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ASSESSMENT OF HUMAN–ELEPHANT CONFLICT IN COMMUNITIES ADJACENT TO TWO PROTECTED AREAS IN BOKI LOCAL GOVERNMENT AREA, CROSS RIVER STATE, NIGERIA

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Abstract
Human-elephant conflict (HEC) poses a threat to biodiversity and rural livelihoods in West Africa. This study utilized a mixed-methods convergent parallel design approach Integrating Household Surveys (n = 159), focus group discussions, and GIS-based spatial analysis to investigate HEC dynamics in Mbe Mountains Wildlife Sanctuary and Okwangwo Division of Cross River National Park, Nigeria. Purposive sampling of four communities was adopted, using structured questionnaires to capture socio-economic impacts and GPS field visits to document crop damage. Data were analysed using the R- environment, employing descriptive statistics, Chi-square tests, and Kruskal-Wallis analyses to determine relationships between proximity, crop selectivity, and mitigation efficacy. Results indicate a pervasive conflict where 100% of respondents experienced elephant incursions, resulting in about 82.1±8.11% crop loss. Spatial analysis confirmed proximity as the primary driver, with 85% of affected farms within 500 meters of protected boundaries. Statistical evidence revealed significant selectivity ($p < 0.01$), with elephants disproportionately targeting high-value cocoa and plantain. Notably, a disconnect exists between attitudes and behavior; mitigation choice is governed by resource constraints than conservation perceptions. Existing deterrents were universally ineffective, showing no statistical relationship with conflict reduction. Moran's I analysis identified nine significant hotspots requiring urgent prioritization. This study recommends strengthening human–elephant conflict management through evidence-based landscape planning that reflects the spatial and seasonal patterns of crop raiding in the study. Interventions should prioritize conflict hotspots, improve collaboration among conservation agencies and local communities, and provide incentives such as compensation, livelihood support, and crop-protection measure to promote long-term human–elephant coexistence.

Keywords: Human-elephant conflict, *Loxodonta cyclotis*, crop depredation, spatial analysis, Mitigation efficacy

Introduction

Human-wildlife conflict (HWC) is a global conservation priority as expanding human populations and agricultural activities increasingly encroach upon wild habitats, leading to intense competition for finite resources (Baruch-Mordo *et al.*, 2013). Among the various forms of these interactions, human-elephant conflict (HEC) is particularly severe due to the elephant's immense size with adult male reaching up to 8.2 to 9.8 feet and adult female reaching up to 5.9 to 7.9 feet, high caloric needs, and intelligence, which often lead to substantial damage to crops (E.g.

cocoa, banana etc.), infrastructure, and human lives.

Historically, elephants and humans have shared landscapes for centuries, developing complex adaptive behaviors to coexist (Mumby & Plotnik, 2018). However, the recent intensification of HEC, driven by rapid human population growth and the conversion of forests into farmland, has shifted this relationship from one of coexistence to one of frequent confrontation (Gunawansa, 2024 and Babar, 2019). As large herbivores with vast home ranges, elephants frequently collide with farmers in agricultural landscapes where natural reserves have been fragmented to make way for cultivation (Nyhus, 2016).

The African forest elephant (Loxodonta cyclotis), recently classified as Critically Endangered by the International Union for Conservation of Nature (IUCN, 2021), faces increasing threats from habitat fragmentation, agricultural expansion, and human–elephant competition. As a keystone species, forest elephants are essential for maintaining forest structure and biodiversity through seed dispersal and ecosystem engineering (Poulsen *et al*., 2018). However, increasing crop raiding has disrupted rural livelihoods, shaped community perceptions of wildlife, and contributed to retaliatory killings that further threaten the species (Mamboleo *et al*., 2017; Nyhus, 2016). This study is guided by the Social–Ecological Systems (SES) framework, which recognizes that human–elephant competition results from interactions between ecological processes, human livelihoods, and institutional responses. The framework provides a basis for understanding how these interactions influence conservation outcomes and sustainable coexistence between people and elephants.

