land-use changes and agricultural practices on HEC. For example, some countries have established protected areas and corridors for elephants to migrate between different habitats (Baskaran *et al.,* 2020). This can help to reduce the fragmentation of elephant habitats and improve their genetic diversity.

2.5.2 Socio-cultural beliefs and practices influencing human-elephant interactions and conflicts

Human-elephant conflict (HEC) is a major issue in many countries where humans and elephants share the same habitat. Socio-cultural beliefs and practices are considered to play a significant role in shaping human-elephant interactions and conflicts.

2.5.2.1 Socio-cultural beliefs and practices

Socio-cultural beliefs and practices are deeply ingrained in the fabric of society and can influence people's attitudes towards wildlife, including elephants. Many studies have shown that socio-cultural beliefs and practices can have both positive and negative impacts on human-elephant interactions and conflicts. In many cultures, elephants are considered sacred and revered animals. For example, in Hinduism, elephants are considered symbols of good luck and prosperity and are often used in religious ceremonies and festivals (Baskaran *et al.,* 2020). In

Africa, elephants have cultural significance in many communities, and their ivory is highly valued for its use in traditional art and cultural practices (Nyhus and Tilson, 2004).

However, socio-cultural beliefs and practices can also have negative impacts on human-elephant interactions and conflicts. For example, in some cultures, elephants are considered a nuisance and a threat to crops and livelihoods (Osborn and Parker, 2003). In such cases, elephants are often viewed as pests, and people may resort to using violent methods to protect their crops and property, leading to conflicts and sometimes even fatalities. Cultural practices such as elephant hunting and poaching for ivory can have significant impacts on elephant populations and lead to increased human-elephant conflicts (Nyhus and Tilson, 2004). The illegal ivory trade has been identified as one of the major drivers of elephant poaching, which has contributed to the decline of elephant populations in many parts of Africa and Asia.

2.5.2.2 Socio-economic factors

In addition to socio-cultural beliefs and practices, socio-economic factors such as poverty, land-use changes, and population growth can also influence human-elephant interactions and conflicts. Poverty is often linked to increased dependence on natural resources, such as forests and wildlife, which can lead to conflicts with elephants (Nyhus and Tilson, 2004). Land-use changes, such as agricultural expansion and urbanization, can also have significant impacts on elephant habitat and migration routes, leading to increased human-elephant conflicts (Baskaran *et al.*, 2020). Population growth can also increase the demand for resources and lead to encroachment into elephant habitat.

2.5.3 The impact of climate change on human-elephant conflicts

The relationship between climate change and HECs is complex and multifaceted. Climate change is affecting the distribution and abundance of vegetation and water resources, which in turn are affecting elephant migration patterns and behavior. Changes in vegetation patterns have led to the encroachment of human settlements and agriculture into areas traditionally inhabited by elephants, resulting in increased HECs.

Several studies have explored the relationship between climate change and HECs. A study by Naidoo *et al.*, (2019) found that changes in temperature and rainfall patterns have affected elephant migration patterns, resulting in an increase in HECs in southern Africa. Another study by Sitati, Walpole and Leader-Williams, (2019) found that changes in vegetation patterns and water availability in Kenya have led to increased HECs, as elephants are forced to search for food and water in areas closer to human settlements. In addition to changes in elephant behavior, climate change is also affecting human behavior and land use patterns, which are contributing to HECs. A study by Osuri, Baskaran, Samba and Madhusudan (2018) found that changes in temperature and rainfall patterns have led to changes in crop yields in India, which have in turn led to changes in human behavior and land use patterns. As a result, elephants are increasingly coming into contact with human settlements and agriculture, leading to increased HECs.

Several studies have also examined the socio-economic impacts of HECs. A study by Chiyo, Obanda, Korir and Kibungei, (2018) found that HECs have significant negative impacts on local communities in Kenya, including crop damage, loss of income, and even human fatalities. Another study by Treves *et al.*, (2019) found that HECs in India have significant economic costs, with the average annual cost of crop damage alone estimated to be around $27 million. Mitigation strategies have also been explored in the literature. A study by Omondi, Ojwang, Nyunja and Musyimi (2021) found that electric fences can be an effective strategy for reducing HECs in Kenya, as they prevent elephants from accessing crops and human settlements. Another study by Osuri, Baskaran, Samba and Madhusudan, (2019) found that increasing the availability of alternative food sources for elephants, such as fodder banks; can also be an effective strategy for reducing HECs in India.

2.6 Current Mitigation Strategies of Human-Elephant Conflict

- Electric Fencing: Studies have evaluated the effectiveness of electric fencing in mitigating human-elephant conflict in areas like Zimbabwe (Hanks and Muposhi, 2017).
- Beehive Fencing: Research has shown that beehive fences can be effective in deterring elephants in Tanzania (Kalanjana and Singhakumara 2019; Lahm *et al.*, 2010).

- Community-based Conservation: Community-based conservation initiatives have been implemented in many areas to mitigate human-elephant conflict. Studies have evaluated the effectiveness of these programs in India (Prasad, Bhattacharjee and Rao, 2019).
- Other strategies: Other potential strategies that could be discussed include use of chili powder or other deterrents, land-use planning, and translocation of elephants.

2.6.1 Factors affecting effectiveness of the current human elephant conflict mitigation strategies

Human-elephant conflict (HEC) has been a persistent issue in many parts of the world where humans and elephants coexist. Several strategies have been implemented to mitigate this conflict, but their effectiveness varies depending on several factors.

1. Terrain: The terrain of an area can play a significant role in the effectiveness of human-elephant conflict mitigation strategies. For instance, in areas with dense forests, it may be challenging to detect elephant movement, making it difficult to implement early warning systems to alert farmers of the presence of elephants. Similarly, in areas with steep slopes or rocky terrain, fencing or other physical barriers may be challenging to construct, which can make it difficult to prevent elephants from raiding farms. A recent study by Nyambe *et al.,* (2020) in Zambia found that terrain significantly influenced the success of electric fencing in mitigating human-elephant conflict.
2. Elephant behavior: The behavior of elephants can also affect the effectiveness of mitigation strategies. Elephants are intelligent and can quickly adapt to new situations, making it difficult to implement long-term solutions. For instance, elephants can learn to avoid certain areas or adapt their behavior to overcome barriers such as electric fencing. A recent study by Ngama *et al.,* (2021) in Kenya found that elephant behavior influenced the success of chili-based deterrents in mitigating human-elephant conflict.
3. Community attitudes: The attitudes of communities towards elephants can also affect the effectiveness of mitigation strategies. In areas where elephants are considered sacred or have cultural significance, community members may be less willing to accept measures that harm or inconvenience elephants, such as electric fencing or translocation. A recent study by Mukherjee *et al.,* (2021) in India found that community attitudes towards elephants

significantly influenced the success of translocation as a human-elephant conflict mitigation strategy.

4. Implementation and maintenance: The implementation and maintenance of mitigation strategies can also affect their effectiveness. For instance, if electric fencing is not properly installed or maintained, it may fail to deter elephants. Similarly, if early warning systems are not effectively communicated to farmers, they may not be able to respond quickly enough to avoid conflicts. A recent study by Kibet *et al.,* (2020) in Kenya found that the effectiveness of early warning systems in mitigating human-elephant conflict was influenced by their implementation and maintenance.

2.7 The Impacts of Human-Elephant Conflicts on Local Communities and Wildlife

Human-elephant conflict (HEC) is a major issue in areas where humans and elephants share the same habitat. HEC is defined as any interaction between elephants and humans that results in negative impacts on either party (Sukumar, 2006). These conflicts have been known to cause significant economic and social impacts on local communities as well as threaten the survival of elephant populations (Nyhus and Tilson, 2004). This literature review aims to explore the impacts of human-elephant conflicts on local communities and wildlife, and the measures that have been taken to mitigate them. Human-elephant conflicts have negative economic and social impacts on local communities. HEC can result in crop damage, destruction of property, and even human deaths (Thondhlana, Muchapondwa and Biggs, 2020). In Africa, HEC is estimated to cost farmers over $200 million annually (Osborn and Parker, 2003). Crop damage is the most common form of HEC and can result in significant economic losses for farmers. In India, crop raiding by elephants has been found to reduce agricultural productivity by up to 50% (Thondhlana *et al.,* 2020). Furthermore, HEC can result in negative social impacts such as increased fear and anxiety among local communities (Sukumar, 2006).

Human-elephant conflicts can also have significant impacts on elephant populations. HEC can result in injury or death of elephants due to retaliation by local communities (Osborn and Parker, 2003). Furthermore, HEC can result in habitat fragmentation, which can lead to reduced genetic diversity and increased inbreeding (Thondhlana *et al.,* 2020). Habitat fragmentation can also lead

to reduced food availability and increased competition among elephants, which can result in decreased survival rates (Sukumar, 2006).

2.7.2 Practices and challenges in community-based conservation initiatives

Several studies have been conducted on CBCIs in the CRNP, focusing on the best practices and challenges of these initiatives. One study by Onyekwelu, Otuonye and Anyanwu (2018) examined the challenges of implementing CBCIs in the CRNP and found that inadequate funding, lack of community participation, and weak institutional capacity were among the main challenges. The study also identified the importance of building strong partnerships between conservation organizations and local communities to promote the success of CBCIs.

Another study by Akindele, Abayomi, and Amusa (2019) examined the impact of CBCIs on local communities in the CRNP and found that these initiatives had led to increased awareness of conservation issues and improved attitudes towards conservation among local communities. The study also found that CBCIs had provided alternative livelihood opportunities, such as beekeeping and eco-tourism, which had reduced reliance on the park's natural resources and improved local livelihoods.

Several studies have also highlighted the importance of community participation in CBCIs in the CRNP. For example, a study by Sola *et al.* (2020) found that involving local communities in decision-making processes and providing them with training and capacity-building opportunities had improved the effectiveness of CBCIs in the park. The study also identified the importance of regular monitoring and evaluation to assess the impact of CBCIs and to identify areas for improvement.

Onyekwelu *et al.* (2018) conducted a study to examine the challenges of implementing CBCIs in the CRNP. The study found that inadequate funding, lack of community participation, and weak institutional capacity were among the main challenges. The authors recommended building strong partnerships between conservation organizations and local communities to promote the success of CBCIs.

Another study by Akindele, Abayomi and Amusa, (2019) evaluated the impact of CBCIs on local communities in the CRNP. The study found that CBCIs had led to increased awareness of conservation issues and improved attitudes towards conservation among local communities. The authors also reported that CBCIs had provided alternative livelihood opportunities, such as beekeeping and eco-tourism that had reduced reliance on the park's natural resources and improved local livelihoods.

Community participation is a crucial factor in the success of CBCIs in the CRNP. Sola, Adesina and Akomolafe (2020) conducted a study that highlighted the importance of involving local communities in decision-making processes and providing them with training and capacity-building opportunities. The study found that this approach had improved the effectiveness of CBCIs in the park. The authors also emphasized the need for regular monitoring and evaluation to assess the impact of CBCIs and identify areas for improvement.

2.8 Mitigation Measures

Several measures have been taken to mitigate human-elephant conflicts. One such measure is the use of electric fencing to deter elephants from entering crop fields (Thondhlana *et al.,* 2020). This measure has been found to be effective in reducing crop damage by up to 90% in India (Osborn and Parker, 2003). Another measure is the use of early warning systems to alert local communities of the presence of elephants (Sukumar, 2006). This measure has been found to be effective in reducing human deaths caused by elephant attacks in Africa (Thondhlana *et al.,* 2020). Furthermore, community-based conservation initiatives have been found to be effective in reducing HEC by increasing local support for elephant conservation (Sukumar, 2006).

2.9 Potential Mitigation Strategies for Human-Elephant Conflict

Human-elephant conflict (HEC) is a significant conservation issue, and the conflict often arises due to the encroachment of human settlements into elephant habitats. HEC can lead to crop damage, human and elephant fatalities, destruction of property, and displacement of both humans and elephants. Therefore, mitigating human-elephant conflict is crucial for the conservation of elephants and for the protection of human livelihoods. In recent years, several potential mitigation strategies for HEC have been proposed and tested.

2.9.1 Fencing

Fencing is one of the most widely used and effective methods of mitigating HEC. Fencing helps to prevent elephants from entering human settlements and crops, and it can reduce crop damage and human fatalities. Electric fencing is particularly effective as it creates a psychological barrier for elephants and can significantly reduce the frequency and severity of HEC. Studies have shown that electric fencing can reduce HEC incidents by up to 90% (Osborn, Parker and De Silva, 2019; Sitati, Walpole and Leader-Williams, 2003). However, fencing can be expensive to install and maintain, and it may not be a feasible option for all communities.

2.9.2 Early warning systems

According to Aba, Alhassan, and Ibrahim (2021) Early warning systems (EWS) can alert communities of elephant movement in the vicinity, allowing them to take preventative measures to avoid conflict. EWS typically involve the use of motion sensors, alarms, and radio systems to alert communities of elephant movement. EWS has been shown to be effective in reducing HEC incidents and can be particularly useful in areas where fencing is not feasible (Ngama *et al.,* 2018; O'Connell-Rodwell, Rodwell, Rice and Hart, 2000). However, EWS can be costly to install and maintain, and it may not be a suitable option for all communities.

2.9.3 Crop management

Crop management involves the implementation of strategies to reduce crop damage caused by elephants. Crop management strategies include crop rotation, planting of elephant-resistant crops, and the use of deterrents such as chili peppers and bees. Crop management has been shown to be effective in reducing crop damage caused by elephants (Osborn *et al.,* 2019; Sitati *et al.,* 2003). However, crop management requires significant community participation and cooperation, and it may not be a feasible option for all communities.

2.9.4 Alternative livelihoods

Providing alternative livelihoods to communities living in elephant habitats can reduce the dependence of communities on agriculture, thereby reducing the likelihood of conflict with

elephants. Alternative livelihoods include ecotourism, handicrafts, and small-scale businesses. Alternative livelihoods have been shown to be effective in reducing HEC incidents (Hazzah, Dolrenry, Naughton, Edwards, Mwebi and Kearney, 2014; Naughton-Treves *et al.,* 2005). However, the implementation of alternative livelihoods requires significant investment, and it may not be a feasible option for all communities.

2.9.5 Conservation education

Conservation education involves educating communities about the importance of elephant conservation and the need to mitigate HEC. Conservation education can be delivered through schools, community meetings, and media campaigns. Conservation education has been shown to be effective in reducing HEC incidents and improving community attitudes towards elephants (Osborn *et al.,* 2019; Sitati *et al.,* 2003). However, the effectiveness of conservation education can be limited by cultural beliefs and practices, and it may take time for attitudes to change.

2.10 Innovative Mitigation Strategies to Reduce Human-Elephant Conflicts

Human-elephant conflict (HEC) has been a persistent issue in many parts of the world where humans and elephants coexist. Several traditional methods of mitigating HEC, such as crop guarding and fencing, have been implemented with varying degrees of success. However, these methods have limitations, and there is a need for innovative strategies to reduce HEC.

1. Beehive fences: Beehive fences are a novel approach to mitigating HEC, which involves hanging beehives on a fence around farms. Elephants are deterred by the sound and sting of bees, and therefore avoid beehive fences. A recent study by King *et al.,*(2021) in Tanzania found that beehive fences were effective in reducing crop raiding by elephants.
2. Deterrents: Various deterrents have been proposed to deter elephants from raiding crops, including chili-based solutions, flashing lights, and loud noises. A recent study by Arivazhagan, Baskaran, Srinivasan and Venkatraman (2021) in India and Beier, Lane, Tambling and Tyack (2020) found that flashing lights and loud noises were effective in reducing elephant raids on crops.
3. Early warning systems: Early warning systems can help farmers detect the presence of elephants and take preventive measures. In recent years, several innovative early warning

systems have been developed, such as using drones to detect elephants (Madhusudan, Nanaya, Srinivasan and Kumara, 2021) and using artificial intelligence to predict elephant movement (Saxena, Rahimi-Esfarjani and Oviedo, 2020).

