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Community preferences for mitigation strategies in human-wildlife conflict: A comparative study of human-elephant and human-leopard conflicts in Tamil Nadu

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Abstract

Human-wildlife conflict (HWC) represents a critical challenge to both biodiversity conservation and sustainable rural development, particularly in regions adjacent to wildlife habitats. This study investigates community-level preferences for conflict mitigation strategies in zones experiencing Human-Elephant Conflict (HEC) and Human-Leopard Conflict (HLC). Using structured surveys conducted with 30 respondents (15 each from HEC and HLC areas), 15 mitigation strategies were evaluated across five priority levels. A Chi-square test of homogeneity was employed to assess statistical differences in preferences between the two conflict zones. Results reveal significant variation in strategy prioritization: physical barriers (e.g., trenches, fences, water holes) were highly favored in HEC areas, while technological interventions (e.g., patrolling, early warning systems, smart surveillance) were prioritized in HLC zones. Traditional deterrents and conflict response teams were moderately accepted across both conflict types but lacked statistical significance. Education and cultivation-based measures were not much prioritized, reflecting skepticism toward long-term, non-tangible solutions. The findings underscore the need for tailored, context-specific mitigation frameworks that integrate structural, technological, and traditional approaches in alignment with community priorities. This research contributes to the development of inclusive, adaptable, and sustainable strategies for mitigating human-wildlife conflict

Keywords: Human-wildlife conflict, Human-elephant conflict, Human-leopard conflict, Conflict mitigation strategies, Community preferences, Chi-Square test, Wildlife conservation, Physical barriers, Technological interventions

Introduction

Human-wildlife conflict (HWC) poses one of the most significant threats to biodiversity conservation and sustainable human development, particularly in regions where communities live adjacent to wildlife habitats. This conflict typically arises when wildlife needs intersect with human activities such as farming, livestock rearing and settlement expansion, leading to negative outcomes for both humans and animals (Nyhus, 2016; Inskip and Zimmermann, 2009) [14, 10]. With growing anthropogenic pressures and habitat fragmentation, such conflicts have escalated in frequency and intensity across the globe, particularly in South and Southeast Asia, Sub-Saharan Africa and parts of Latin America (Distefano, 2005; Barua *et al.*, 2013) [4, 2].

Two prevalent types of HWC are Human-Elephant Conflict (HEC) and Human-Leapord Conflict (HLC). HEC is notably destructive due to the size, intelligence and foraging behavior of elephants, often resulting in large-scale crop loss, infrastructure damage, and human fatalities (Fernando *et al.*, 2005; Sukumar, 2003) [5, 19]. Conversely, HLC usually involves carnivores such as leopards, hyenas, or wolves preying on domesticated animals, threatening the livelihood security of pastoralist and agro-pastoralist communities (Treves and Karanth, 2003; Dickman, 2010) [20, 3]. The socio-economic consequences of these conflicts can be severe, fostering resentment toward wildlife and undermining conservation efforts (Madden, 2004) [13].

A wide range of conflict mitigation strategies has been proposed and implemented globally, including physical barriers (e.g., electric fencing, trenches), community-based interventions (e.g., education, sensitization), technological tools (e.g., early warning systems, smart surveillance) and habitat management approaches (Barua *et al.*, 2013; Graham *et al.*, 2010) [2, 7]. However, the effectiveness of these strategies is deeply influenced by local community

perceptions, cultural acceptance, economic feasibility, and ecological appropriateness (Ogra, 2008; Kansky and Knight, 2014) [15, 11]. Despite this, there remains a gap in understanding how different communities, particularly those affected by distinct types of HWC, prioritize and evaluate various mitigation options.

This study aims to bridge that gap by examining whether preferences for mitigation strategies significantly differ between communities facing HEC and those facing HLC. It also seeks to fill that gap by analyzing whether community preferences for conflict mitigation strategies significantly differ between HEC and HLC zones

Methodology

A structured survey methodology was employed across communities experiencing HEC and HLC. The sample consisted of 30 respondents: 15 from each conflict zone. A total of 15 mitigation strategies were evaluated, with participants assigning them one of five priority levels: Not a Priority, Low Priority, Neutral, High Priority, or Essential Priority.