The Cross River landscape represents the last significant refuge for the African forest elephant (Loxodonta cyclotis) in Nigeria, with remnant populations occurring within the Okwangwo Division of Cross River National Park (CRNP) and the Mbe Mountain Wildlife Sanctuary (MMWS) (Omoregie *et al*., 2020). These protected areas are connected to forest ecosystems extending into Cameroon, allowing seasonal elephant movements through transboundary forest corridors while also increasing interactions with neighboring farming communities (Ofuya *et al*., 2022). Communities including Bamba, Abo-Mkpang, Bashu, Bukalum, and Kanyang have experienced repeated incidents of crop raiding over the years, particularly affecting cassava, banana, plantain, maize, cocoyam, and yam farms located close to forest boundaries. Habitat fragmentation, agricultural expansion, and the loss of traditional movement corridors have increased the frequency of elephant incursions into farmland, resulting in substantial livelihood losses and escalating tensions between local communities and wildlife. Conservation of the landscape is supported through collaborative efforts involving the Cross River National Park, the Community Association of the Mbe Mountains (CAMM), the Cross River State Forestry Commission, and the Wildlife Conservation Society (WCS), which implement anti-poaching patrols, habitat protection, environmental education, and community-based conservation programs. Despite these interventions, human–elephant conflict remains one of the most persistent conservation and livelihood challenges in the landscape, highlighting

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the need for context-specific strategies that balance elephant conservation with the socioeconomic well-being of local communities. These anthropogenic pressures restrict elephant movement, forcing them into closer contact with human settlements as they navigate between protected forest patches (Dunn *et al*., 2014).

The Guinean Forests of West Africa, within which the Cross River region lies, are among the world's most threatened biodiversity hotspots (Mittermeier *et al*., 2004). Local communities depend heavily on these forests for food, fuel, and raw materials, yet the stress of rural development and population growth is degrading the very ecosystems they rely on. The rise in HEC in Cross River State is a direct result of agricultural settlements expanding into elephant migration corridors (World Wildlife Fund, 2022). In communities like Bamba, Abo Mkpang, and Basu, farmers practice subsistence agriculture, growing staples such as cassava, maize, and plantains When elephants enter these farmlands in search of water and forage, the resulting crop depredation causes acute financial hardship and threatens Local Food Security (LFS). These economic losses often drive farmers to take punitive actions, such as laying snares or using poison, creating a cycle of violence that undermines conservation efforts (Sitati *et al*., 2005)

The socioeconomic impact of HEC extends beyond immediate financial loss to include psychological stress and the erosion of social cohesion. Farmers living in constant fear of raids may experience decreased well-being and a loss of trust in conservation authorities, especially when they feel excluded from decision-making processes (Schüßler *et al*., 2018). Furthermore, the lack of effective, community-based conflict management strategies has left both people and wildlife vulnerable. Identifying the timing, frequency, and specific crops most susceptible to raids is essential for developing targeted mitigation interventions (Galley *et al*., 2024). Without data-driven compensation plans or alternative farming techniques, the conflict will continue to perpetuate a cycle of poverty and environmental degradation (Nyhus *et al*., 2016).

The core problem addressed by this study is the increasing intensity of HEC in the Cross River region, where habitat fragmentation has forced elephants and humans into a precarious struggle for space. This issue is exacerbated by the lack of a defined management strategy that incorporates local perspectives and needs. The justification for this research lies in the urgent necessity to protect the critically endangered *Loxodonta cyclotis* while simultaneously safeguarding the livelihoods of rural farming communities. By quantifying crop damage and understanding local attitudes, this study provides the data needed to design inclusive, sustainable mitigation measures. Consequently, the general objective of this study was to evaluate human–elephant conflict and its implications for local livelihoods and elephant conservation in communities surrounding the Mbe Wildlife Sanctuary and the Okwangwo Sector of Cross River National Park, Cross River State, Nigeria, to propose workable solutions that balance human welfare with wildlife preservation.