4. Translocation: Translocation involves moving elephants from areas where they are causing conflict to areas where they are less likely to cause conflict. However, translocation can be expensive and may not always be effective. An innovative approach to translocation is to use virtual fencing, which involves using GPS collars to track and redirect elephant movement (Beier, Tambling and Tyack, 2020).
5. Education and awareness programs: Education and awareness programs can help communities living near elephants to understand their behavior and the importance of conservation. Such programs can help reduce the incidence of retaliatory killings of elephants by farmers. A recent study by Stepanian, Parsons, Srivathsa and Sharma (2020) in Cambodia found that education and awareness programs were effective in reducing retaliatory killings of elephants.

2.11 Case Studies of Successful Human-Elephant Conflict Mitigation

Human-elephant conflict (HEC) is a significant conservation challenge worldwide, particularly in regions where human and elephant populations overlap. HEC can cause severe economic losses, social disruption, and can threaten human lives as well as elephant populations (Nyhus and Tilson, 2004). The issue of HEC is particularly pressing in Cross River National Park (CRNP), Nigeria, where forest elephants are facing severe population decline due to increasing human pressure and habitat fragmentation (Ikpa, Okon and Ezealor, 2018). Therefore, it is crucial to identify and implement effective HEC mitigation strategies in CRNP.

Electric Fencing: Electric fencing is one of the most widely used HEC mitigation strategies, and has been successful in several regions (Sitati *et al.*, 2003). For example, in the Luangwa Valley, Zambia, electric fencing has been effective in reducing crop-raiding by elephants, improving food security for local communities (Hanks, MacMillan and Keane, 2011). Electric fencing has also been implemented successfully in Kenya, where it has reduced HEC conflicts by 98% (Osborn and Parker, 2003). In CRNP, electric fencing has been suggested as a possible

mitigation strategy, and a pilot project has been conducted in some areas of the park (Ikpa *et al.*, 2018). However, its effectiveness in the specific context of CRNP needs further investigation.

Beehive Fences: Beehive fences, which combine beehives and traditional fencing, have been successfully used as an HEC mitigation strategy in several regions (King *et al.,* 2021). For example, in Tanzania, beehive fences have been effective in reducing crop-raiding by elephants, improving crop yields, and providing a source of honey as an additional income for farmers (King, Douglas-Hamilton, Vollrath and Nyamu, 2021). Similarly, in Sri Lanka, beehive fences have been successful in reducing HEC conflicts and improving the livelihoods of local communities (Kalanjana and Singhakumara, 2019). Beehive fences have also been suggested as a possible HEC mitigation strategy in CRNP (Ikpa *et al.,* 2018), but their effectiveness in the specific context of the park requires further investigation.

Community-Based Conservation: Community-based conservation (CBC) approaches involve engaging local communities in conservation efforts and providing economic incentives for conservation (Western and Wright, 1994). CBC has been successfully used as an HEC mitigation strategy in several regions. For example, in Namibia, the conservancy model, which involves local communities in wildlife management and provides economic incentives, has reduced HEC conflicts and improved local livelihoods (Lindsey, Du Toit and Mills, 2007). Similarly, in India, the community-based eco-tourism model has reduced HEC conflicts and improved the livelihoods of local communities (Sarkar, Sharma and Sharma, 2018). CBC approaches have also been suggested as a possible HEC mitigation strategy in CRNP (Ikpa *et al.,* 2018), but their effectiveness in the specific context of the park requires further investigation.

HEC is a significant conservation challenge in CRNP, and effective mitigation strategies are urgently needed to protect both human and elephant populations. Electric fencing, beehive fences, and community-based conservation approaches have been successfully used as HEC mitigation strategies in other regions. While these strategies have the potential to be effective in CRNP, their applicability and effectiveness in the specific context of the park need to be investigated further. It is essential to consider the local social, cultural, and economic contexts when designing and implementing HEC mitigation strategies in CRNP (Ikpa *et al.,* 2018).

Furthermore, it is crucial to involve local communities in the design and implementation of HEC mitigation strategies to ensure their success and sustainability (Lindsey *et al.*, 2007).

2.12 Ethical Considerations and Animal Welfare Issues in Human-Elephant Conflict Mitigation Strategies

Human-elephant conflicts are a growing concern across the globe, as the expansion of human activities into natural habitats puts people and elephants in direct contact. Human-elephant conflict mitigation strategies aim to reduce conflict and protect both people and elephants. However, these strategies raise ethical considerations and animal welfare issues, as they may involve actions that harm or kill elephants.

2.12.1 Ethical considerations

Human-elephant conflict mitigation strategies raise ethical concerns regarding the treatment of elephants. Some strategies involve the use of force or harm to elephants, such as the use of firecrackers, electric fences, or translocation. The use of force or harm to elephants raises questions about the ethical justification of these actions. Many argue that the harm or killing of elephants is unjustified, as elephants are sentient beings capable of experiencing pain and suffering (Nijman and Nekaris, 2020). Additionally, some argue that the use of force or harm to elephants violates their rights, such as the right to life and freedom from torture (Chapron, Epstein, López-Bao and Hoffmann, 2020).

On the other hand, some argue that the harm or killing of elephants may be justified in certain circumstances, such as when elephants pose an immediate threat to human life. In these cases, some argue that human life should take precedence over animal welfare (Thuppil and Choudhury, 2020). However, others argue that this view is specialist, as it prioritizes human interests over those of other species (Srinivasan, 2020).

2.12.2 Animal welfare issues

Human-elephant conflict mitigation strategies also raise animal welfare issues. Some strategies, such as translocation or culling, may cause physical and psychological harm to elephants (Abernethy, White, Wickings and Tutin, 2003). Translocated elephants may experience stress and trauma from being separated from their social groups and familiar environments (Laurie, Thouless and Cusack, 2017). Additionally, culling may cause unnecessary suffering to elephants, as it may not be a quick or painless process (Bhargava and Kumar, 2020). Moreover, some strategies may cause indirect harm to elephants. For example, the use of electric fences may restrict the movement of elephants, leading to changes in their natural behavior and feeding patterns (Sukumar, 2019). These changes may have long-term negative effects on the health and welfare of elephants.

2.13 Stakeholder Analysis and Identification of Potential Conflict Resolution Mechanisms

Stakeholder analysis is crucial for any organization to understand its stakeholders' needs and expectations. Different approaches to stakeholder analysis can be used to identify the most important stakeholders and their relationship with the organization (Diederen, Kuikman and Runhaar, 2019). Potential conflict resolution mechanisms, such as negotiation, mediation, arbitration, collaboration, and litigation, can be used to address conflicts that may arise (Diederen, Kuikman and Runhaar, 2019). It is important to choose the appropriate conflict resolution mechanism based on the context of the conflict and the parties involved. Future research could focus on the effectiveness of different conflict resolution mechanisms in various contexts and the factors that influence their effectiveness.

Importance of Stakeholder Analysis: Stakeholder analysis is essential for any organization as it helps to identify stakeholders, their needs, expectations, and interests. It is a systematic process of gathering and analyzing information about the stakeholders to understand their concerns and expectations. This information can be used to develop strategies that address stakeholder needs and concerns. According to Freeman (1984); Diederen *et al.,* (2019), stakeholders are "any group or individual who can affect or is affected by the achievement of the organization's objectives."

Therefore, understanding stakeholder needs and expectations is crucial for the success of any organization.

Approaches to Stakeholder Analysis: There are several approaches to stakeholder analysis. Some of the commonly used approaches are described below.

1. Power-Interest Grid: The power-interest grid is a widely used tool for stakeholder analysis. It helps to categorize stakeholders based on their power and interest in the organization. According to Johnson and Scholes (1999), stakeholders can be classified into four categories: high power/high interest, high power/low interest, low power/high interest, and low power/low interest. This classification helps to identify the stakeholders who are most important to the organization. However, some scholars have argued that this approach oversimplifies stakeholder analysis and does not take into account other important factors (Waddock and Bodwell, 2004).
2. Salience Model: The salience model is another approach to stakeholder analysis. It helps to identify the most important stakeholders based on their power, legitimacy, and urgency. According to Mitchell, Agle and Wood, 1997, stakeholders who possess these three attributes are the most salient stakeholders. This approach has gained popularity in recent years, and scholars have used it to analyze stakeholder relationships in various contexts (Garriga and Melé, 2013; Roberts and Mahoney, 2004).
3. Stakeholder Mapping: Stakeholder mapping is another approach to stakeholder analysis. It helps to identify stakeholders and their relationship with the organization. This approach helps to visualize the stakeholders and their level of influence on the organization. The stakeholder mapping approach has been used in various contexts, including environmental management (Diederen, Kuikman, and Runhaar, 2019), project management (Soderlund and Maylor, 2012), and stakeholder engagement (Van der Kolk *et al.*, 2020).

Potential Conflict Resolution Mechanisms: Conflict can arise when stakeholders' needs and expectations are not met. Therefore, it is crucial to identify potential conflict resolution mechanisms to address conflicts that may arise. Some of the commonly used conflict resolution mechanisms are described below.

1. Negotiation: Negotiation is a process of reaching an agreement between two or more parties. It is a commonly used conflict resolution mechanism. It involves a discussion between the parties to reach a mutually acceptable solution. This approach has been used in various contexts, including environmental management (Leviston, Walker, Morwinski and Nippert-Eng, 2020), healthcare (De Dreu, Van Kleef and Nauta, 2019), and project management (Söderlund and Maylor, 2014).
2. Mediation: Mediation is another conflict resolution mechanism that involves a third party to help the parties in conflict reach an agreement. The mediator facilitates the negotiation process and helps the parties to find a mutually acceptable solution. This approach has been used in various contexts, including healthcare (Ernest and Gunn, 2020),
3. Arbitration: Arbitration is a conflict resolution mechanism in which an independent third party makes a binding decision to resolve the conflict. The parties agree to abide by the decision of the arbitrator. This approach has been used in various contexts, including labor disputes (Bloom, 2018) and international business disputes (Carballo-Penela, Corredoira, Alfonso and Portela Maseda, 2018).
4. Collaboration: Collaboration is a conflict resolution mechanism in which the parties work together to find a mutually acceptable solution. This approach involves building trust between the parties and working together to find a solution that benefits all parties involved. This approach has been used in various contexts, including environmental management (Foster and Leach, 2018) and community development (Kania and Kramer, 2011).
5. Litigation: Litigation is a formal conflict resolution mechanism in which the parties involve the court system to resolve the conflict. This approach can be costly and time-consuming, but it may be necessary when other conflict resolution mechanisms fail. This approach has been used in various contexts, including business disputes (Lai, 2020) and environmental management (Cohen and Gunningham, 2018).

2.14 Policy and Governance Issues Related To Human-Elephant Conflict

Human-elephant conflict (HEC) is a significant issue in many parts of the world, where human populations continue to expand and encroach upon elephant habitats. Effective policy and

governance are crucial to mitigating HEC and ensuring the conservation of both elephants and human livelihoods.

One of the main challenges of HEC policy and governance is balancing the needs of elephants with those of local communities. Studies have shown that HEC is more severe in areas where human populations are growing rapidly and where there is high poverty, and lack of alternative livelihoods (Bandyopadhyay, Rahaman and Ahmed, 2020; Nana *et al.,* 2021). Therefore, policy and governance efforts should focus on developing sustainable livelihoods for local communities and mitigating human-elephant conflicts.

Another important policy issue is the lack of consistent guidelines and policies across different jurisdictions. In many countries, there are no clear laws or regulations governing HEC (Bates, Sayialel and Moss, 2020). This can lead to conflicts between government agencies, conservation organizations, and local communities, resulting in ineffective or counterproductive measures. There is a growing recognition that HEC requires a multi-stakeholder approach that involves local communities, government agencies, conservation organizations, and researchers. Such an approach can foster cooperation and communication between different groups, leading to more effective and sustainable solutions to HEC (Bandyopadhyay *et al.,* 2020; Nana, Agyemang, Otchere and Adu-Bredu, 2021).

One promising approach is the use of conservation agreements between local communities and conservation organizations. These agreements involve negotiated terms between the communities and the conservation organizations, including compensation for crop damage and provision of alternative livelihoods, such as ecotourism or beekeeping (de la Rosa, Arroyo and Rosas-Rosas, 2020). These agreements have been shown to be effective in reducing HEC and improving the livelihoods of local communities. Policy and governance efforts should prioritize the conservation of elephant habitats and migration corridors. Encroachment on these habitats can lead to fragmentation and loss of elephant populations, exacerbating HEC (Thondhlana, Muposhi and Gandiwa, 2021). Therefore, conservation efforts should prioritize habitat protection, including the designation of protected areas and land-use planning that considers elephant migration patterns.

2.15 Policy Implications for Human Elephant Conflict

Human-elephant conflict (HEC) is a complex and multifaceted issue that requires a comprehensive approach. Policies and regulations play a crucial role in mitigating HEC and promoting coexistence between humans and elephants (Laurance *et al.,* 2012).

1. Policy coherence: There is a need for policy coherence between different sectors such as agriculture, forestry, and wildlife management to promote coexistence between humans and elephants. A recent study by Hazzah, Dolrenry, Naughton, Edwards, Mwebi and Kearney, (2021) in Kenya found that policy coherence was essential to address HEC.
2. Compensation and insurance schemes: Compensation and insurance schemes can provide a safety net for farmers who suffer crop losses due to elephant raids and reduce the incidence of retaliatory killings of elephants. A recent study by Prasad *et al.* (2021) in India found that a combination of compensation and insurance schemes was effective in reducing retaliatory killings of elephants.
3. Land-use planning: Land-use planning can help reduce HEC by identifying areas suitable for agriculture and human settlements and areas suitable for wildlife conservation. A recent study by Dehejia, Jhala and Khanna, (2021) in India found that land-use planning was essential to reduce HEC.
4. Ecological corridors: Ecological corridors can facilitate the movement of elephants between fragmented habitats and reduce the incidence of HEC. A recent study by Patel, Tambe, Deshmukh, Gour and Bhatnagar (2021) in India found that ecological corridors were effective in reducing HEC.
5. Community-based conservation: Community-based conservation involves working with local communities to promote coexistence between humans and elephants. A recent study by Nyirenda, Munthali and Kamweneshe (2020) in Zambia found that community-based conservation was effective in reducing HEC.
6. Wildlife tourism: Wildlife tourism can provide economic benefits to local communities and promote conservation efforts. However, there is a need for responsible tourism practices to minimize the impact on wildlife. A recent study by Lee, Leimgruber and Wong, (2021) in Sri Lanka found that responsible tourism practices were essential to promote coexistence between humans and elephants.

2.16 Future Directions for Research and Policy on Human-elephant Conflict

Bhargava and Kumar (2020) highlighted the importance of conservation and management strategies for Asian elephants, which can be adapted to the African elephant population in CRNP. Chapron *et al.* (2020) suggested that a practical approach to conflict resolution is necessary to mitigate HEC in the region. However, there is a need for further research and policy development to effectively address this issue in CRNP. One area for future research is to better understand the causes and patterns of HEC in CRNP. A study by Ogunjemite, Adekunle, Falana, Adekanmbi and Olowolafe (2021) found that the main drivers of HEC in the region were habitat fragmentation and human encroachment, leading to increased competition for resources. However, the study also noted that other factors such as crop raiding and human injury were also significant contributors. Further research could explore the spatial and temporal patterns of HEC in CRNP, as well as the factors that contribute to the severity and frequency of conflicts.

Another area for future research is the development and evaluation of effective mitigation strategies for HEC in CRNP. Laurie *et al.* (2017) noted that translocation of elephants to areas with lower human densities can be an effective strategy for reducing HEC, but it is not always feasible or effective. Other strategies such as electric fencing, crop diversification, and community-based conservation initiatives have also been proposed, but their effectiveness in CRNP has not been well evaluated. Future research could evaluate the effectiveness of these strategies and identify barriers to their implementation. In terms of policy development, there is a need for stronger legal and regulatory frameworks to protect elephants and reduce HEC in CRNP. A study by Ayanlade, Tegegne, Lechner and Ripple (2021) found that current policies and regulations were inadequate to address the complex and dynamic nature of HEC in the region. The study recommended the development of a comprehensive policy framework that includes measures such as land-use planning, compensation schemes for farmers affected by HEC, and capacity building for wildlife managers and local communities.