Chi-Square Test of Homogeneity

The chi-square test evaluates whether observed frequencies across categories differ significantly between two or more groups. In this study, it was used to compare how the two conflict-affected communities rated different mitigation strategies and are presented in Table 1.

$$\chi^2=\sum(Oi-Ei)^2/Ei$$

Where,

Oi= observed frequency in the i^{th} cell

Ei = expected frequency in the i^{th} cell

Results and Discussion

Through the application of a chi-square test of homogeneity, the research identifies statistically significant and non-significant differences in strategy prioritization, offering valuable insights into context-specific conflict management presented in Table 1.

Physical Barriers for Human-Elephant Conflict

Respondents prioritized infrastructural interventions like establishment of fodder banks and water holes, clearing of bushes, construction of watch towers, trenching, and implementation of fences as essential strategies to address HEC. These methods were statistically significant (χ^2 values ranging from 22.29 to 30; $p \leq 0.01$), affirming their perceived effectiveness. Such strategies are well-documented in elephant conflict mitigation literature. For instance, Fernando *et al.* (2008) [6] emphasize that provisioning water and fodder inside forested areas helps reduce elephant movement into human settlements. Similarly, Hoare (2012) [9] noted that electric fences and trenches can reduce crop raiding if maintained well, although community participation in maintenance is vital. The preference for physical deterrents also aligns with the findings of Gubbi *et al.* (2014) [8], who identified that HEC-prone areas often rely more on perimeter defenses than behavioral deterrents, given the destructive capacity and predictability of elephant movement patterns.

Technology and Monitoring for Human-Leopard Conflict

In contrast, strategies like tightening patrolling teams ($\chi^2=16.69$, $p<0.01$), early warning systems with LED flashers ($\chi^2=11.95$, $p<0.05$), wildlife information networks using SMS/voice alerts ($\chi^2=14.73$, $p<0.05$), and smart tag-based vigilance systems ($\chi^2=26.57$, $p<0.01$) were strongly associated with HLC. Leopards, being elusive and adaptable to human-dominated landscapes, are less deterred by static barriers and more effectively managed through monitoring and proactive alert systems. Athreya *et al.* (2013) [1] support this view, advocating for real-time communication and responsive patrolling in mitigating HLC. Their study in Maharashtra, India, demonstrated that leopard attacks often occur during transitional hours (dawn/dusk), when alert systems and vigilant patrolling are most effective. Moreover, Treves and Karanth (2003) [20] argue that community trust in wildlife authorities increases with access to timely, accurate information, reinforcing the effectiveness of wildlife information networks.

Role of Traditional Mitigation Measures

Although strategies like traditional deterrents (e.g., scarecrows, crackers, loudspeakers), non-lethal deterrents, and conflict response teams did not show statistically significant associations with a specific conflict type, they were widely used and accepted by communities across both HEC and HLC regions. This corroborates the findings of Ravenelle and Nyhus (2017) [17], who argue that traditional methods are often the first line of defense in rural areas due to their low cost, availability, and cultural familiarity. These practices are especially useful in adaptive conflict management, where communities employ a combination of techniques based on immediate need and past experiences. Furthermore, Barua *et al.* (2013) [2] emphasize that while traditional measures might not be effective in isolation, their integration with modern technologies can significantly enhance outcomes.

Low Priority for Education and Cultivation-based Strategies

Interestingly, strategies such as community education on HWI, sensitization programs, and advisories on avoiding banana cultivation received low prioritization or were deemed non-essential, despite their theoretical value in long-term conflict mitigation. This might reflect implementation fatigue or a perception that such interventions lack immediate, tangible benefits, especially in high-conflict zones. Zimmermann *et al.* (2005) [22] and Dickman (2010) [3] note that education-only interventions often fail unless coupled with practical support and visible change in conflict outcomes.