Methods and methods

Study area

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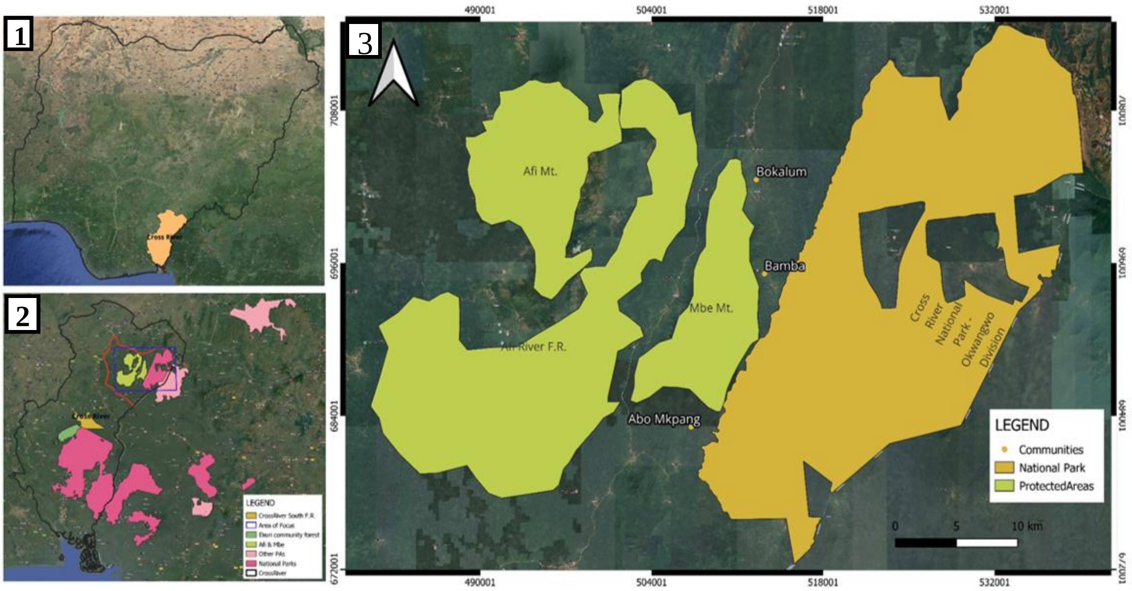
The study was conducted within two key protected areas in Boki Local Government Area, Cross River State, Nigeria: Mbe Mountains Wildlife Sanctuary (MMWS) approximately 85 km^2 and the Okwangwo Division of Cross River National Park (CRNP) approximately 640 km^2. Mbe Mountains Wildlife Sanctuary is located in the southwestern part of Boki LGA, lying approximately between latitudes 5°55′N and 6°10′N and longitudes 8°40′E and 9°00′E (WCS 2020).



Map 1: Map of Nigeria showing Cross River State in the South
Map 2: Map of Cross River State and part of Western Cameroon showing Protected Areas (PAs) around the region
Map 3: Part of Boki LGA with PAs, study area and communities

FIG. 1: Map of the study area

The sanctuary covers about 250 km² of predominantly montane and submontane forest habitat, characterized by rugged terrain with elevations ranging from 500 m to over 1,700 m above sea level. The climate is tropical with annual rainfall exceeding 3,500 mm and a distinct wet season from March to November (Ayuk & Eniang, 2018). The Okwangwo Division of Cross River National Park, located to the northeast of MMWS, spans approximately 1,000 km² between latitudes 6°05′N and 6°28′N and longitudes 9°02′E and 9°27′E (Ayuk & Eniang, 2018). It was established in 1991 from the amalgamation of several forest reserves and is recognized for its diverse lowland and submontane rainforests. The area experiences heavy rainfall between 3,000 mm and 3,800 mm annually and supports populations of forest elephants, Cross River gorillas (*Gorilla gorilla diehli*), and various other wildlife species. Both sites are surrounded by communities with high levels of interaction with wildlife, particularly elephants, resulting in frequent human-elephant conflict (HEC) manifested as crop raiding and property damage. The study specifically focused on communities within the buffer zones of these protected areas, including the Bamba community (Okwangwo) and nearby villages around the Mbe Mountains (Mojeed *et al*., 2024).

Research Design and Data Collection

To comprehensively evaluate the dynamics of human-elephant conflict (HEC), this study employed Convergent Parallel Design, a mixed-methods approach, integrating quantitative and qualitative data collection and analysis (Creswell & Poth, 2018). The research was conducted over a five-month period from August to December 2025. This timeframe commenced with a reconnaissance survey and a pilot study to identify the most affected areas within the Okwangwo Division of the Cross River National Park and the Mbe Mountain Wildlife Sanctuary. Based on these preliminary findings, four communities namely; Bashu 1, Bashu 2, Abo-Mkpang, and Bamba were selected for in-depth study, representing a 44.4% sampling intensity of the surrounding settlements (Table 1).