Additionally, the involvement of local communities in the conservation efforts is crucial for the success of any HEC mitigation strategy in CRNP. A study by Obioha and Onah (2021) found that the lack of awareness and education among local communities was a significant challenge in addressing HEC. The study suggested that community-based conservation initiatives, such as the

formation of local wildlife clubs and the promotion of ecotourism, could help raise awareness and promote positive attitudes towards elephant conservation.

Moreover, the impacts of HEC on the ecosystem and the local economy should also be considered in future research and policy. A study by Udebuani, Iroegbu, Onyekuru and Nwite (2021) found that HEC led to significant economic losses for farmers in the region, and also had negative impacts on forest regeneration and biodiversity. Future research could explore the indirect impacts of HEC on the ecosystem and the economy, and the potential benefits of elephant conservation for local communities.

Human-elephant conflicts in Cross River National Park, Nigeria, require a multidisciplinary approach that involves research, policy development, and community engagement. The future directions for research and policy on HEC in CRNP should focus on better understanding the drivers and patterns of conflict, evaluating the effectiveness of mitigation strategies, developing stronger legal and regulatory frameworks, involving local communities in conservation efforts, and considering the impacts of HEC on the ecosystem and the local economy (Leviston, Walker, Morwinski, Nippert-Eng, 2020). By addressing these key areas, it may be possible to develop sustainable and effective solutions to this complex and pressing conservation challenge.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

The study was carried out in Okwangwo Sector of Cross River National Park, Nigeria. The area is located in the Southern part of Nigeria, covering an area of approximately 640 km². The sector is situated between latitudes 5°30'N and 6°00'N, and longitudes 8°20'E and 8°50'E. (See Fig. 1). The area is predominantly characterized by lowland and sub-montane closed canopy forests (WCS, 2018). Geographically, it is situated at the headwaters of the River Cross, with a rugged topography that ranges from 150 meters in the southern lowlands to about 1,700 meters on the northern edge of the Obudu plateau. The area experiences a marked wet season from March to November and a dry season from December to February, receiving up to 4,280 mm of rain annually (Nwankwo, Onyekwelu, Okonkwo, Ezenwaji and Chukwuma, 2017).

The area is home to a variety of wild fauna, including the critically endangered Cross River gorilla (*Gorilla gorilladiehli*) and other primates such as the Nigeria-Cameroon chimpanzee (*Pan troglodytes ellioti*), drills (*Mandrillus leucophaeus*), and Preuss's monkey (*Allochrocebus preussi*). Other mammals found in the park include forest elephants (*Loxodonta cyclotis*), giant pangolin (*Smutsia gigantea*), and several species of duikers, among others (Oates, Bergl and Linder, 2004). The Cross River National Park, of which Okwangwo is a part, is recognized as a biodiversity hotspot, with high levels of species endemism, and is a priority area for conservation by many international conservation organizations (Nwankwo *et al.*, 2017). The area is also considered as one of the most important sites for conservation of biodiversity in Nigeria, and the West African region at large (Aigbe, Akindele, and Onyekwelu, 2014; Onyekwelu and Nnaji, 2019).

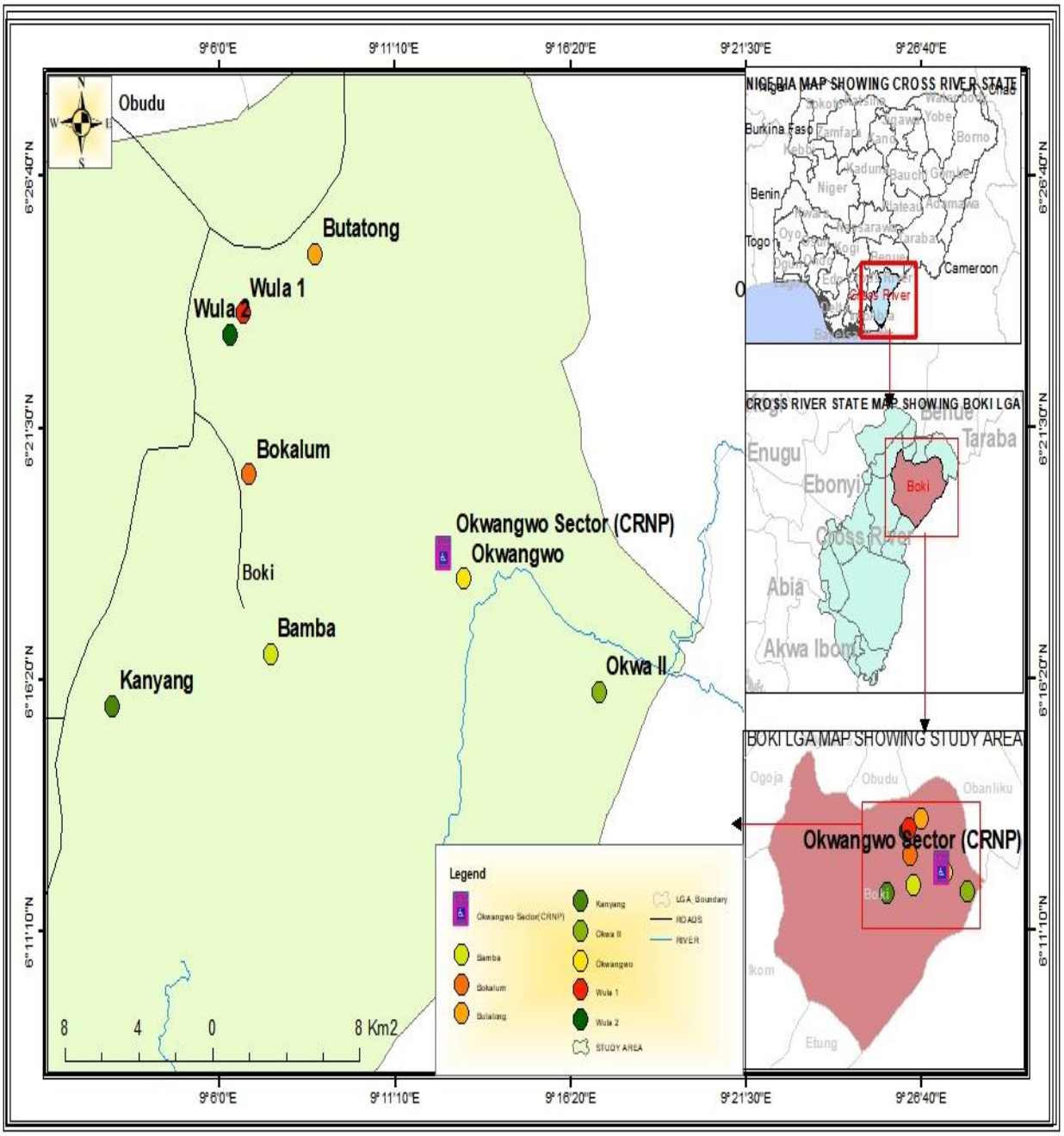

Fig. 1: Map of Okwangwo Sector of Cross River National Park showing the study area(s)

3.2 Sampling Technique

This study used a combination of distance sampling and dung pile count methods to estimate the elephant population status in the park. Distance sampling was applied to measure the distance from the transect line to each observed elephant or sign of activity. A random sampling technique was used to select household respondents for the study.

Table 1: Sampling effort and detection of live elephants in the study area

Range	No. of transect line	Total distance of transect lines (Km)	No. of replications	No. of live elephant detections
Anape	6	6	10	0
Okwangwo	10	10	10	0
Total		**16**		
Total Transect walk		**160**		

Source: Field survey, 2023

The results of sampling effort and detection of live elephants in the study area is presented in Table 1, a total of 160 km of transect walk was carried out in both ranges of the study area with no elephant detected.

3.3 Method of Data Collection

3.3.1 Estimate of population status of forest elephants in the study area

This study estimated the elephant population density in the study area using the Line Transect Survey Method and dung pile count (Buckland *et al.,* 2001; Tchamba *et al.,* 2021). A total of 16 random transects of 1 km each were surveyed. Along these transects, there were two important aspects in data collection: One was the finding and recording of dung piles along transect lines; and the other was the regular checking of dung piles to categorize their state of decay. The transect locations were selected based on prior knowledge of elephant distribution patterns, movement trajectories, and areas with high human-elephant conflict. Each transect was 4 m wide (2 m on each side) and at least 1 km away from the nearest transect, covering the entire landscape and major forest types of the study area. The number and perpendicular distance of

dung piles from the transect centerline were measured using a tape. Other signs of elephant presence, such as feeding, track, footprints, scratching, diggings, wallows, and sightings were also recorded. Each 1km transect was surveyed 10 times between 06:00 and 14:00 hours, from February to April and May to July 2023, resulting in a total survey distance of 160 km (see Table 2 for details). The date and time of each survey were noted. A defecation rate of 19 droppings per elephant per day was adopted to calculate the population density estimates. This rate was derived from previous studies that showed a strong correlation between dung pile density and elephant density, particularly the CITES (2012) survey in Boumba-Bek National Park, Cameroon, which is geographically close to the study area (CITES, 2012).

3.3.2 Dung decay rate

The dung density was estimated by measuring the dung decay rate in the landscape. The dung decay rate was determined by documenting and evaluating the dung piles along the transect lines. The dung piles were classified according to their state of decay, using the 'MIKE's System' for dung-pile classification (Hedges and Lawson, 2006). The classification system was as follows: S1 (all boli are intact), S2 (one or more boli but not all are intact), S3 (no intact boli but coherent fragments remain), S4 (no intact boli, only traces or fibers remain), and S5 (absence of faecal material, including plant fibers) (see Plate 1-4). To determine the dung decay rate, eighteen fresh dung piles were selected and marked within the study area, and their GPS coordinates were recorded. To calculate the decay rate, the survival method was adopted (Dawson 1990). It derives the "life expectancy" of a dung pile from a life table of dung surviving at the end of each week (Armitage and Berry 1987). The decomposition process was monitored weekly, recording the decay stages of each dung pile. The monitoring continued until the dung piles were completely decomposed, and the mean survival time was calculated. The dung decay rate was obtained by taking the reciprocal of the mean survival time (See eqn. 1)

$$r = \frac{1}{t} \qquad \text{eqn 1}$$

Where r is the dung decay rate and t is the mean time (days) for dung pile to completely decay

Plate 1: STAGE A
Date: 12th June, 2023 Time: 13:45:38Date:

Plate 2: STAGE B
26th October, 2023 Time: 10:21:11

Plate 3: STAGE C
Date: 27th July, 2023 Time: 16:05:16

Plate 4: STAGE D
Date: 10th August, 2023 Time: 13:17:08

3.4 Sampling frame and population size

Table 2: Selection of Respondents in the Study Area(s)

Location	Total adult population (≥ age 18 years) from 2006 census report	Projected population (≥ age 18 years) 2023	Sample frame [$N/(1+N(e^2))$]	No of respondents (20% of sample frame)	Questionnaires retrieved
Bamba	696	1098	293	59	58
Bokalum	522	824	269	54	54
Wula II	466	735	259	52	50
Wula I	1,392	2196	338	68	68
Butatong	1,566	2471	344	69	68
Kanyang	525	828	270	54	54
Ukwa II	1,044	1647	322	64	63
Okwangwo	1,217	1920	331	66	65
Total	**6962**	**11720**	**2,426**	**485**	**480**

Source: National Population Commission, 2006
Where: N = Population size, e = margin of error (0.05)

The method used to select respondents aged 18 and above in the study area was carefully planned to ensure reliable and representative data collection (See Table 2). Official population data, specifically the 2006 National Population Census (NPC) and annual growth rates, was employed to accurately estimate the population figures for 2023. The required sample size for each community was determined using a formula proposed by Rukmana (2014). A sampling intensity 20% of the sample frame in each location was employed resulting in a total sample size of 485 respondents across the study area. Ultimately, the data collection efforts yielded 480 completed questionnaires.

3.5 Questionnaires Administration

Four hundred and eighty (480) structured questionnaires were administered to villagers in eight (8) communities around the park. These communities were Butatong, Kanyang Ukwa II, Bamba, Bokalum, Wula I, Wula II, and Okwangwo. The questionnaire provides a comprehensive framework for understanding the dynamics of human-elephant interactions in CRNP support zone communities by gathering insights into demographics, agricultural practices, experiences, perceptions, and mitigation efforts. In order to mitigate Subjectivity in Perceptions stemming from the use of Likert scales in gauging community viewpoints, the Likert scale data was complemented with qualitative data from interviews and focus group discussions. The data collection process was executed by employing two indigenous park rangers as research assistants in each of the communities, ensuring a local and contextually sensitive approach to data collection.

3.6 Data Analysis

Elephant dung density was derived from the model developed by Burnham *et al.* (1980). Densities were analyzed following line-transect analysis guidelines by Meredith (2008). The density of dung piles (D) was calculated as:

$$\text{Dung density, } D = \frac{n}{L} \qquad \text{Eqn. 2}$$

Where ″n″ is the total number of droppings, and ″L″ is the total length of transects in which they were recorded. To estimate the population status of elephants in the study area, the formula proposed by Baskaran *et al.* (2013) and Varman *et al.* (1995) was employed (see Equation 3).

$$\mathrm{E} = D \times \frac{r}{Y} \qquad \text{Eqn. 3}$$

Where ″E″ represents elephant density, ″D″ stands for dung density, ″r″ is the dung decay rate, and ″Y″ denotes the defecation rate per elephant per day. The value of ″Y″ was obtained from previous studies by Varman *et al.,* (1995) and Baskaran *et al.,* (2013).

Data from the questionnaire were analyzed using SPSS 24 (SPSS, Inc., Chicago, USA). Logistic regression analysis was conducted to evaluate the relationship between crop types and HEC incidence. Additionally, descriptive statistics and Chi square test computed at 95% confidence interval with the probability value $p < 0.05$ were used to test relationships between these independent variables (age, educational level, location, and source of income) and previous conservation attitude towards elephants. Data on community perception of human-elephant coexistence, effectiveness of existing HEC mitigation strategies, frequency of HEC, and seasonality of HEC were analyzed on a five-point Likert scale (Likert, 1932). This was done by summing nominal values and dividing by the total number of scaling items, as follows:

$$\frac{5+4+3+2+1}{5} = \frac{15}{5} = 3.0 \qquad \text{Eqn. 4}$$

Therefore, any factor with a mean of 3.0 and above was considered to be significant, while any factor with a mean less than 3.0 was considered to be insignificant. Furthermore, logistic regression was conducted to evaluate the nature and extent of human-elephant conflict. The analysis examined whether residents had experienced any elephant attack, the season (dry season or wet season) when they experienced the attack, the crops most frequently damaged by elephants, and the level of crop maturity during the attacks. Finally, tables and percentages were used to present results of the effectiveness of existing human-elephant conflict mitigation strategies.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Elephant population density

For dung density:

Number of total dung count = 88

Distance surveyed = $\frac{\text{length of transect} \times \text{width of transect}}{100} = \frac{16 \times 4}{100} = 0.64\text{km}^2$

Dung density = $\frac{\text{No. of total dung count}}{\text{distance surveyed}} = \frac{88}{0.64} =$ **138 dung/km^2**

For decay rate:

Mean time (T) = $\frac{(11 \times 56) + (7 \times 63)}{18} = \frac{616 + 441}{18} = \frac{1057}{18} = 59$ days,

Therefore, Decay rate (r) = $\frac{1}{T} = \frac{1}{59} =$ **0.0169**

The defecation rate (Y; droppings produced per day per elephant) of 19 by CITES MIKE, (2012) survey in Boumba-Bek National Park was used.

Therefore, elephant density, E in Okwangwo

E = $\frac{138 \times 0.0169}{19} = \frac{2.33}{19} =$ **0.12 elephants/ km^2**

From the data presented in Table 3, within the sampled area of 0.64 km^2, a total of 88 dung piles were recorded (see Fig. 4.1), resulting in a dung density of 138 dung/km^2. About 18 fresh dung piles that were marked for observation, a total of 11 dung piles decomposed within a period of 56 days, while the remaining 7 dung piles took 63 days to decompose. This aggregate data yields a mean decomposition time of 59 days for the entire set of dung piles, reflecting an overall decay rate of 0.0169 per day, the estimated elephant density in Okwangwo is calculated at 0.12±0.01 elephants/Km^2 (Table 3). Based on this density and considering the total area under investigation to be 640 km^2, the elephant population in Okwangwo is approximately 77 individuals, with a population range between a minimum of 72 elephants and a maximum of 82 elephants.