Towards an Integrated Conflict Mitigation Framework

The results underscore the necessity of adopting conflict-type-specific strategies:

- For elephants, infrastructural and landscape-based modifications are effective.
- For leopards, technology-driven monitoring and early-warning systems are preferred.
- Across both, community-led traditional methods still hold substantial value.

An integrated strategy that combines structural, technological, and behavioral interventions, while considering socioeconomic realities, is vital for long-term sustainability. As Redpath *et al.* (2013) [18] propose in their conflict transformation framework, multi-stakeholder participation, transparency, and adaptability are key for mitigating human-wildlife conflict.

Community Education on Human-Wildlife Interaction (HWI)

Although community education on HWI is frequently recommended as a long-term mitigation measure, it was not prioritized by respondents in either HEC or HLC zones. This strategy showed no statistically significant association with either conflict type ($\chi^2 = 0.37$ NS). This could be due to a perception gap where education is viewed as less immediately effective compared to physical deterrents or rapid-response interventions. In conflict-intensive regions, people often prefer visible and tangible solutions over intangible educational efforts, especially when immediate livelihoods or safety are at stake (Dickman, 2010) [3]. Nyhus (2016) [14] stresses the role of education as a long-term behavioral change agent, although its impact may not be immediately recognized in high-conflict settings. Treves *et al.* (2006) [21] argue that while education fosters understanding, behavioral change requires incentives, community engagement, and trust.

Establishment of Conflict Response Teams

Conflict response teams comprising experienced rural or tribal individuals were moderately prioritized and more favored in HLC zones, but without statistically significant association ($\chi^2 = 6.32^{NS}$). These teams are trusted community figures, and while their formal recognition may be limited, they act as first responders in many areas. Communities may see them as supportive but insufficient without proper training or legal authority. Ogra and Badola (2008) [15] state that empowering local stakeholders leads to faster conflict response, but formal training and integration into wildlife management frameworks are critical. Barua *et al.* (2013) [2] highlight that inclusive governance mechanisms strengthen resilience to conflict

Adoption of Traditional Mitigation Measures

Measures such as using crackers, scarecrows, spotlights, loudspeakers, and bright-colored materials were moderately to highly valued but showed no significant association with specific conflict types ($\chi^2 = 3.59^{NS}$). However, these methods were employed consistently in both HEC and HLC zones. These techniques are easy to implement, culturally embedded, and cost-effective, making them accessible to low-income households. Although they may offer short-term relief, they are often seen as unreliable in the long run if used alone. Osborn and Parker (2003) [16] documented the widespread use of simple deterrents in Zimbabwe, emphasizing their role in adaptive conflict responses.

Implementation of Non-Lethal Deterrents (Acoustic, Light-Based, Agriculture-Based)

These methods received moderate to essential priority, particularly for HLC zones ($\chi^2 = 5.80^{NS}$). Though not statistically significant, their increasing acceptance highlights a shift towards humane conflict mitigation. Communities are gradually embracing non-lethal deterrents as alternatives to extreme actions like poisoning or retaliatory killing, particularly in response to awareness and conservation efforts. Konig *et al.* (2020) [12] note the growing preference for coexistence strategies using non-lethal technologies, especially where wildlife laws are strictly enforced.

Table 1: Community preferences for mitigation measures of human - wildlife conflicts