A purposive sampling technique was used to identify these communities, specifically targeting those with documented histories of frequent elephant crop raids as confirmed by park incident reports and local conservation leaders. Within these communities, a total of 159 questionnaires were administered, reflecting a 1.5% sampling intensity of the total household population. Households were selected using simple random sampling to ensure representativeness (Digun-Aweto, 2024), while a non-probability snowballing method was utilized to specifically locate farmers who had recently experienced rare or severe conflict incidents.

The primary data collection tool consisted of a standardized structured questionnaire, pre-tested for reliability (Kumar, 2019), which captured demographic profiles, elephant raid frequencies, crop types affected, and the economic burden on households. To complement the quantitative data, Key Informant Interviews (KIIs) were held with representatives from the Wildlife Conservation Society and the Cross River Forestry Commission to gather institutional perspectives on HEC policies (Okonkwo & Ezealor, 2014). Additionally, Focus Group Discussions (FGDs) were conducted with segmented groups of men, women, and youth to capture nuanced community attitudes and diverse coping mechanisms.

Field observations were conducted to verify reported incidents, documenting physical evidence such as dung, footprints, and vegetation damage. GPS coordinates of these conflict hotspots were recorded for spatial mapping (Barnes, 1996). Secondary data were integrated from NGO reports and park patrol logs to provide historical and ecological context.

Data analysis

Quantitative and qualitative data were analyzed using R statistical software (R Core Team, 2021), with relevant packages for statistical and spatial analyses, including leaflet for mapping and visualization (Cheng et al., 2021). Geographic coordinates were referenced to WGS 84 (EPSG:4326), while spatial analyses were conducted in UTM Zone 32N (EPSG:32632).

Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarise respondents' socio-demographic characteristics, crop damage, crops affected, community perceptions, mitigation strategies, and economic impacts. Chi-square tests were used to examine associations among categorical variables, including factors influencing

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crop-raiding patterns, community perceptions, and mitigation strategies. One-way ANOVA and Kruskal–Wallis tests were used to compare crop losses among communities where appropriate. Spatial analyses, including buffer analysis, Euclidean distance, and Moran's I, were used to assess farm proximity to protected areas and identify human-elephant conflict hotspots. Qualitative responses from open-ended questions were analyzed using thematic content analysis by coding similar responses into themes that complemented the quantitative findings. Statistical significance was assessed at $p < 0.05$.

Table 1: Population of villages selected for the study

LGA	Villages	Total (1991)	2025 Projection (3.2%)	2.0 % sampling intensity
Boki	Abo Mkpang	651	1900	38
	Bamba	666	1944	39
	Bashu 1	435	1269	25
	Bashu 2	972	2836	57
Total				159

Adopted and modified from National Population Commission Census Result of 1991
Note: 2025 population was obtained using the formulae.
$P_n = P_o (1 + r)^n$
Where; P_n = Estimated population, P_o = Initial population/population under consideration
r = growth rate, n = number of years estimated

Results

Socio-Economic and Demographic Characteristics of Respondents

The socio-demographic characteristics of the respondents are presented in Table 2. The respondents were predominantly male (70.44%), while females accounted for 29.56%. Most participants were between 28 and 37 years of age (52.20%) with mean and standard deviation of 39.2±9.60 years, followed by those aged 38–47 years (25.79%), indicating that the majority belonged to economically active age groups. Most respondents were married (77.99%). In terms of educational attainment, 50.94% had secondary education, 22.01% had tertiary education, and 10.69% had no formal education. Farming was the primary occupation for 88.68% of the respondents, reflecting the agricultural nature of the study area. Additionally, the mean and standard deviation number of years respondent had lived in their communities was 34.6±11.9 years with 90.57% had lived in the area for more than 20 years, suggesting that they were familiar with the local environment and its human–wildlife interactions.

Table 2: Socio-Economic and Demographic Characteristics of Respondents

Variable	**Category**	**Frequency**	**Percentage**
Gender	Female	47	29.56
	Male	112	70.44
Age	18-27	5	3.14
	28-37	84	52.83
	38-47	41	25.79
	48-57	15	9.43
	58-67	11	6.92
	68 Above	3	1.89
Marital Status	Married	124	77.99
	Single	33	20.75
	Widow	2	1.26
Education Level	Secondary	81	50.94
	Tertiary	35	22.01
	Primary	26	16.35
	No Formal Education	17	10.69
Occupation	Farmer	119	74.84
	Farmer Other	22	13.84
	Farmer Civil servant	8	5.03
	Other	3	1.89
	Trader Other	3	1.89
	Civil servant	2	1.26
	Farmer Trader	2	1.26
Number of Years living in Area	0-10 years	9	5.66
	11-20 years	6	3.77
	21-30 years	39	24.53
	31-40 years	76	47.8
	41-50 years	18	11.32
	Over 50 years	11	6.92
Total		**159**	**100.00**