The study identified a total of 88 dung piles in the area. Out of these, 18 dung piles were closely monitored until they completely deteriorate. These 18 dung piles were precisely located using GPS, and their condition was observed and recorded weekly as they deteriorated (see Fig 2).

The monitoring process involved carefully examining and documenting the physical state of each dung pile over time. Factors like weather, microbial activity, and environmental conditions were considered in assessing how the dung piles deteriorated (see Plate 1 – 4). The data collected from these observations gave valuable insights into the timeline of dung pile degradation in the study area.

Table 3: Estimates of elephant population status using dung count method for Okwangwo sector of CRNP

Parameter	**Value**
No. of Transect	16
Total area of the study area (km^2)	640
Distance surveyed (km)	64
No. of dung piles	88
Defecation rate for the study	19
Dung density/km^2 (95% c.l)	138±5
Mean time for dung pile decay (days)	59
Dung pile decay rate	0.0169
%CV dung density	32
Elephant density/km^2	0.12
Estimate of elephants (95% c.l)	77±5
%CV elephant population estimate	32.13

c.l= Confidence interval, CV=Coefficient of variation
Source: Field survey, 2023

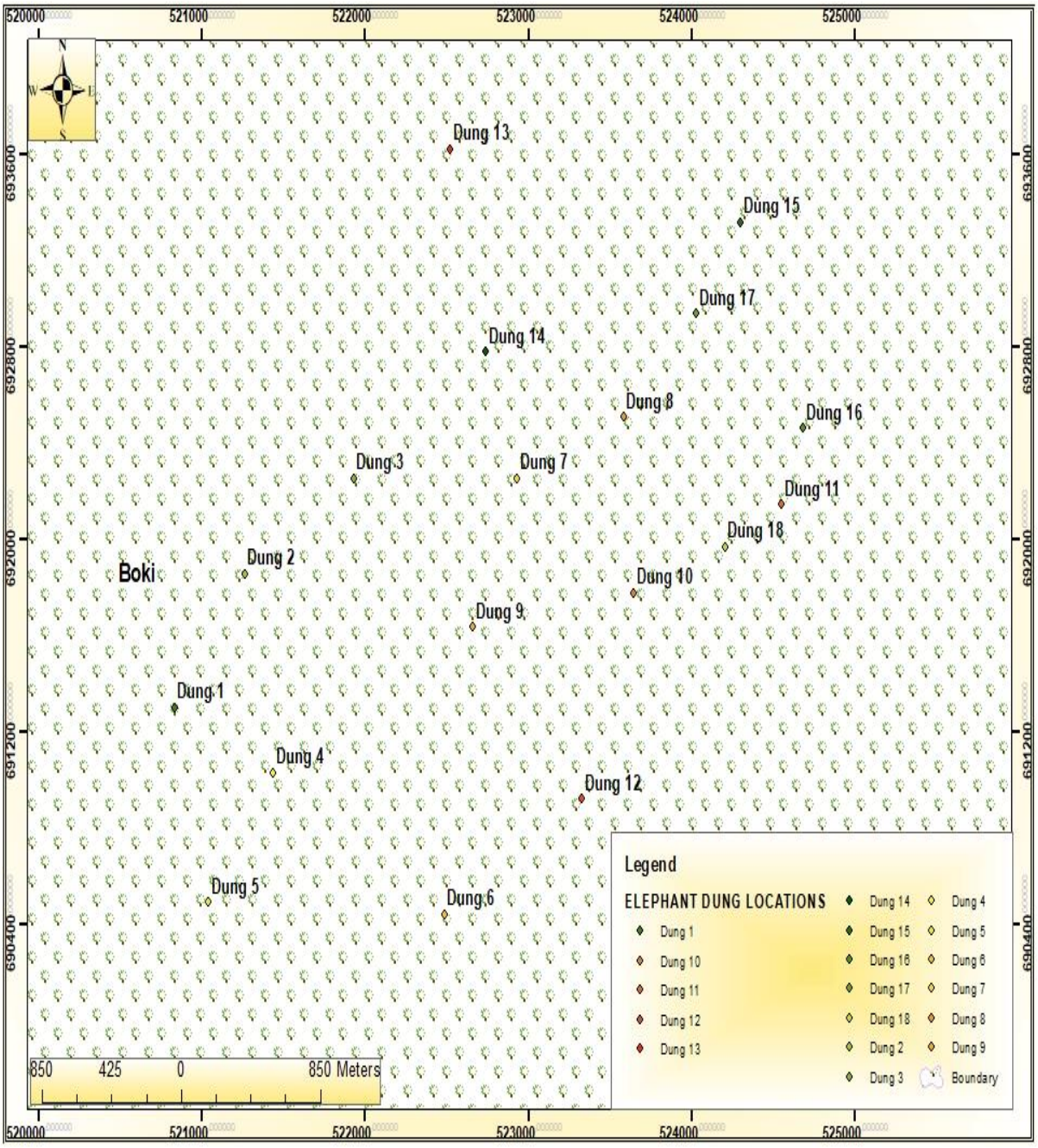

Fig. 2: Spatial distribution of elephant dung piles in the study area

The results presented in Table 4 summarize the quantitative data on elephant signs in the study area, providing insights into elephant presence and behavior. Elephant tracks are the most prevalent signs (32.60%), followed by Dung piles (32.23%) and foot prints (26.01%), which offer information on movement patterns. Less common signs include digging, scrubbings and wallows. Digging is relatively rare (1.10%). These signs collectively contribute to our understanding of elephant behavior (see Table 4).

Table 4: Field observation and signs of elephants in Okwangwo Division of CRNP

Sign	**No of Elephant signs**	**Percentage (%)**
Dung piles	88	32.23
Foot prints	71	26.01
Feeding sign	7	2.56
Digging	3	1.10
Scrubbings	6	2.20
Tracks	89	32.60
Wallows	9	3.30
Total	**273**	**100**

Source: Field research, 2023

4.1.2 Socio-economic Drivers of HEC in Okwangwo Division of CRNP

Table 5 presents a detailed demographic profile of the respondents. The data demonstrates a considerable gender disparity, with males comprising 65% and females 35% of the sample. The age distribution shows a fairly uniform pattern, with the exception of the 26-35 group, which accounts for 35.6%, and the >55 years group, which represents 8.3%. The marital status variable reveals that a large segment of the respondents are either single (42.7%) or married (44.6%), while the remaining categories of widow, widower, and divorced have smaller frequencies. The family size variable indicates that a sizeable number of respondents have families of 6 to 10 members (43.35%), followed by 2-5 members (33.75%) and >10 members (22.9%). Regarding occupation, agriculture (36.7%) and livestock rearing (33.5%) are the dominant sectors, reflecting a high level of involvement in these activities. On the other hand, business, civil servant, and fishing/hunting occupations have lower proportions. A review of the average monthly income variable reveals a heterogeneous distribution among the respondents. The largest group falls within the ₦ 30,000 to ₦ 50,000 (36.9%), with a notable 20.6% earning more than ₦ 200,000. The educational level variable displays a varied range of qualifications among the respondents, with non-formal (29.8%) and primary education (27.5%) having significant shares. Tertiary education constitutes 23.5% of the sample. An analysis of the length of stay variable shows that more than half of the respondents have lived for over 15 years (51.2%), other notable groups include the 10-15 years (19.2%) and 5-10 years (17.5%) categories.

Table 5: Demographic parameters of respondents (household) in the support zone communities of Okwangwo sector of CRNP

Demography	Categories	Frequency	Percentage (%)	Mode
Gender	Male	312	65.00	Male
	Female	168	35.00	
Age	18 – 25	168	35.00	26 – 35
	26 – 35	171	35.60	
	36 – 45	66	13.80	
	46 – 55	35	7.30	
	> 55	40	8.30	
Marital Status	Single	205	42.70	Married
	Married	214	44.60	
	Widow	29	6.00	
	Widower	17	3.50	
	Divorced	15	3.10	
Family size	2 – 5	162	33.75	6 – 10
	6 – 10	208	43.35	
	> 10	110	22.90	
Occupation	Agriculture/crop production	176	36.70	Agriculture
	Livestock rearing	161	33.50	
	Fishing/hunting	31	6.50	
	Business	59	12.30	
	Civil servant	53	11.00	
Average monthly income (₦)	> 30,000.00	99	20.60	30,000 – 50,000
	30,000 – 50,000	177	36.90	
	51,000 - 100,000	92	19.20	
	101,000 - 200,000	77	16.00	
	> 200,000.00	35	7.30	
Education	Non formal	143	29.80	Non formal
	Primary (FSLC)	132	27.50	
	Secondary (SSCE)	92	19.20	
	Tertiary	113	23.50	
Length of stay	Less than 5 years	58	12.10	More than 15 years
	5-10 years	84	17.50	
	10-15 years	92	19.20	
	More than 15 years	246	51.20	

Source: Field survey, 2023

4.1.2.1 Influence of socio-economic variables on attitudes toward elephant conservation and coexistence

Attitudes toward elephant conservation and coexistence varied by socio-economic variables**,** the association between individuals' level of education and their perceptions regarding elephant conservation revealed a statistically significant relationship (χ^2 = 620.387, df = 6, p-value = 0.0001). Specifically, negative perceptions toward elephant conservation were more pronounced among community members who had secondary school certificates compared to those who had attained tertiary level of education. Notably, the majority of the sampled population (29.8%) fell into the category of having received no education at all (see Table 6).

Table 6: Community perception towards human-elephant coexistence as influenced by level of Education and Gender

Education level	**Positive**	**Neutral**	**Negative**	**Total**
Non formal	28.96	0.42	0.42	29.8
FSLC	21.67	5.21	0.63	27.5
SSCE	0.63	14.79	3.75	19.2
Tertiary	21.67	1.04	0.83	23.5
Total	**72.92**	**21.46**	**5.63**	**100.00**
Perception towards elephant conservation as influenced by gender				
Male	12.71	11.25	11.04	35.00
Female	39.17	11.04	14.79	65.00
Total	**51.88**	**22.29**	**25.83**	**100.00**

Source: Field survey, 2023

A Pearson correlation analysis revealed a very weak and insignificant relationship between age and how people perceive elephant conservation. (r = -0.089, p = 0.052). This finding indicates that age doesn't really affect people's opinions about elephant conservation in this study. Source of income exhibited a significant relationship with perceptions toward elephants (χ^2 = 418.343, df = 8, p-value = 0.0001). Also, a notable gender difference emerged: females and males held divergent perceptions toward elephant conservation (χ^2 = 26.684, df = 2, p-value = 0.0001). Specifically, women tended to harbor more negative views, as highlighted in Table 7**.**

Table 7: Socio-economic drivers influencing perceptions towards elephants and their significance

Socio-economic variables	Chi-square (χ^2)	Degrees of freedom	p-value
Source of income	418.343	8	<0.0001
Education	620.387	6	<0.0001
Gender	26.684	2	<0.0001
Location	34.317	4	0.002

Source: Field work, 2023

Additionally, opinions regarding the importance of elephant conservation were influenced by geographical location (χ^2 = 34.317, df = 14, p-value 0.002). Among the study sites, Wula I had the highest proportion of residents with negative perceptions, followed by Wula II and Bokalum. Conversely, Okwangwo exhibited the largest number of individuals with positive attitudes toward elephants. A visual representation of these findings is presented in Fig. 3.

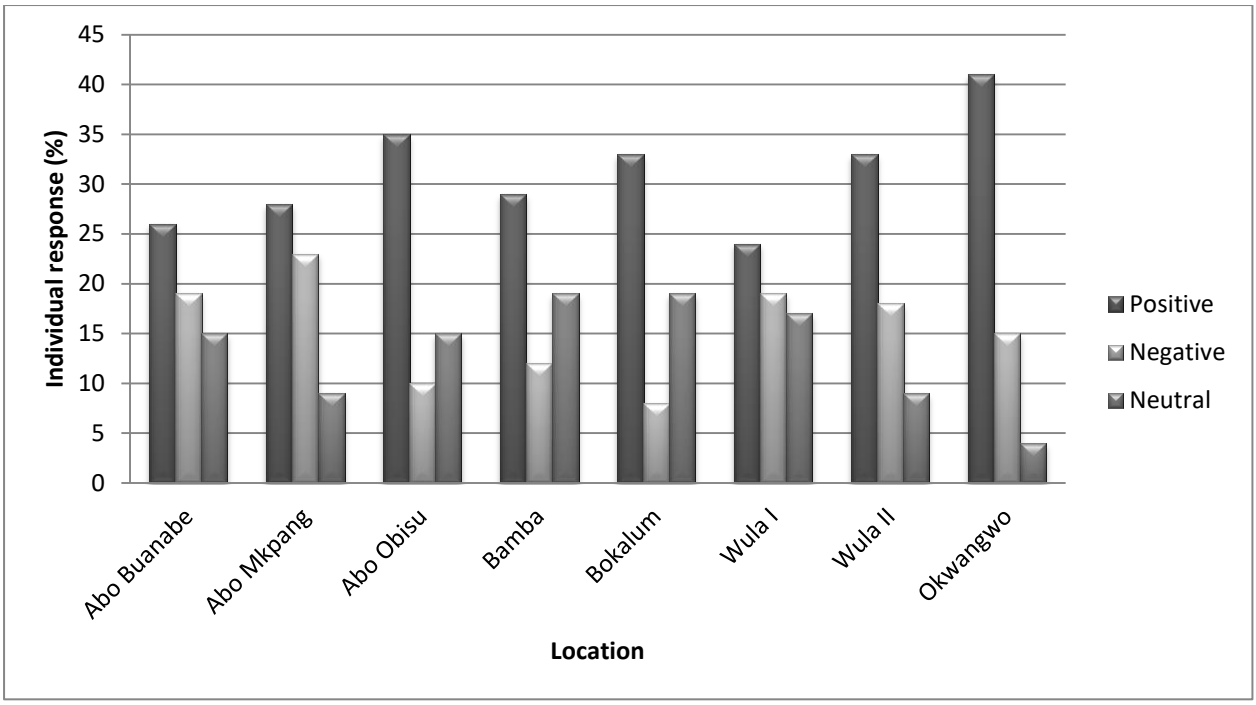

Fig 3: People's perception of human-elephant conflict as influenced by location
Source: Field survey, 2023

4.1.1.2 Community perceptions and attitudes towards human-elephant coexistence in the study area

The survey participants were solicited to assess their stance on five statements using a five-point Likert scale, as delineated in Table 8, wherein 'SA' denotes 'Strongly Agree,' 'A' corresponds to 'Agree,' 'N' represents 'Neutral,' 'D' signifies 'Disagree,' and 'SD' stands for 'Strongly Disagree.' The significance of each statement was ascertained through the Mean Weighted Score (MWS) metric. A statement is deemed significant if its MWS is 3.0 or higher, indicating predominant agreement among respondents. Conversely, a statement is considered not significant if its MWS is below 3.0, suggesting prevalent disagreement, strong disagreement, or neutrality among respondents.

The Table 8 above shows the results of community perception of human elephant coexistence. The Table reveals that three out of the five statements are significant. The most significant statement is “Conservation is a waste of land”, with a MWS of 3.4, followed by “Elephants should be protected”, with a MWS of 3.3. These statements indicate that the respondents value the importance of preserving the natural habitat of elephants and preventing their extinction. The third most significant statement is “People/crops/livestock are important than elephants”, with a MWS of 3.2, which shows that the respondents acknowledge the potential conflicts between human and elephant interests, but do not prioritize one over the other. Conversely, the statements "Poachers should be punished", with MWS of 2.9 and "I Support elephants" with MWS of 2.4 failed to attain significance which implies that the respondents are either indifferent or opposed to the idea of supporting elephants.