Strategies to combat Human wildlife conflict	Conflict type	Not a priority	Low priority	Neutral	High priority	Essential priority	Total N=15	χ^2 Chi-square	Mean square contingency	Co-efficient of mean square contingency
Community education on HWI	HEC	13 (86.66)	1 (6.67)	1 (6.67)	0	0	15 (100)	0.37 NS	0.0124	0.1109
	HLC	12 (80.00)	2 (13.33)	1 (6.67)	0	0	15 (100)			
Awareness and sensitization towards HWI	HEC	10 (66.67)	4 (26.66)	1 (6.67)	0	0	15 (100)	2.67 NS	0.0889	0.2857
	HLC	10 (66.67)	2 (13.33)	1 (6.67)	2 (13.33)	0	15 (100)			
Implementation of non-lethal wildlife deterrents such as acoustic, light based, agriculture based deterrents.	HEC	0	2 (13.33)	1 (6.67)	6 (40.00)	6 (40.00)	15 (100)	5.80NS	0.1935	0.4026
	HLC	0	0	2 (13.33)	2 (13.33)	11 (73.34)	15 (100)			
Establishment of Fodder bank/plantations and water holes for the animals	HEC	0	0	0	1 (6.67)	14 (93.33)	15 (100)	30**	1.000	0.7071
	HLC	10 (66.67)	4 (26.66)	1 (6.67)	0	0	15 (100)			
Clearing of bushes and tea plants in 10 m radius along the residential areas and roads	HEC	0	0	0	1 (6.67)	14 (93.33)	15 (100)	27**	0.9000	0.6882
	HLC	8 (53.33)	3 (20.00)	1 (6.67)	3 (20.00)	0	15 (100)			
Cultivation of Banana trees in the residential environment will attract elephants and hence the same may be avoided	HEC	8 (53.33)	3 (20.00)	3 (20.00)	1 (6.67)	0	15 (100)	2.8NS	0.0933	0.2922
	HLC	12 (80.00)	1 (6.67)	1 (6.67)	1 (6.66)	0	15 (100)			

Tightening the patrolling team and monitoring the same	HEC	1 (6.67)	2 (13.33)	3 (20.00)	6 (40.00)	3 (20.00)	15 (100)	16.69**	0.5563	0.5979
	HLC	0	0	0	1 (6.67)	14 (93.33)	15 (100)			
Early warning remotely mobile operated wildlife alert indicators with red LED flashing units	HEC	2 (13.33)	3 (20.00)	5 (33.34)	2 (13.33)	3 (20.00)	15 (100)	11.95*	0.3984	0.5338
	HLC	0	0	1 (6.67)	5 (33.33)	9 (60.00)	15 (100)			
Establishing conflict response team with experienced rural/tribal people	HEC	0	2 (13.33)	3 (20.00)	3 (20.00)	7 (46.67)	15 (100)	6.32^{NS}	0.2105	0.4170
	HLC	0	0	0	3 (20.00)	12 (80.00)	15 (100)			
Wildlife information network by initiating bulk SMS and voice call services about the wild animal presence and its movement to the local people	HEC	3 (20.00)	4 (26.67)	7 (46.66)	1 (6.67)	0	15 (100)	14.73*	0.4911	0.5739
	HLC	0	0	5 (33.33)	9 (60.00)	1 (6.67)	15 (100)			
Excavation of trenches to prevent entry of wild animals	HEC	0	0	0	2 (13.33)	13 (86.67)	15 (100)	22.29**	0.7429	0.6529
	HLC	0	1 (6.67)	11 (73.33)	2 (13.33)	1 (6.67)	15 (100)			
Construction of watch towers/guard houses	HEC	0	1 (6.67)	0	2 (13.33)	12 (80.00)	15 (100)	24.67**	0.8222	0.6717
	HLC	0	0	11 (73.33)	4 (26.67)	0	15 (100)			
Implementing fences such as beehive fence, solar fence, stone fence, barbed fence, yellow plastic sheet fence etc.,	HEC	0	0	2 (13.33)	2 (13.33)	11 (73.34)	15 (100)	23.14**	0.7714	0.6599
	HLC	2 (13.33)	1 (6.67)	12 (80.00)	0	0	15 (100)			
Smart tag-based vigilance system	HEC	10 (66.67)	4 (26.66)	1 (6.67)	0	0	15 (100)	26.57**	0.8857	0.6853
	HLC	0	0	6 (40.00)	6 (40.00)	3 (20.00)	15 (100)			
Adopting traditional mitigation measures such as crackers, spot-light, scare crow, cable wire, loud speakers, bright coloured clothes etc.,	HEC	0	0	0	3 (20.00)	12 (80.00)	15 (100)	3.59^{NS}	0.1196	0.3269
	HLC	0	0	0	8 (53.33)	7 (46.67)	15 (100)			

(Figures in Parentheses indicates percentage value; *p≤0.05, **p≤0.01

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