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Frequency and Extent of Elephant-Induced Crop Damage

The frequency and cause of damage, the study found that human-elephant conflict is a constant reality, with 100% of respondents reporting elephant visits. The mean and standard deviation crop loss of 82.1±8.11%. These interactions follow a distinct seasonal pattern, with a peak occurring between May and July when approximately 68% of conflicts are recorded. Statistical testing through Chi-square (X^2 = 39.69, $p < 0.01$) and Kruskal-Wallis analyses confirmed that the frequency of these visits is significantly influenced by the geographic proximity of farms to protected areas (Table 3). An additional Chi-square test (X^2 = 89.019, $p < 0.01$) further established the significant association between elephant presence and the frequency of damage reported.

Table 3: Descriptive Statistics for Conflict Frequency and Extent

Variable	**Significant Categories**	**Frequency (%) / Mean ± SD**	**Remark**
Crop Loss Severity	61–80% loss	50.31%	Validates H_{01} rejection
	81–100% loss	47.80%	Confirms catastrophic impact
Average Annual Crop Loss (%)		82.10 ± 8.11	Catastrophic impact on livelihoods
Peak Conflict Months	May	20.81%	Increasing seasonal concentration
	June	23.86%	Critical seasonal concentration
	July	23.86%	Critical seasonal concentration
Elephant Visit Frequency	Occasionally	62.89%	Persistent, recurring problem
	Monthly	35.22%	A significant portion face regular raid

Crop Vulnerability and Economic Impact

The results in Table 4 indicates that elephant crop raiding is selective rather than random, and this is supported by significant inferential evidence (X^2 = 113.43, $p < 0.01$). There is also a clear hierarchy of vulnerability, with a high statistical preference for cocoa (27.19%) and plantain (26.67%). While the types of crops targeted vary, ANOVA results (F = 1.473, p = 0.224) demonstrate that the overall percentage of crop loss is uniformly high across all surveyed communities, with averages ranging from 80.7% in Bashu 2 to 83.9% in Bamba.

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Community perceptions, attitudes, and coping strategies

Community perception, 55.97% of respondents view elephants as dangerous pests, and fire emerged as the most prevalent coping strategy, utilized by 44.36% of the population (Table 5). However, the relationship between perception and action presented conflicting results; while a significant association was found regarding the combined number of mitigation strategies used ($X^2 = 15.588$, $p < 0.01$), the primary coping strategy analysis showed no significant relationship ($X^2 = 2.2704$, $p > 0.05$) (Table 6). This suggests that the choice of a primary deterrent is likely influenced by factors such as cost or accessibility rather than personal attitude alone.

Efficacy of Existing Mitigation Strategies

The perceived efficacy of existing mitigation strategies (Table 7) is notably low, as 100% of respondents reported that their current methods are either entirely ineffective (45.28%) or only partially successful (54.72%). This subjective assessment was statistically validated by a Chi-square test showing no significant relationship between the perceived effectiveness of strategies and the actual frequency of elephant visits ($X^2 = 1.5434$, $p > 0.05$). These findings underscore that the methods currently employed are failing to achieve a measurable reduction in conflict encounters.

Table 4: Crop Vulnerability to Elephant Raids

Variable	Category	Result (%)	Remark
Community crop loss	Abo mkpang	83.0	Consistent high impact
	Bamba	83.9	Highest among communities
	Bashu 1	81.2	Slightly lower but severe
	Bashu 2	80.7	Slightly lower but severe
Crop type	Cocoa	27.19	Primary target; major economic impact
	Plantain	26.67	Secondary target; food security impact
	Cassava	13.68	Moderately affected
	Yam	9.65	Least affected among major crops

Table 5: Descriptive summary of perceptions and primary coping strategy

Variable	**Category**	**Percentage**	**Remark**
Perception of Elephants	Dangerous Pests	55.97%	Predominant negative view
	Other/Neutral	44.03%	Minority less negative view
Primary Coping Strategy	Use of Fire	44.36%	Most common method
	Other Methods	55.64%	All other strategies combined