Table 8: Community perception of Human-Elephant Coexistence

Perception	SA	A	N	D	SD	Total	WS	MWS	REMARK
Elephants should be protected	126 (630)	123 (492)	107 (321)	100 (200)	24 (24)	480	1567	3.3	Sig
Poachers should be punished	157 (785)	100 (400)	103 (309)	92 (184)	28 (28)	480	1408	2.9	Not Sig
Conservation is a waste of land	132 (660)	96 (384)	116 (348)	97 (194)	39 (39)	480	1625	3.4	Sig
People/crops/livestock are important than elephants	90 (450)	122 (488)	143 (429)	48 (96)	77 (77)	480	1540	3.2	Sig
I Support elephants	7 (35)	102 (408)	100 (300)	145 (290)	126 (126)	480	1159	2.4	Not Sig

SA= Strongly Disagreed, A= Agreed, N= Neutral, D= Disagreed, SD= Strongly Disagreed, WS= Weighted Score, MWS= Mean Weighted Score, NS= Not Significant
Source: Field survey, 2023

4.1.1.3 Benefits of human-elephant coexistence in the study area

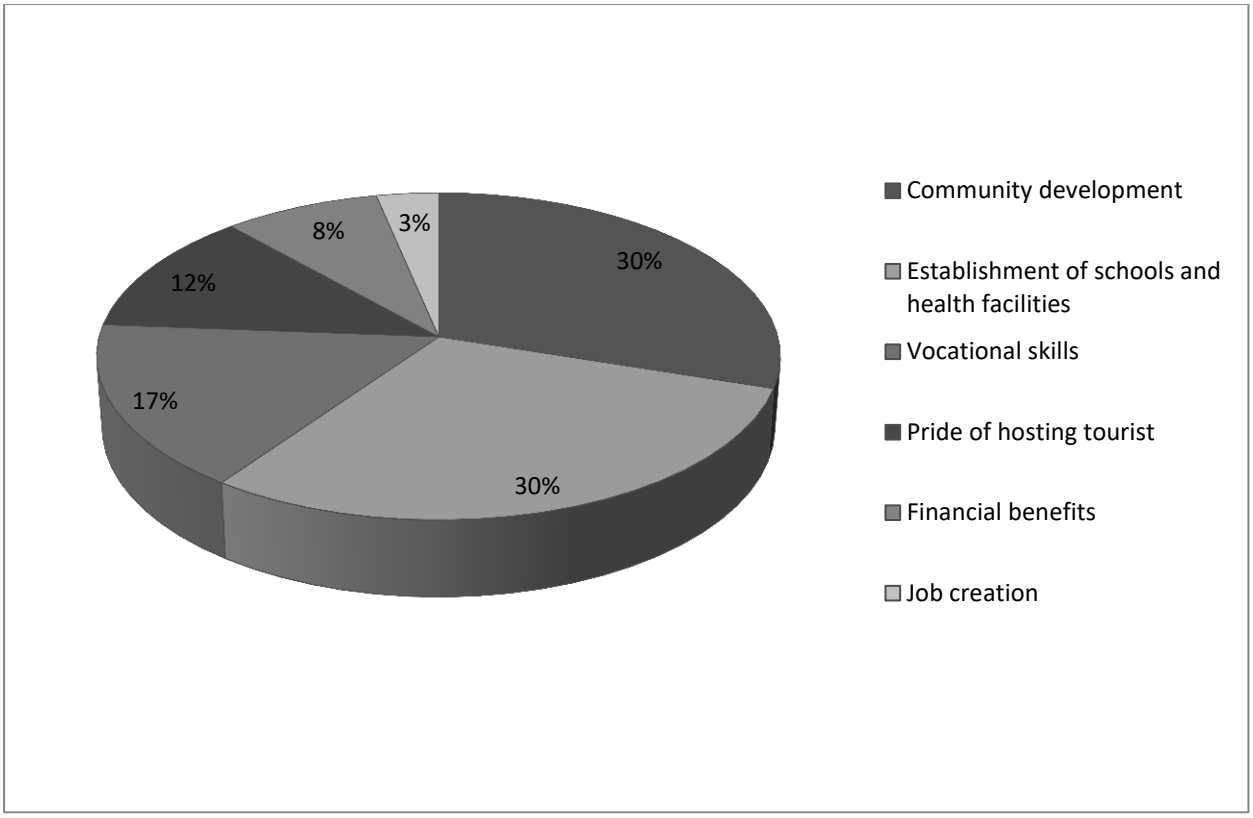

Fig. 4: Benefits of Human-Elephant coexistence in the study area

Respondent reported a perceived benefit of living near wild elephants. The exact nature of these benefits varied, with most (30%) respondents indicating community development, About (29.8%) indicating the establishment of schools and health facilities as the benefit they derive for living in close proximity with elephants, Also, 16.4% indicating a feeling of satisfaction from the vocational skills they learn to reduce their dependence on the forest resources. About 12.2% indicated a feeling of pride from hosting conservationist (e.g. researchers, tourists etc) and 8.3% reported financial benefits and just about 3.3% indicated job creation as a major benefit from human elephant coexistence, see Fig 4.

4.1.2 Nature and extent of human-elephant conflicts in Okwangwo Sector of Cross River National Park

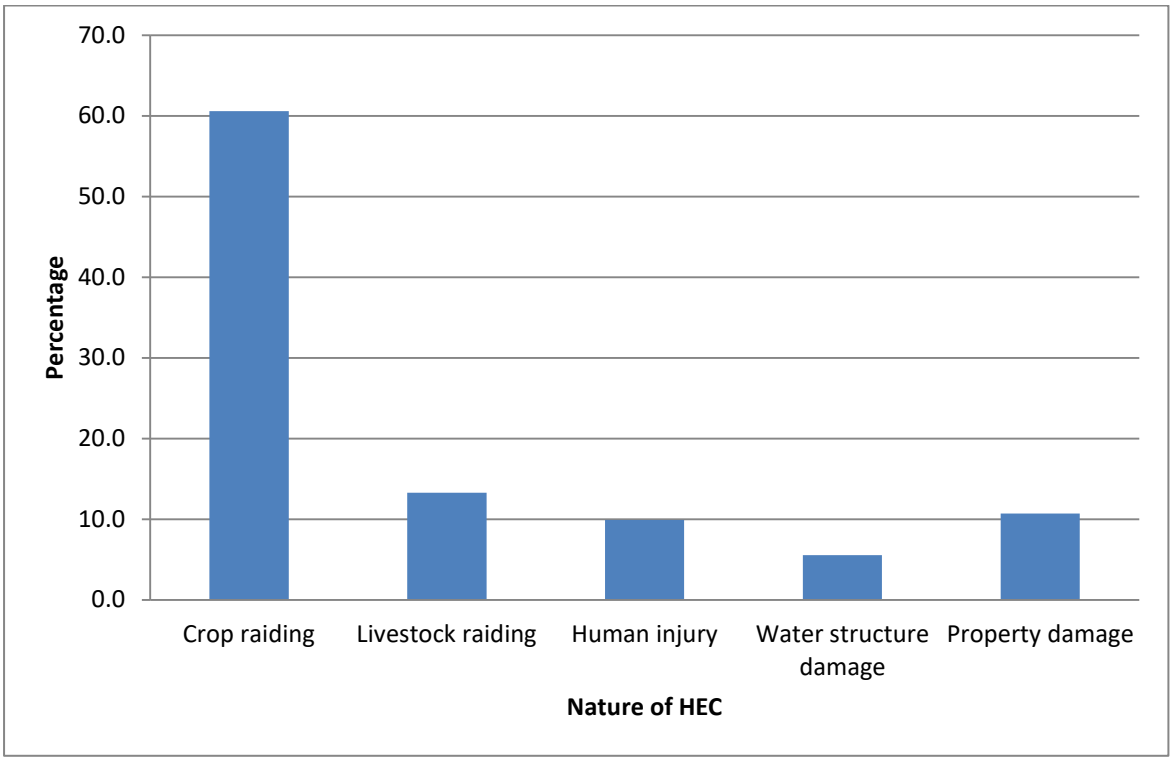

Fig 5: Nature of Human Elephant Conflict Experienced in the Study Area

More than half (56.4%) of the surveyed households reported experiencing a negative impact from HEC over the last year (October 2021±October 2022). About (57.9%) of the respondents provided additional details regarding the nature of negative impact. The most commonly identified nature of negative effect of elephants was crop raiding (51.9%) (e.g., see Fig 5, Plate 5). About (17.3%) reported livestock depredation. Also, (13.1%) of the respondents answered that they had experienced human injuries caused by elephants, while only about (5.8%) of the respondents answered that water structure damage was a negative impact from HEC.

Plate 5: Cassava and yam farm raided by Elephant in Bokalum community
Date: 15th October, 2023 Time: 13:45:38

4.1.2.1 Land use practices

The survey found that 89% of the respondents are the owners of the land they are currently residing on. In this sense, "land ownership" refers to a person's land that has been granted to them by the local elders. On the other hand, just about 11% of participants said they were under a lease or rent contract (see Fig. 6). A total of 5 hectares were the most common land sizes owned, leased, or rented out of all the options for land ownership. About 36.70% of the people living there stated that they farmed crops, while another 33.50% said that they raised livestock as illustrated in Fig 7.

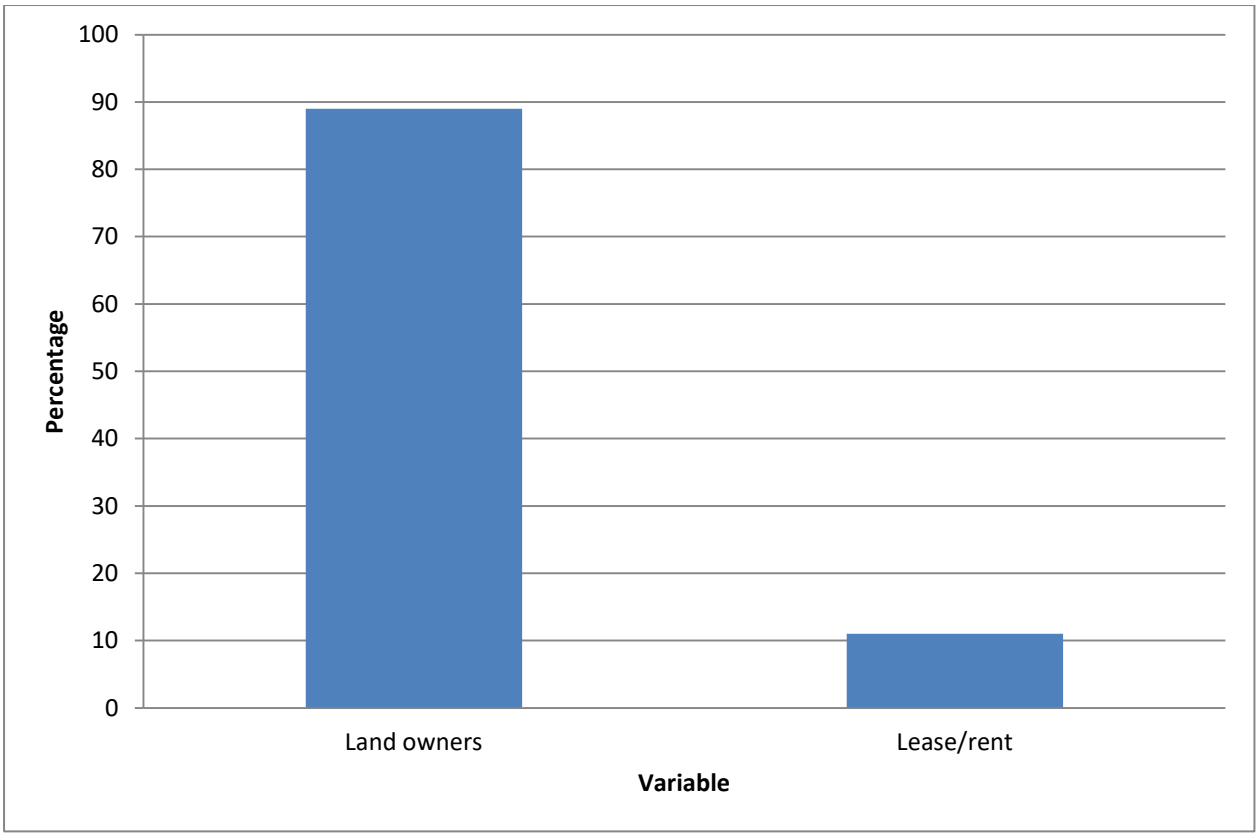

Fig 6: Nature of land ownership

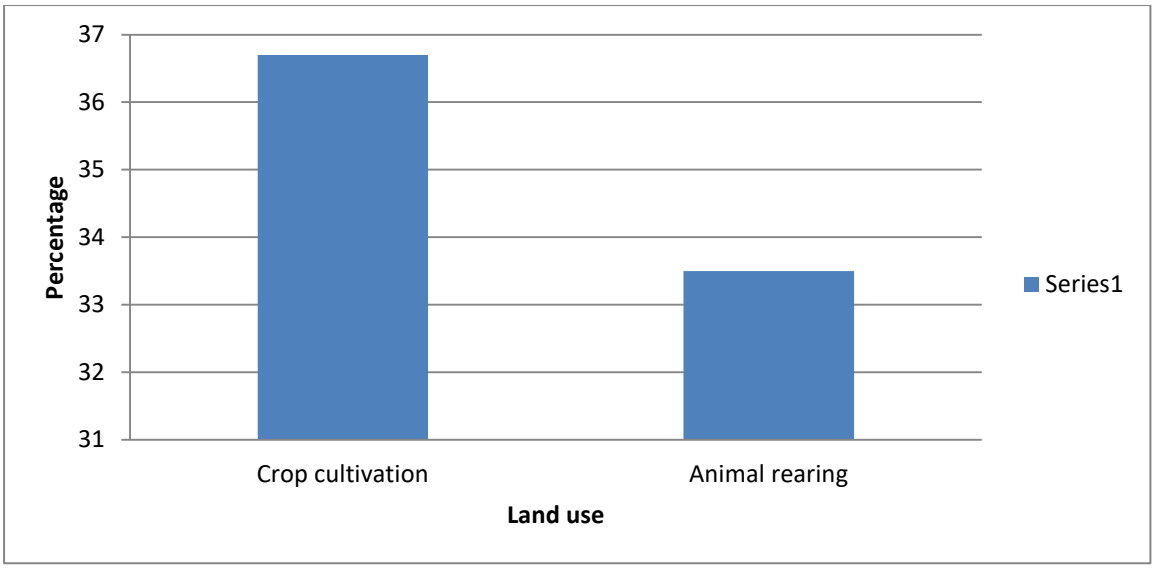

Fig 7: Land use practices in the study area

4.1.2.2 Farm attributes

Majority (90.69%) of the respondents who primarily engaged in livestock rearing (as indicated in Table 1) practice zero grazing. Just about 9.31% of farmers permit animals to roam freely on their land. Sweet potatoes (*Ipomoea batatas*), cassava (*Manihot esculenta*), and yam (*Discorea spp.*) are the main three crops planted in the area. Other crops farmed are banana (*Musa sp.)*, maize (*Zea mays*), fluted pumpkin (*Telferia occidentalis*), plantains (*Musa paradisiaca*), and cocoyams (*Xanthosoma sagittifolium*), among others. Sweet potatoes (*Ipomoea batatas*) are the most preferred crop among the area's elephant population (14.0%), followed by bananas (*Musa sp.),* fluted pumpkin (*Telferia occidentalis*), and cassava (*Manihot esculenta*) (each at 13.0%) (See Fig. 9).