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Table 6: Chi-square analysis of Perception and coping strategy

Analysis Type	Statistical Test	Test Statistic	p-value	Interpretation
Combined Mitigation	Chi-square	$X^2 = 15.588$	0.00041	Significant association
Primary Coping Strategy	Chi-square	$X^2 = 2.2704$	0.1319	No significant association

Table 7: Perceived effectiveness of current mitigation strategies

Perceived effectiveness	Percentage	Remark		
Not effective	45.28%	Nearly half find methods wholly inadequate		
Partially effective	54.72%	The remainder find methods only somewhat useful		
Hypothesis	Statistical Test	Test Statistic	p-value	Verdict
H_{04}	Chi-square Test	$X^2 = 1.54$	0.4622	Supported

Spatial Analysis of Affected Farms and Proximity to Protected Areas

Spatial analysis revealed that the mean distance from farms to protected area boundaries is only 0.28 km, with a minimum recorded distance of 0 km (Table 8). The data showed that 90% of surveyed farms fall within a high-risk 1-kilometer buffer, while 85% are situated within an extreme risk zone of less than 500 meters. Buffer zone analysis indicated that the Okwangwo Division influences 100% of the surveyed farms within a 3-kilometer radius. Finally, spatial autocorrelation through Moran's I statistic (0.5648, $p < 0.01$) confirmed that these conflict incidents are significantly clustered, identifying nine distinct HEC hotspots across the study area.

Table 8: Community-level HEC risk profile

Community	Number of Farms	Mean Distance (km)	High-Risk Farms (%)	Hotspot Farms (%)
Abo-Mkpang	10	0.53	60.0	40.0
Bamba	19	0.22	73.7	26.3
Bashu	11	0.14	100.0	0.0

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Discussion

Socio-Economic Context and the Scale of Conflict

The findings indicate that most respondents had lived in the study area for many years and depended primarily on agriculture for their livelihoods. These characteristics provide important context for understanding the widespread occurrence of human-elephant conflict in communities surrounding the Okwangwo Division of Cross River National Park and Mbe Mountains Wildlife Sanctuary, as households with long-term residence and high dependence on farming are more likely to experience the impacts of recurrent crop-raiding incidents. The finding highlighted that over 90% of respondents have resided in the area for more than two decades suggests a deeply established agrarian society whose livelihood strategies have become increasingly incompatible with elephant conservation as land use intensifies. The high experience of elephant raids among respondents indicates that HEC is no longer a peripheral issue but a systemic threat to the socioeconomic status of the region. While research across Africa consistently demonstrates that communities adjacent to protected areas bear disproportionate conservation costs, the average crop loss of over 80% observed in this study is among the higher values reported in the African human–elephant conflict literature. For example, studies from Kenya and Tanzania have reported crop losses in the range of approximately 40–60% (Mumby & Plotnik, 2018). Because these estimates were generated under different ecological and methodological conditions, they should be regarded as indicative rather than directly comparable. This discrepancy suggests that the Cross River region is experiencing an exceptionally high intensity of conflict, likely exacerbated by the high dependence on subsistence farming and the shrinking buffers between human and elephant domains. In many other African landscapes, there are transition zones or mosaic land-use patterns that allow for some degree of spatial separation; however, in the Cross River region, the direct interface between high-density agricultural activity and core elephant habitat creates a zero-sum game for resources (Fuashi *et al*., 2017). The high level of reported crop loss indicates that human-elephant conflict has substantial livelihood implications for farming households in the study area. Given that many respondents depend on agriculture as their primary source of livelihood, recurrent crop damage is likely to reduce agricultural productivity and household economic security. Similar observations have been reported in other human-elephant conflict studies, where crop losses have been associated with increased economic burdens on affected communities (Nyhus, 2016).

Furthermore, the long-term residency of many respondents indicates that they have experienced human-elephant conflict over an extended period. Combined with the high level of reported crop loss, this finding suggests that the conflict represents a persistent livelihood challenge for affected communities. Similar observations have been reported elsewhere, where prolonged human-elephant conflict has influenced community perceptions of conservation initiatives (Gunawardana, 2024). Although the present study did not assess community attitudes toward conservation authorities or evaluate specific mitigation interventions, the reported extent of crop damage and the limited institutional support identified by respondents suggest that management approaches aimed at reducing the socioeconomic impacts of crop raiding, including compensation mechanisms, community-based support programs, or livelihood diversification initiatives, may warrant further investigation in the study area

Temporal Dynamics and Edge Effects

The strong relationship between farm proximity to protected areas and the frequency of raids reinforces the well-documented edge effect in human-wildlife conflict. This spatial pattern is consistent with observations by Sitati *et al*. (2005), where conflict probability increases exponentially as the distance to the park boundary decreases. In the Cross River landscape, the average distance of 0.28 km from farms to the forest edge effectively places the entire agricultural community within the path of foraging elephants. This lack of a physical or biological buffer means that elephants do not have to expend significant energy to transition from natural forage to high-calorie agricultural crops. This phenomenon is often referred to as optimal foraging at the interface, where the boundary of the protected area acts as a buffet line for the mega-herbivores (Branco *et al*., 2019).

Furthermore, the distinct seasonal concentration of raids during the mid-year months, particularly May through July aligns perfectly with the peak ripening periods of primary staples and cash crops in South-South Nigeria. This temporal clustering mirrors patterns identified by Chiyo *et al*. (2010) in the Amboseli ecosystem, where male elephants, in particular, engage in high-risk, high-gain foraging strategies during specific crop cycles. The timing suggests that elephant foraging activity may increase in response to seasonal changes in food availability, enabling individuals to exploit nutritionally valuable crops before the onset of the drier months or during periods of increased energetic demand. From a management perspective, the observed seasonal concentration of crop-raiding incidents suggests that targeted seasonal monitoring and community-based mitigation strategies may warrant further evaluation. The predictability of raid occurrence may provide an opportunity for conservation authorities to prioritize surveillance and conflict-mitigation efforts during high-risk periods rather than distributing limited resources uniformly throughout the year. However, the effectiveness of such approaches was not assessed in this study and requires further investigation. However, as noted by Ndem *et al*. (2025), the success of seasonal interventions depends heavily on real-time intelligence and the ability of park rangers to work in tandem with community scouts. In the absence of such coordination in Cross River, the seasonal peak remains a period of unmitigated disaster for local farmers.

Crop Selectivity and Economic Vulnerability

The observed pattern of crop damage, particularly the disproportionate damage to cocoa and plantain, indicates selective crop use by African forest elephants (Loxodonta cyclotis). Similar crop selection patterns have been reported in previous studies, which suggest that elephants preferentially

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utilize crops with relatively high nutritional value, moisture content, or mineral availability compared with surrounding natural forage (Poulsen *et al.*, 2018; Mumby & Plotnik, 2018). However, the present study did not evaluate the nutritional drivers of crop selection; therefore, these mechanisms should be regarded as plausible explanations rather than confirmed causes.

The concentration of damage on cocoa and plantain has important implications because these crops represent major livelihood resources for households in the study area. Although this study did not assess household income, debt, or other long-term socioeconomic outcomes, substantial damage to these crops is likely to reduce agricultural productivity and may increase the economic vulnerability of affected households. Future studies integrating ecological and socioeconomic data are needed to quantify these broader livelihood impacts.

Despite differences in the types of crops damaged, the overall level of reported crop loss remained consistently high across the surveyed communities. This finding differs from studies that reported greater spatial variation in crop damage among communities (Zeng *et al.*, 2023). The discrepancy may reflect differences in elephant population density, landscape configuration, farm distribution, study design, sampling approaches, or local environmental conditions between study areas. These factors were not examined in the present study but represent important avenues for future research.

This suggests that the conflict is no longer a series of random incidents but a fundamental characteristic of the current landscape. As elephants habituate to these high-value food sources, their behavior may become even bold. According to Chama et al. (2025), once elephants have tasted high-energy crops like plantain and cocoa, they are likely to bypass natural forage entirely, leading to a permanent change in their ranging patterns. This makes the problem-elephant narrative less relevant, as the entire local population may become crop-dependent.

Perceptions and the Inefficacy of Mitigation

A notable disconnect was observed between community perceptions of elephants and the mitigation measures adopted in the study area. Although most respondents perceived elephants as dangerous pests, these perceptions were not significantly associated with the primary deterrent methods used. This finding suggests that mitigation behavior may be influenced by factors beyond individual attitudes. Consistent with the Theory of Planned Behavior, behavioral decisions are shaped by the combined influence of attitudes, subjective norms, and perceived behavioral control (Ajzen, 1991). In the present context, the continued use of particular deterrent methods may reflect constraints in access to financial resources, technical support, and feasible alternatives rather than attitudes alone (Tsegaye *et al.*, 2023).