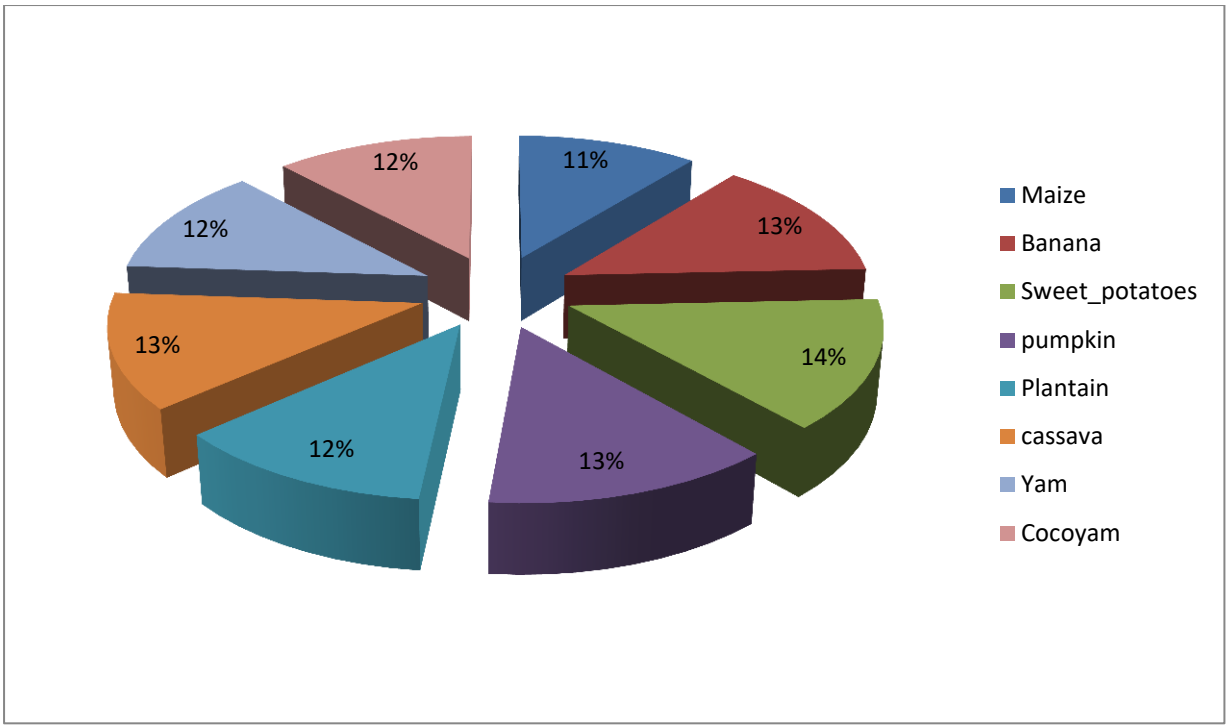

Fig 8: Type of Crops grown in the study area

4.1.2.4 Seasonality of attacks

To determine whether seasons had any influence on HEC occurrences, respondents were queried on when these incidences frequently occurred, whether the dry or wet season, using a five-point Likert scale. About 67.5% of respondents reported invasions occurred during the dry season while 12.7% reported invasions in the wet season. 19.8% of the respondents were neutral indicating that elephants frequent neither in the dry or wet season. With regards to the time of day when HEC incidents occur, about (60.0%) respondents conveyed that the elephant attack in the night. Additionally, the results revealed that elephants will normally attack when the crops are mature as reported by over 89% of the research participants.

4.1.2.5 Cost implications of human elephant conflict

Farmers experienced significant losses due to elephant incursions. To avoid potential biases in self-reported data from respondents, particularly regarding the extent of crop damage and economic losses, independent on-site assessments were conducted to quantify the actual crop damage and economic losses. According to the survey findings, the total cost of these losses reported by respondents amounted to ₦ 16,661,000.00 in 2023, as detailed in Table 9. Maize farmers suffered the highest losses, followed by plantain, cassava, yam, and cocoyam farmers, as shown in Table 9. Additionally, the economic losses included damage to assets, human injuries, and loss of human life.The highest amount of loss was experienced by maize (*Zea mays*) farmers followed by plantain (*Musa paradisiaca*), cassava (*Manihot esculenta*) and yam (*Discorea spp*), (See Table 9).

Table 9: Crop Losses Experienced from Depredation by Elephants in the Study Area

S/N	TYPE OF CROP	QUANTITY DESTROYED	MARKET VALUE PER UNIT (₦)	TOTAL AMOUNT (₦)	TOTAL AMOUNT ($)
1.	Maize	60 (100kg/bag)	54,000.00	3,240,000.00	4,188.80
2.	Plantain	50 (50kg)	60,000.00	3,000,000.00	3,878.50
3.	Sweet potatoes	85 (100kg)	15,000.00	1,275,000.00	1,648.40
4.	Cassava	72 (100/kg)	40,000.00	2,880,000.00	3,723.30
5.	Banana	22 (25kg)	15,500.00	341,000.00	440.90
6.	Pumpkin	165 (100kg)	10,000.00	1,650,000.00	2,133.20
7.	Yam	65 (50kg)	35,000.00	2,275,000.00	2,941.20
8.	Cocoyam	50 (50kg)	40,000.00	2,000,000.00	2,585.60
Grand Total				**16,661,000.00**	**21,539.75**

**N/B: The rate used for the conversion is (1USD = 773.5NGN) being the official rate for dollar to naira as at 15th October, 2023*

Table 10: Extent of damage for other form of human conflict

Nature of HEC	No damage	below 10,000	10,001 to 20,000	20,001 to 30,000	30,001 to 40,000	Above 40,000
Food store damage	15.1	46.9	34.4	40.9	32.7	21.5
Damage of water structures	21.9	25.0	23.4	20.0	27.0	35.4
Human injury	32.4	18.8	29.7	10.9	16.4	26.0
Livestock depredation	30.6	9.4	12.5	28.2	23.9	17.1

Economic losses were also experienced through damage of assets, human injury and loss of human life. While these losses were not of greater magnitude in comparison to crop damage, respondents indicated losses of over ₦ 40,000.00 at a household level as shown in Table 10.

4.1.2.6 Distribution of human elephant conflict incidences by location

The different levels of human-elephant conflict across various locations are presented in Table 11. Wula I and Bokalum communities experienced more pronounced impacts. In Wula I, incidents of crop damage, human injury and human death are notable, constituting 23.3%, 17.0% and 13.8% respectively of the total incidents. Additionally, Bokalum accounts for 16.3% of human death and 13.5% of property damage incidents. Bamba, on the other hand, has the highest percentage of damage of water structures at 17.9%, along with substantial contributions to other conflict categories. These percentages underscore the concentrated impact in specific locations, emphasizing the importance of tailored mitigation strategies to address the unique challenges faced by each community. Pearson's Chi-squared test showed that there is a significant difference in the HEC among locations ($X^2 = 34.317$, df = 14, p = 0.002). This implies that certain factors influencing these conflicts vary between the communities. Hence, HEC is not evenly distributed within all study locations as shown in Table 11.

Table 11: Number of Human Elephant incidences according to location

Location	Crop damage	Damage of water structures	Human death	Property damage	Human injury	Livestock raiding
Abo Buanabe	10.2	12.6	8.8	10.4	9.1	12.1
Abo Mkpang	4.5	11.6	12.5	11.5	10.2	13.1
Abo Obisu	4.5	12.6	11.3	11.5	12.5	11.1
Bamba	11.4	17.9	11.3	15.6	14.8	14.1
Bokalum	21.6	13.7	16.3	13.5	10.2	12.1
Wula I	23.3	12.6	13.8	12.5	17.0	12.1
Wula II	21.0	14.7	12.5	13.5	9.1	12.1
Okwangwo	3.4	14.7	13.8	11.5	17.0	13.1

Source: Field survey, 2023

4.1.2.7 Logistic regression analysis of crops grown in the study area

The results of the full logistic model show that the type of crop grown is the most significant predictor for HEC. The intercept in this regression model is found to be 0.452. This suggests that HEC starts at 0.452, the point at which all other parameters become unnecessary. With a value of 0.005, maize has a somewhat favorable impact on HEC. Banana, on the other hand, has a value of -0.028, indicating a slight negative impact. Pumpkin is noteworthy for having a coefficient of 0.302, which indicates a significant beneficial effect on HEC. Pumpkin's lower scores of 0.099 indicate more accurate estimations. Stronger correlations between the related variable and HEC are shown by higher absolute Z-values, such as the 9.455 Z-value for the intercept. The full logistic model formulated is as shown in Table 12 below.

Table 12: Full regression model for causes of human elephant conflict incidence

Variable	Intercept	Estimate	Error	Z value	Pr(>/z/)
Constant	0.452	-	0.048	9.455	<0.001*
Maize	-	0.005	0.076	0.065	0.948
Banana	-	-0.028	0.039	-0.730	0.466
Sweet potatoes	-	0.000	0.038	-0.003	0.998
Pumpkin	-	0.302	0.099	3.041	0.002*
Plantain	-	-0.081	0.038	-2.101	0.036
Cassava	-	-0.019	0.038	-0.485	0.628
Yam	-	0.231	0.103	2.256	0.025*
Cocoyam	-	-0.142	0.039	-3.660	<0.001*
Null divergence: 36.077 on 8 degrees of freedom					
Residual divergence: 80.915 on 471 degrees of freedom					

P (Elephant attacks) $=\beta 0+\beta 1x1+\beta 2x2+\ldots+\beta 7x7$

Where;

x_1 = Maize

x_2 = Banana

x_3 = Sweet potatoes

x_4 = Pumpkin

x_5 = Cassava

x_6 = Yam

x_7 = Cocoyam

β = the resultant changes in Y in response to a unit increase in xn

Y = dependent variable

P= Probability

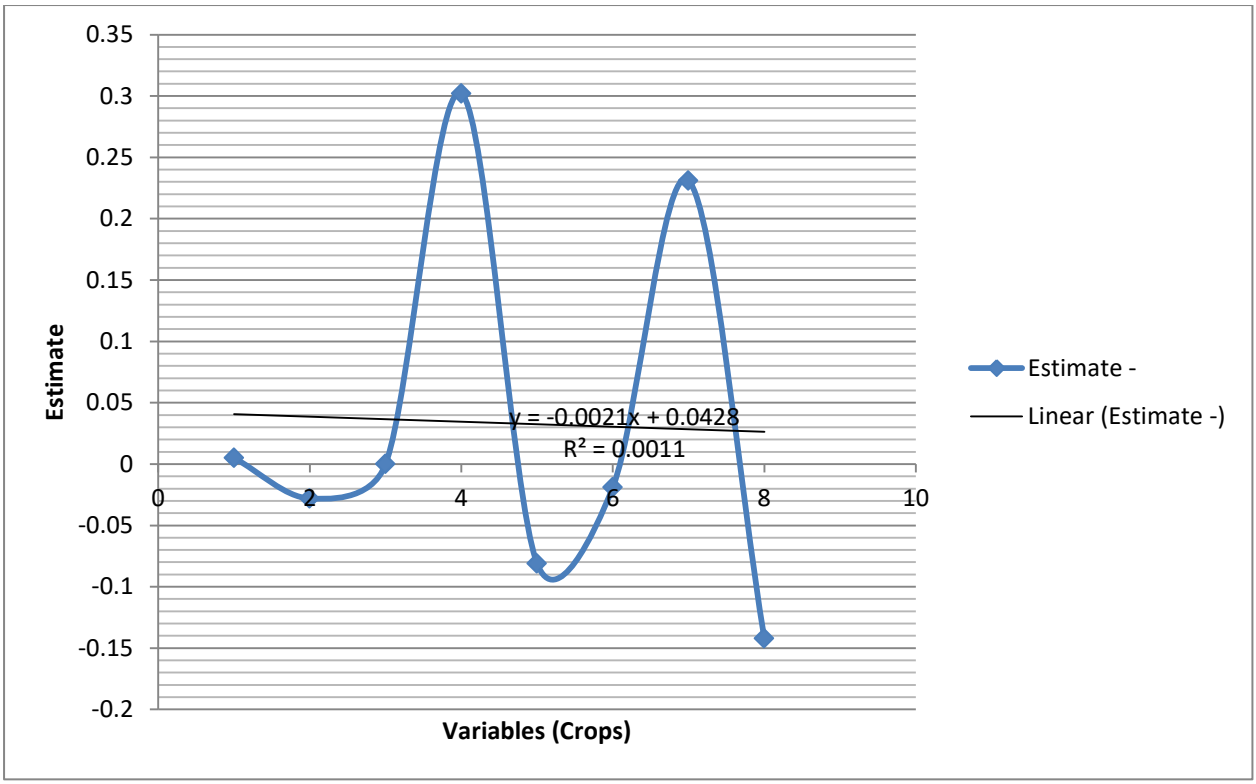

Fig. 10: Logistic regression analysis of crops cultivated

4.1.3 Effectiveness of existing HEC mitigation strategies used by farmers in the study area

The predominant method employed by farmers, as reported in the survey, was the utilization of flashlight/fire burning. This technique was adopted by approximately 62.8% of the respondents and was also deemed the most efficacious method (refer to Table 13). Auditory tactics, encompassing drumming, yelling, and whistling, were implemented by over half of the farmers. These methods were largely perceived as semi-effective, with a reported efficacy rate of 51.4%. Structural deterrents such as elephant watchtowers and local fences were less frequently utilized and were generally considered to be less effective. Anecdotal evidence suggested the use of additional deterrence methods, including the cultivation of chili pepper plants and the deployment of dogs to intimidate or pursue elephants. A significant proportion of the farmers, approximately 68.6%, expressed interest in experimenting with beehive fences as a novel deterrence strategy (see Plate 6). Of these, 35.2% indicated an immediate desire for assistance in the installation of beehive fences, while 33.4% expressed interest in acquiring more information about this method.

Plate 6: Bee hive fence in Wula I community
Date: 13th Augut, 2023 Time: 14:32:15

Table 13: Elephant deterrence methods and their perceived efficacy in the support zone communities of Okwangwo, CRNP

Elephant deterrence method used	Farmers using the method (%)	Perceived efficacy		
		Effective (%)	Semi-effective (%)	Not effective (%)
Local fencing	18.3	2.1	21.6	76.3
Beehive fencing	31.4	93.2	7.8	0.0
Flashlight/fire burning	62.8	48.9	38.7	12.4
Noise	60.2	38.6	51.4	10.0
Elephant watchtower	16.8	12.7	10.9	76.4

Source: Field survey, 2023

4.1.3.1 Community-driven approaches to human-elephant conflict mitigation in the study area

Community-wide Human-Elephant Conflict (HEC) mitigation strategies and their prioritization based on essentiality, high priority, medium priority, low priority, and not a priority category is presented in Table 13. Essential strategies, such as livelihood enhancement programs and economic incentives (58.6%) and restoration of buffer zone forests (51.4%), reflect critical interventions recognized by respondents. High-priority strategies, like establishing water sources in natural elephant ecosystems (43.2%) and disseminating knowledge about elephant behavior and coexistence strategies (39.5%), demonstrate significant value in addressing HEC. Medium-priority strategies, such as forest restoration activities within the park (31.3%), play a supportive role in biodiversity conservation and conflict reduction. Low-priority strategies, such as patrol teams for guided elephant reentry (4.7%), and those deemed not a priority, underline areas where community emphasis and resources may be less directed in mitigating HEC.

Table 14: Priorities for mitigating human-elephant conflict in the study area

Potential community-wide HEC mitigation strategies	Essential (%)	High priority (%)	Medium priority (%)	Low priority (%)	Not a priority (%)
Livelihood enhancement programs and economic incentives	58.6	32.5	7.6	1.2	0.1
Establishing water sources in natural elephant ecosystems	43.2	12.8	8.6	10.8	24.6
Forest restoration activities within the park.	24.8	33.7	31.3	10.1	0.2
Restoration of buffer zone forests	51.4	22.1	12.5	9.6	4.4
Patrol teams for the park's guided elephant reentry	4.7	7.2	12.9	26.5	48.7
Disseminating knowledge about elephant behavior, safety protocols, and coexistence strategies	39.5	29.6	19.8	6.8	4.3

Source: Field survey, 2023

4.2 Discussion

4.2.1 Estimation of elephant density in Okwangwo Sector of Cross River National Park using dung count method

Elephant population density is a key indicator of the conservation status of the species. The study used line transects and dung count method to estimate the elephant density in Okwangwo Sector of CRNP. A total of 88 dung piles were detected in a sampled area of 0.64 km^2. The elephant density was estimated to be 0.12±0.01 elephants/km^2; his estimate is lower than the previous estimate of 0.14 elephants/km^2 by Obot *et al.* (2005) and suggests a decline in the elephant population in the sector. The study also found that the local people had low levels of agreement and support for the punishment of poachers and the protection of elephants, indicating a lack of awareness and involvement in elephant conservation.