The continued reliance on fire and noise-making, despite respondents' perceptions that these methods have limited effectiveness, reflects the constrained mitigation options available to farming households. Rather than indicating confidence in these measures, their continued use may be attributed to their low cost, ease of implementation, and the

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absence of accessible alternative interventions. These findings suggest that local responses to human-elephant conflict are constrained by limited technical, financial, and institutional support, highlighting the need to evaluate practical and locally appropriate mitigation strategies.

Previous studies have reported that elephants may become habituated to repeated acoustic and visual deterrents when these are used without reinforcement (Abdullah et al., 2025). Although the present study did not assess elephant behavioural responses directly, the perceived low effectiveness of fire and noise-making reported by respondents is consistent with this explanation. Further behavioural studies are required to determine whether similar patterns occur in the Okwangwo Sector and Mbe Mountains Wildlife Sanctuary.

Institutional Gaps and Spatial Risk

The findings indicate limited institutional support for communities affected by human-elephant conflict in the study area. This limited support may reduce the capacity of households and local institutions to respond effectively to crop-raiding incidents. In contrast, some human-elephant conflict management programmes in other African countries have incorporated mechanisms such as compensation, insurance, or other forms of community support to help reduce the socioeconomic impacts of wildlife-related losses (Nyhus, 2016). However, the present study did not assess the effectiveness of such interventions, and their applicability to the study area requires further evaluation. In the absence of such frameworks, the cost of conserving a critically endangered global icon is being paid almost exclusively by the poorest farmers in Cross River State. This institutional neglect contrasts sharply with integrated models used in Southern Africa, where community-based natural resource management (CBNRM) allows local people to benefit from wildlife tourism, which offsets crop losses (Heffernan, 2022).

From a spatial perspective, the extreme proximity of farms to protected boundaries documented as zero meters in some cases creates a frontline vulnerability that is statistically clustered into nine distinct hotspots. The Moran's I analysis confirming these hotspots provides a scientific mandate for spatial prioritization. Rather than attempting to protect every kilometer of the park boundary, authorities could focus on these specific corridors of conflict. However, as Wall et al. (2021) point out, spatial hotspots are often dynamic; as one area is defended, elephants may simply shift their raids to the next undefended farm. Therefore, the spatial data must be used not just for fencing, but for land-use planning. The fact that 85% of farms are within 500 meters of the park boundary suggests that the current agricultural layout is fundamentally unsustainable. Without a buffer zone where low-palatability crops (like ginger or chili) are grown, the direct interface between cocoa and elephants will continue to result in catastrophic losses (Hoare, 2012).

Conclusion and Recommendation

This study found that human-elephant conflict is a persistent and widespread challenge in communities surrounding the Okwangwo Sector of Cross River National Park and Mbe Mountains Wildlife Sanctuary. The high level of reported crop loss, the concentration of farms close to protected area boundaries, and the dependence of households on subsistence agriculture indicate that the conflict has important implications for both rural livelihoods and the conservation of the critically endangered African forest elephant (*Loxodonta cyclotis*). The findings further suggest that the proximity of agricultural activities to protected areas is an important factor influencing the occurrence of crop-raiding incidents.

The study also found that respondents perceived commonly used traditional deterrent methods to be largely ineffective in preventing elephant incursions. In addition, respondents reported limited institutional support for mitigating the impacts of crop damage. Although the effectiveness of specific management interventions was not evaluated in this study, these findings highlight the need for coordinated approaches that address both community livelihoods and wildlife conservation.

Based on these findings, several management actions may warrant consideration and further evaluation. First, government agencies and conservation partners could explore appropriate mechanisms for supporting households affected by crop damage, including compensation or community-based risk-sharing schemes, subject to feasibility and sustainability assessments. Second, the identified high-incidence communities may provide suitable locations for prioritizing monitoring and mitigation efforts where resources are limited. Third, the potential use of non-palatable buffer crops and other locally appropriate deterrent measures along farm–forest interfaces should be evaluated through pilot studies before wider implementation. Finally, future research should assess the effectiveness, cost implications, and community acceptance of these interventions to provide stronger evidence for policy and management decisions aimed at promoting sustainable human-elephant coexistence in the study area

Data availability

The data set will be available on request

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