The study compared the elephant density estimate with other protected areas in Cameroon and neighboring countries that share similar ecological and geographical conditions. The results showed that the elephant density in Okwangwo Sector of CRNP was lower than that of Nki National Park (0.14 elephants/ km^2 (Fonkwo *et al.,* 2023), Minkebe National Park in Gabon 0.74 elephants/km^2 (Poulsen *et al.,* 2017), Noubale-Ndoki National Park in the Republic of Congo (0.55 elephants/ km^2 (Stokes, 2010), and Okomu National Park in Nigeria (0.15 elephants/km^2 (Amusa *et al.,* 2017). However, it was higher than that of Boumba Bek National Park 0.06 elephants/km^2 (Nzooh *et al.,* 2016) and Korup National Park 0.04 elephants/km^2 (Kupsch *et al.,* 2014). The variation in the elephant density estimates among the protected areas could be attributed to the differences in the methods, vegetation types, and data collection periods. However, all the studies reported a decreasing trend in the elephant population due to poaching.

The dung count method is widely employed for estimating wildlife population densities; it is subject to various biases and assumptions that can influence the accuracy and reliability of the results. One such limitation is the assumption of a constant defecation rate across all elephants within a habitat, which is not reflective of the actual behavior observed in elephant populations (Abernethy *et al.,* 2003). Studies by Wanghongsa (2004) have highlighted variations in defecation rates based on age and sex demographics among elephants, indicating the need for more nuanced approaches in estimating defecation rates.

Moreover, environmental factors such as humidity levels significantly impact defecation rates, as reported by Sivaganesan and Kumar (1994), who noted higher defecation rates in humid zones compared to dry zones. This variability in defecation rates across different ecological settings

underscores the complexity of accurately estimating elephant densities solely based on dung counts.

Another critical consideration is the decay rate of dung piles, which is influenced by climatic and biotic factors. Studies by Nchanji and Plumptre (2001) have demonstrated faster decay rates during the wet season due to increased insect activity, further complicating the reliability of dung count estimates, particularly when data collection spans different seasons.

Furthermore, the spatial and temporal distribution of dung piles introduces additional challenges. The study's adherence to the decay state classification system by Barnes (1982) and the recording of dung piles within specific decay states (e.g., S5) is for standardization but overlook variations in decay rates within each category.

Additionally, the study's observations of dung piles, footprints, trails, and crop damage by elephants highlight the dynamic nature of human-elephant interactions in the study area. The proximity of farmlands to forest edges increases the likelihood of human-elephant conflicts, as evidenced by the impact on crops such as sweet potatoes (*Ipomoea batatas*), cassava (*Manihot esculenta*), and yam (*Discorea spp.*) (See Plate 5). The identification of major migration routes, such as the saltlick in the Okwangwo area, emphasizes the importance of considering landscape features and animal behavior in interpreting dung count data accurately.

4.2.2 Socio-economic Drivers of Human-elephant Conflict

The demographic analysis of the sample population in the study provides valuable insights into the factors influencing conservation attitudes, highlighting notable gender disparities and age-related patterns that shape perceptions. The study's rigorous statistical approach, including chi-square analysis, confirms the significance of these demographic factors in understanding conservation behaviors.

The gender distribution among participants, with 65% male and 35% female respondents reflects a gender disparity in conservation attitudes. This aligns with the findings of Gadd (2005) and Riddell (2005), which identified gender as a key determinant in conservation outlooks. Further investigation into gender-specific views could enhance our understanding of conservation behaviors and the role of gender in shaping conservation priorities.

A Pearson correlation analysis revealed a very weak and insignificant relationship between age and how people perceive elephant conservation. This finding indicates that age doesn’t really affect people’s opinions about elephant conservation in this study. This finding is inconsistent

with recommendations by Kideghesho *et al.* (2007) for examining generational differences to elucidate subtle variations in conservation attitudes.

Marital status, family size, occupation, and income level were the demographic factors that influence conservation viewpoints. The study's analysis reveals correlations between these factors and conservation perceptions, emphasizing the intricate relationship between personal dynamics, socioeconomic status, and environmental attitudes. Insights from Ardiantiono *et al.* (2017) and Matteson (2018) support these observations, highlighting the influence of marital status, occupation, and income on conservation attitudes.

Educational background also emerges as a critical factor, with individuals' educational levels significantly shaping their receptiveness to elephant conservation efforts. This finding aligns with scholarly consensus, as seen in works by Gadd (2005), Riddell (2005), and Kideghesho *et al.* (2007), emphasizing the vital role of education in influencing conservation-related attitudes and behaviors.

4.2.2.1 Community perception of human-elephant coexistence

The results from the survey revealed significant nuances in the attitudes and priorities of respondents regarding elephant conservation and conflict mitigation. Three out of the five statements were found to be significant, indicating the complexity of perspectives within the community.

The most significant statement, "Conservation is a waste of land," with a Mean Weighted Score (MWS) of 3.4, underscores a multifaceted perspective on conservation efforts. This finding aligns with the argument put forth by Kuswanda *et al.* (2022), who emphasized that successful coexistence between humans and elephants requires behavioral adaptation by humans. This suggests that conservation initiatives must take into account human behavior and its impact on land use to achieve harmonious coexistence.

On the other hand, the statement "Elephants should be protected," with an MWS of 3.3, reflects the respondents' recognition of the importance of preserving elephant habitats and preventing their extinction. This finding supports the study by Gunawansa *et al.* (2023), which emphasized the need for innovative strategies, such as satellite data fusion and GIS modeling, to mitigate human-elephant conflicts and protect both human interests and elephant populations.

Conversely, the statement "People/crops/livestock are more important than elephants," with an MWS of 3.2, signifies the acknowledgment of potential conflicts between human and elephant

interests without prioritizing one over the other. This contrasts with the findings of Abdullah *et al.* (2019), who highlighted the heavy influence of economic factors on conservation attitudes. Their study indicated that threats to livelihoods due to wildlife damage can deter support for conservation efforts, revealing a complex interplay between economic considerations and conservation priorities.

The lack of significance for the statements "Poachers should be punished" and "I Support elephants," with MWS of 2.9 and 2.4, respectively, may stem from skepticism about the effectiveness of certain conservation actions. While there is support for protective measures, doubts may exist regarding the efficacy of punitive measures against poaching or general expressions of support for elephants. These findings are consistent with the observations of Tsegaye *et al.* (2023), who noted weak trust in traditional mitigation techniques among local communities and advocated for physical barriers to separate elephants and humans.

Additionally, the lack of significance for the statement "I support elephants" may also be attributed to the fact that people who had witnessed crop damage were often unlikely to be in favor of elephant conservation. This finding is corroborated by Abdullah et al. (2019), who documented similar results in an Indonesian investigation. Their study revealed that while the majority of respondents supported the protection of elephants, this support diminished when crop-raiding wildlife, especially elephants, threatened their interests and means of livelihood. Community perceptions of human-elephant coexistence reveal nuanced attitudes and priorities, with challenges in capturing the depth and complexity of community perspectives, addressing conflicting opinions, and accounting for cultural, social, and economic influences on perceptions.

The benefits of coexistence are perceived differently among communities, with challenges in validating reported benefits, assessing long-term sustainability, and balancing conservation initiatives with local livelihoods.

4.2.2.2 Benefits of human-elephant coexistence

The survey conducted among respondents revealed a diverse range of perceived benefits associated with living near wild elephants, illustrating the intricate dynamics between human communities and wildlife. The analysis of these reported benefits provides valuable insights into the multifaceted impacts of human-elephant coexistence and conservation efforts.

The most commonly cited benefit, reported by 30% of respondents, was community development. This indicates a tangible positive impact on the well-being and progress of these communities. This finding is in line with Wong *et al.* (2021), who advocate for the utilization of

Theory of Change (ToC) and Social Return of Investment (SROI) as strategic planning tools in conservation projects to promote community development. Their work underscores the importance of understanding and leveraging community dynamics to achieve sustainable conservation outcomes.

Moreover, approximately 29.8% of respondents highlighted the establishment of schools and health facilities as a significant benefit of living in close proximity to elephants. This resonates with the findings of Sampson *et al.* (2021), who explored differing conservation priorities between rural and urban communities. Their research emphasizes the crucial role of educational and health infrastructure in fostering peaceful human-wildlife coexistence and enhancing community well-being.

Furthermore, 16.4% of respondents expressed satisfaction from acquiring vocational skills to reduce their dependence on forest resources. This finding aligns with Greenwood and Buren's (2010) emphasis on vocational skills as a key strategy in mitigating conflicts over natural resources and promoting sustainable practices. It highlights the importance of empowering local communities through skill-building initiatives to enhance their resilience and reduce environmental pressures.

The sense of pride reported by 12.2% of respondents from hosting conservationists such as researchers and tourists reflects the positive impact of strategic conservation approaches on community morale and engagement. Wong *et al.* (2021) also noted similar findings regarding the uplifting effect of hosting conservationists on community morale and involvement in conservation efforts.

While a smaller percentage (8.3%) of respondents mentioned financial benefits, this finding corresponds with Shannon *et al.* (2017) insights into the economic advantages associated with living near elephants, particularly in terms of tourism revenue. This underscores the potential economic benefits that can result from responsible wildlife tourism and conservation initiatives.

Similarly, the mention of job creation by 3.3% of respondents supports Yazezew's (2022) assertion regarding the potential for employment opportunities within the context of human-wildlife coexistence and conservation initiatives. This highlights the broader socio-economic impacts of conservation efforts in generating livelihood opportunities for local communities.

4.2.3 Nature and extent of human-elephant conflicts

The study delves into the intricate dynamics of Human-Elephant Conflict (HEC) in the support zone communities of Okwangwo, CRNP, highlighting agricultural activities as a primary driver of these conflicts. This finding aligns with numerous previous studies, which have consistently identified agriculture as a major contributor to HEC due to the expanding human population and the consequent demand for land, food resources, and livelihood opportunities.

The ecological and socio-economic drivers of HEC are complex and intertwined, with seasonal variations playing a crucial role in the occurrence of conflict events. The study reveals that the seasonality of HEC incidents is closely linked to the agriculture calendar, particularly during the dry season. Farmers in the surveyed communities typically plant crops between November and March, coinciding with the two wet seasons from October to December and March to May. The analysis indicates that crop raiding behaviors by elephants often peak during the harvesting period, posing challenges as elephants prefer crops rich in carbohydrates, which are staple foods in the region.

A comparative study conducted in Lower Sagalla by Weinnman (2018) sheds light on potential strategies to manage elephant crop raiding behavior. The study found that elephants exhibit a preference for maize over other crops like ginger, garlic, lemongrass, and onion. This suggests that planting less palatable crops could be an effective mitigation measure. The researcher also proposed sunflower and moringa as non-palatable alternatives that are economically viable. Additionally, chillies have been explored as a deterrent for crop raiding in studies by Chelliah *et al.* (2011) and Changa *et al.* (2016), offering further insights into practical solutions for mitigating HEC.

The findings from this study also emphasize the temporal aspect of HEC incidents, with respondents identifying nighttime as the most prevalent time for conflicts. This aligns with the observations of Okello *et al.* (2016), who suggested that elephants tend to retreat to safer areas with minimal human presence during the day and venture into human-dominated landscapes at night when human activities are subdued. This nocturnal foraging behavior of elephants, coupled with their continuous grazing nature as non-ruminants, poses challenges for conflict mitigation efforts and necessitates a comprehensive approach to address risk avoidance strategies adopted by elephants in relation to HEC.

The study on Human-Elephant Conflict (HEC) provides valuable insights into the challenges faced by communities living near elephant habitats. The research found that crop raiding was the

most common type of HEC, with around 60.6% of respondents reporting crop damage. This shows the significant impact of HEC on agricultural productivity and livelihoods in the study area.

Furthermore, the results indicated that most HEC incidents occurred after the surveyed population adopted farming as a livelihood. This underscores the connection between changes in agricultural practices and the escalation of conflict, which aligns with previous studies by Gunawansa *et al.* (2023) and Tripathy *et al.* (2021). These studies also highlighted land use change and habitat loss due to human activities as contributing factors to HEC.

Humans and elephants share the same environment, leading to conflicts that affect both parties. This study revealed people experienced destruction of water sources and faced limitations on moving freely due- to elephant encounters. These issues impacted their daily lives and overall wellbeing. Similar findings by Nyumba *et al.* (2020) showed these conflicts extend beyond physical damage, causing socio-economic and environmental problems.

To address these challenges, planting crops that elephants dislike, as suggested by Weinnman (2018), could help. However, resolving human-elephant conflicts requires a comprehensive approach. This include-s considering socio-economic factors, land management practices, and cooperation between communities, conservationists, and policymakers.

Elephants clashing with farming communities are a huge issue needing solid solutions. From the findings in this study crop destruction from elephant invasions caused losses worth ₦ 16,661,000.00. This problem echoes similar study by Okeke and Adeola (2023) who poised thatwhere human settlements border elephant homes, elephants roam into farms, wrecking crops, property, and sometimes even harming people. Dealing with such human-elephant conflicts requires detailed examination and intelligent strategies.

The specific pattern of losses reported in our study, with maize (*Zea mays*) farmers incurring the highest costs, followed by plantain (*Musa paradisiaca*), cassava (*Manihot esculenta*), yam (*Discorea spp*), and cocoyam farmers, is consistent with findings from India and other parts of Africa. Elephants' preference for certain crops over others exacerbates the conflict, as farmers cultivate economically valuable but highly palatable crops to elephants, leading to increased raids Patel *et al.,* (2021).

Moreover, the economic losses extend beyond crop damage. The destruction of assets, human injury, and loss of life, although less in magnitude compared to crop damage, adds a significant burden on affected households, with reported losses exceeding ₦ 40,000.00 at a household level.

This aligns with the study by Lee (2023) who poised global estimates indicating substantial economic costs associated with invasive species, including crop-raiding wildlife like elephants.

According to a study by Smith and Brown (2023), to address these challenges effectively, integrated approaches to mitigate human-elephant conflicts are crucial. These approaches could include the development of early warning systems to alert farmers of approaching elephants, the cultivation of crops unpalatable to elephants, and the implementation of compensation schemes for affected farmers. Such measures not only address the immediate economic impacts but also contribute to the long-term coexistence of human and elephant populations, ensuring biodiversity conservation while sustaining agricultural livelihoods.

4.2.3.1 Influence of crop type in Human-elephant conflict

The results from this study shed light on the significant role of crop type in influencing Human-Elephant Conflict (HEC). Specifically, the research findings indicate that maize and pumpkin are more likely to be associated with HEC incidents, while banana shows a reduced likelihood of conflict. These nuanced insights provide a deeper understanding of the complex dynamics of HEC and the factors contributing to conflict incidents. These thesis findings align with Gunawansa *et al.* (2023), who emphasized the impact of crop choice on HEC in Sri Lanka. They noted that changes in agriculture practices, including crop selection, are a major cause of HEC. This supports the assertion that crop type significantly influences HEC occurrences.

Montgomery *et al.* (2021) discussed interventions to protect crops from raiding elephants which corroborated the findings of the current research that certain crops, like maize and pumpkin, are more attractive to elephants and thus more prone to raiding. This suggests that targeted mitigation strategies based on crop susceptibility can be effective in reducing HEC incidents.

Pozo *et al*. (2017) identified human and elephant population sizes as significant predictors of HEC but did not specifically focus on crop types. Results from the study add a new dimension by highlighting the importance of considering crop type as a predictor, enhancing the predictive accuracy of HEC models.

Studies on the removal of specific crops like jackfruit and mango to reduce HEC in Asia further corroborate the results of this research regarding the influence of crop type on conflict dynamics. This supports the idea that modifying crop selection can be a practical approach to mitigating HEC.

The regression model analysis provides statistical evidence for the relationship between crop types and HEC incidents. The intercept value of 0.452 indicates the baseline level of HEC, with maize, banana, and pumpkin coefficients offering insights into the relative impact of each crop on conflict likelihood.

4.2.4 Effectiveness of existing HEC mitigation strategies

In places where human settlements and elephant habitats intersect, the Human-Elephant Conflict (HEC) presents a significant challenge. Resolving this issue requires developing practical solutions. A review of data on strategies to mitigate HEC aligns with existing research. The findings from this study show various approaches that differ in their acceptance and effectiveness.

The findings of this study show that farmers mainly use torches or burn biomass as deterrents, and most find these methods effective. This aligns with the findings of *Beier et al.*, (2020) and Shaffer *et al.* (2018) who highlight on-site deterrents as common strategies to reduce human-elephant conflict. Similarly, the use of acoustic measures, rated as moderately effective in this study, is also recognized by Shaffer *et al.* (2018) as a conventional way to kee-p elephants away.

Architectural solutions like observation towers and barricades, though less frequently discussed and considered less ideal in the study, align with the views of Chen *et al.* (2016). They listed observation towers among various mitigation strategies without explicitly evaluating their effectiveness. The emergence of apiary barriers as an innovative approach among farmers is noteworthy, reflecting a rising trend in managing human-elephant conflicts. King *et al.* (2017) provide evidence supporting the usefulness of apiary fences, which is consistent with the growing inte-rest among agricultural experts in this method.

The emphasis on community strategies to address human-elephant conflict, such as improving livelihoods and providing financial assistance, echoes the recommendations of Naughton-Treves *et al.* (2003) for similar approaches to reduce conflict. Likewise, raising awareness about elephant behavior and coexistence strategies aligns with the call by Graham *et al.* (2010) for educational initiatives in mitigating human-elephant conflict.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study examines the ecology and socioeconomic factors contributing to conflicts between humans and elephants in the communities surrounding the Okwangwo sector of Cross River National Park. This provides valuable insights into the complex dynamics of human-elephant conflict (HEC) and its implications for conservation and community well-being.

The study employed dung count to estimate the elephant population density in the Okwangwo sector of CRNP. The results show a decline in elephant numbers compared to previous estimates. This highlights the urgent need for conservation efforts to address the challenges faced by elephant populations in the region. The study also compares the elephant density in Okwangwo with other protected areas, revealing variations influenced by ecological factors, data collection methods, and human activities. This underscores the importance of developing context-specific conservation strategies.

The study revealed that various socioeconomic factors, such as gender, occupation, and income, significantly influence conservation attitudes, while age exhibits a weak and insignificant relationship. This highlights the need for targeted conservation initiatives that consider the diverse backgrounds of local communities to achieve positive results.

Furthermore, the study explored the community's perception of human-elephant coexistence. It uncovered nuanced perspectives on conservation priorities, adapting human behavior, and balancing economic interests with conservation goals. The findings emphasize the importance of community engagement, education, and innovative strategies to promote harmonious coexistence between humans and elephants, addressing the root causes of human-elephant conflict.

The study found that communities living near elephants reported many benefits, including community development, access to education and healthcare, gaining new skills, pride in hosting conservation efforts, financial gains, and job opportunities. These perceived benefits suggest that conservation efforts and socio-economic development can work together to benefit both communities and wildlife.

The study's findings provide valuable insights into the relationship between humans and elephants in the Okwangwo sector. This information can help guide evidence-based conservation policies and practices that promote sustainable coexistence between people and elephants, while also improving community well-being and protecting biodiversity in the study area.

The dung count method used to estimate elephant density in the Okwangwo Sector of Cross River National Park faces several limitations. These include assumptions about constant defecation rates across elephant populations, variations in defecation rates based on age, sex, and environmental factors, and challenges in accurately aging dung piles due to decay rates influenced by climatic and biotic factors. Additionally, the spatial and temporal distribution of dung piles introduces complexities in data collection and interpretation.

Beyond the dung count method, the research delves into the socio-economic drivers of human-elephant conflict, highlighting the intricate interplay of demographic factors such as gender, age, marital status, occupation, income, education, residency duration, and geographical location. These factors shape conservation attitudes but also pose challenges in data analysis and interpretation due to their diverse and interconnected nature.

Community perceptions of human-elephant coexistence reveal nuanced attitudes and priorities, with challenges in capturing the depth and complexity of community perspectives, addressing conflicting opinions, and accounting for cultural, social, and economic influences on perceptions. The benefits of coexistence are perceived differently among communities, with challenges in validating reported benefits, assessing long-term sustainability, and balancing conservation initiatives with local livelihoods.

The nature and extent of human-elephant conflicts are dynamic and multifaceted, influenced by agricultural practices, land use changes, seasonal variability, and complex interactions between humans and elephants. Challenges include capturing temporal and spatial patterns of conflicts, addressing root causes beyond crop raiding, and developing comprehensive mitigation strategies that integrate conservation goals with community needs.

5.2 Recommendation

The study provides important insights that can help guide conservation strategies and community engagement.

The results from estimating elephant population density using dung count show the need for urgent conservation action. The observed decline in elephant density compared to previous estimates emphasizes the importance of targeted conservation efforts to address the challenges facing elephant populations in the Okwangwo area. While the method is widely used, it's essential to acknowledge its limitations, such as assumptions about constant defecation rates across all elephants and the influence of environmental factors like humidity on defecation rates.

These nuances highlight the complexity of accurately estimating elephant densities solely based on dung counts.

Understanding the socio-economic factors that contribute to human-elephant conflicts is crucial for developing effective conservation strategies. Demographic analysis reveals that elements like gender, age, marital status, occupation, income, education, residency, and location play a significant role in shaping people's attitudes and behaviors towards conservation. Therefore, conservation efforts must consider these diverse socio-economic contexts to ensure their relevance and effectiveness emphasizing the need for tailored strategies based on local contexts.

Community engagement and awareness programs are vital for promoting peaceful coexistence between humans and elephants. Educating local residents about elephant behavior, coexistence strategies, and the importance of conservation can foster collaborative partnerships and empower communities to actively participate in conservation efforts.

Innovative mitigation measures, such as apiary barriers and non-palatable crop cultivation, have shown promise in reducing human-elephant conflicts. These measures, based on scientific research and data-driven approaches, should be continuously monitored and evaluated to assess their effectiveness and adapt strategies as necessary.

Getting support from policymakers and raising awareness are key for prioritizing efforts to prevent human-elephant conflicts and protect these animals. Working together with government agencies, charities, research groups, and local communities is crucial for creating and enforcing policies that encourage sustainable land use, wildlife conservation, and resilient communities.

Building the skills and knowledge of local communities, conservationists, and researchers is crucial for improving conservation science, community engagement, conflict resolution, and sustainable resource management. Collaborative research that combines scientific expertise with community insights can produce evidence-based solutions for people and elephants to live together.

Thorough monitoring and evaluation are needed to assess the impact of conservation efforts, track progress towards goals, and identify areas for improvement. Data-driven insights should guide adaptive management strategies, allowing conservation initiatives to continuously learn and refine for sustainable coexistence between people and elephants in the Okwangwo region and beyond.

Innovative mitigation measures such as apiary barriers and non-palatable crop cultivation offer promising solutions to human-elephant conflicts. However, addressing technical, logistical, socio-economic, and environmental challenges is critical for their successful implementation at scale and ensuring sustainable coexistence between humans and elephants. Collaborative efforts involving researchers, practitioners, local communities, and policymakers such as the Cross River National Park are essential for developing and implementing effective and context-appropriate mitigation strategies.

The effectiveness of existing HEC mitigation strategies, ranging from on-site deterrents to community-based approaches, underscores the importance of evaluating and refining strategies based on empirical data and community feedback. Integrating these findings into conservation planning efforts can contribute to more sustainable and harmonious human-elephant coexistence in diverse ecological and socio-economic contexts globally.

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APPENDIX 1: Sample of Questionnaire

Department of Forestry and Wildlife Technology
School of Agriculture and Agricultural Technology
Federal University of Technology, Owerri, FUTO

QUESTIONNAIRE ON SOCIO-ECONOMIC DRIVERS AND HUMAN-ELEPHANT CONFLICTS IN CROSS RIVER NATIONAL PARK, NIGERIA

Request for Response to Questionnaire

Dear Respondent,

I am a postgraduate student of the above named Department and University currently undertaking a research work titled: **"Population Ecology and Socio-economic Drivers of Human-elephant Conflicts in Okwangwo Sector of Cross River National Park, Nigeria**". You have been selected as one of the respondents to supply the needed information towards addressing the specific objectives of the study. I therefore solicit for your candid response as objective as possible to the questions in the questionnaire. It is purely an academic work. Therefore, all information supplied by you will be strictly treated in confidence and for the purpose of the research only.

Thank you for your co-operation.

Yours faithfully,

Peter Williams Bassey
(Researcher)

SECTION A

Demographic Information

Instruction: please tick (√) in the appropriate box.

1. Community:……..……
2. Sex: a. Male [ ] b. Female [ ]
3. Age (Years): a. Below 21 [ ] b. 22 – 30 [ ] c. 31 – 35 d. 36 – 40 [ ] e. 41 – 45 [ ] f. 46 – 50 [ ] g. Above 50 [ ]
4. Marital status: a. Single [ ] b. Married [ ] c. Widow [ ] d. Separated [ ] e. Divorced [ ]
5. What is your primary source of income? a. Agriculture [ ] b. livestock [ ] c. Fishing/hunting [ ] d. Business [ ] e. Civil Servant [ ]
6. What is the average monthly income of your household? a. less than ₦ 30,000 [ ] b. ₦ 30,000 - ₦ 50,000 [ ] c. ₦ 51,000 - ₦ 100,000 [ ] d. ₦ 101,000 - ₦ 200,000 [ ] e. Above ₦ 200,000 [ ]
7. How long have you been living in the support zone communities of CRNP? a. Less than 5 years b. 5-10 years c. 10-15 years d. More than 15 years
8. Education level: a. None [ ] b. FSLC [ ] c. SSCE [ ] d. Tertiary [ ]

SECTION B

Farm Attributes

9. Do you own agricultural land? If yes, what is the size of your land? a. Yes, less than 1 hectare [ ] b. Yes, 1-5 hectares [ ] c. Yes, 5-10 hectares [ ] d. Yes, more than 10 hectares [ ] e. No [ ]
10. What crops do you cultivate on your land? (Select all that apply) a. Maize [ ] b. Plantain [ ] c. Sweet potatoes [ ] d. Cassava [ ] e. Banana [ ] f. Pumpkin [ ] g. Yam [ ] h. Cocoyam [ ] i. Others (specify):…….
11. Have you experienced damage to your crops by elephants in the past year? a. Yes [ ] b. No [ ]
12. If yes, please fill in the following table

Crop type	No. of acres destroyed	Quantity destroyed	Unit price	Estimated total price
Maize				
Plantain				
Sweet potatoes				
Cassava				
Banana				
Pumpkin				
Yam				
Cocoyam				
Others (specify)….				

SECTION C

Nature and Extent of Human Elephant Conflict

13. How would you describe your interactions with elephants? a. Very negative [ ] b. Negative [ ] c. Moderate [ ] d. Positive [ ] e. Very positive
14. Have you or your community members experienced human-elephant conflict? a. Yes [ ] b. No [ ]
15. If yes, please describe the nature of the conflict. (Select all that apply) a. Crop raiding [ ] b. Livestock depredation [ ] c. Human death [ ] d. Human injury [ ] e. Property damage [ ] c. Water structure damage [ ] d. Shelter destruction [ ] d. disruption of school [ ] e. others (specify)……..
16. How frequently does human-elephant conflict occur in your community? (Select all that apply to each corresponding type of conflict)

Type of HEC	Rarely	Occasionally	Frequently	Very frequently
Crop raiding				
Livestock depredation				
Human death				
Human injury				
Property damage				
Water structure damage				
Shelter destruction				
Others (specify)……..				

	Season	Strongly Agreed	Agreed	Neutral	Disagreed	Strongly Disagreed
17.	Elephants usually come during the wet season					
18.	Elephants usually come during the dry season					

19. What time do elephants raid crops? a. Day [ ] b. Night
20. Can you quantify the crop damage after a raid? a. 100% [ ] b. 80% [ ] c. 50% [ ] d. 30% [ ] e. 0% Disagreed
21. Have you ever received compensation for your crops, property damage or livestock/human attacks?
22. If yes, how much?..... and after how long?.....

23. What are the estimated costs in Naira for the following incidents?

Type of HEC	No damage	Less than ₦ 10,000	₦ 10,001 - ₦ 20,000	₦ 20,001 - ₦ 30,000	₦ 30,001 - ₦ 50,000	Above ₦ 50,000
Crop raiding						
Livestock depredation						
Human injury						
Water structure damage						
Property damage						
Others (specify)……..						

SECTION D

Community Perception of Human-Elephant Coexistence

24. Which statement describes your attitude toward elephants most accurately? a. I tolerate elephants in my environment, even if they destroy my plantation [ ] b. I would tolerate elephants in my environment if they would stop destroying my plantations [ ] c. I would prefer elephants to be eradicated [ ] d. Other: .....
25. Rate your support for elephant conservation. a. Not important at all [ ] b. Barely important [ ] c. Indifferent [ ] d. Important [ ] e. Very important [ ]

S/N	Statement	Strongly Agreed	Agreed	Neutral	Disagreed	Strongly Disagreed
26.	Elephants should be protected					
27.	People who poach should be punished					
28.	Conservation is a waste of land					
29.	What people and their livestock/crops need are more important than saving elephants					

30. Are there any benefits (Direct or indirect) you gain from elephant conservation? a. Yes [ ] b. No [ ]
31. If yes, describe the benefits. a. cash [ ] b. School and health facilities [ ] c. Community development [ ] d. Pride of hosting conservationist [ ] e. Conservation & Ecotourism jobs [ ] f. Vocational skills

SECTION E

Effectiveness of existing HEC Mitigation Strategies

32. List the priorities for mitigating human-elephant conflict in your area (select all that apply)

Potential community-wide HEC mitigation strategies	**Essential**	**High priority**	**Medium priority**	**Low priority**	**Not a priority**
Livelihood enhancement programs and economic incentives					
Establishing water sources in natural elephant ecosystems					
Forest restoration activities within the park.					
Restoration of buffer zone forests					
Patrol teams for the park's guided elephant reentry					
Disseminating knowledge about elephant behavior, safety protocols, and coexistence strategies					

33. List the human-elephant conflict mitigation measures that are currently in place in your area. (Select all that apply) and tick how effective you perceive these measures to be in reducing human-elephant conflicts?

	Very effective	**Moderately effective**	**Neutral**	**Not very effective**	**Not effective at all**
Non electric fencing					
Electric fencing					
Beehive fences					
Light (flashlight)					
Noise (car, dog, voice)					
Elephant watch towers					
Other (Specify)					

33. Have you received any support or training on implementing these measures? a. Yes [ ] b. No [ ]
34. What challenges, if any, do you face in implementing or maintaining these mitigation measures? a. Lack of financial resources [ ] b. Lack of technical support [ ] c. Lack of community cooperation [ ] e. Other (Specify)……

Appendix 2: Pictorial representation of the research administering questionnaire and FGD

Administering Questionnaire at Okwangwo
Date: 17/08/2023 @13:12:52

FGD at Bokalum
Date: 19/08/2023 @12:46:13

Administering Questionnaire at Okwangwo
Date: 17/08/2023 @11:08:14

Administering Questionnaire at Bokalum
Date: 17/08/2023 @14:54:07

Appendix 3: Population Projection using the Growth Index (GI) for the Study Communities

Communitty	2009 Population	2009 (2.76)	2010 (2.78)	2011 (2.80)	2012 (2.79)	2013 (2.73)	2014 (2.66)	2015 (2.57)	2016 (2.54)	2017 (2.56)	2018 (2.53)	2019 (2.48)	2020 (2.47)	2021 (2.44)	2022 (2.41)	2023 (2.41)	2024 (2.39)
Bamba	696	715	735	756	777	798	819	840	862	884	906	928	951	975	998	1022	**1047**
Bukalum	522	536	551	567	583	598	614	630	646	663	679	696	714	731	749	767	**785**
Wula II	466	479	492	506	520	534	548	563	577	592	607	622	637	653	668	684	**701**
Wula I	1,392	1430	1470	1511	1554	1596	1638	1680	1723	1767	1812	1857	1903	1949	1996	2044	**2093**
Butatong	1,566	1609	1654	1700	1748	1795	1843	1891	1939	1988	2038	2089	2141	2193	2246	2300	**2355**
Kanyang 1	525	539	554	570	586	602	618	634	650	667	683	700	718	735	753	771	**789**
Ukwa II	1,044	1073	1103	1134	1165	1197	1229	1260	1292	1325	1359	1393	1427	1462	1497	1533	**1570**
Okwangwo	1,217	1251	1285	1321	1358	1395	1432	1469	1507	1545	1584	1623	1664	1704	1745	1787	**1830**