International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Living on the Edge: Understanding Human - Elephant Conflict in Keonjhar, Odisha

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Abstract: ***The coexistence of humans and elephants in the Indian state of Odisha has become increasingly strained, leading to a deepening crisis of human - elephant conflict (HEC). The rapid growth of state's human population, many developmental activities including mining and railway lines in the corridor escalating the conflicts. and encroached on traditional elephant habitats, the potential for confrontation between the two species has escalated, resulting in devastating consequences for both communities. This review article examines the key drivers and dimensions of HEC in Odisha in general and Keonjhar district in particular, including ecological, economic, and social factors that have contributed to the crisis. It explores the wide - ranging impacts of the conflict, from livelihood and economic disruptions to threats to human life and elephant conservation. The article also critically analyzes the various mitigation strategies and policy interventions implemented to address the problem, highlighting both their successes and the persistent challenges that continue to undermine their effectiveness. Finally, it identifies emerging issues, such as the impacts of climate change, that will shape the future trajectory of HEC management in the region. Ultimately, this review underscores the urgent need for a comprehensive, collaborative approach to resolving the human - elephant conflict in Keonjhar district of Odisha and preserving the delicate balance between human development and ecological conservation.***

Keywords: Human- Elephant Conflict, Odisha, Habitat Fragmentation, Mitigation Strategies, Policy Interventions, Environmental Stressors, Conservation

1. Introduction

The coexistence of humans and elephants in India has long been a delicate and complex relationship, shaped by cultural traditions, economic pressures, and the competing needs for land and resources. As India's population has grown rapidly over the past several decades, the once - balanced equilibrium between these two species has become increasingly strained, leading to a deepening crisis of human - elephant conflict (HEC) across many parts of the country (Bist, 2002; Sukumar, 2003).

Nowhere is this conflict starker than in the eastern state of Odisha, where the competing demands on land and resources have created a tinderbox of tension between the human and elephant populations. Odisha is home to the second largest elephant population in India, with an estimated 1, 976 elephants as of the most recent census in 2017 (Elephant Census, 2017). However, the state also has a large and growing human population, with over 41 million people as of 2018 (ST&SC D, M&BWD Govt. Odisha 2018). This demographic pressure, combined with the expansion of human settlements, agricultural lands, and infrastructure, has steadily encroached on traditional elephant habitats, forcing the great pachyderms into increasingly close and confrontational contact with local communities (Santiapillai & Jackson, 1990; Nath & Sukumar, 1998).

The Scope of Human - Elephant Conflict in India

Human - elephant conflict is not a new phenomenon in India - it is a challenge that has existed for centuries, rooted in the long history of coexistence between humans and elephants on the subcontinent. However, the scale and severity of the problem has escalated dramatically in recent decades, as India's human population has grown rapidly and economic development has accelerated, leading to unprecedented levels of habitat loss and fragmentation for the country's elephants (Sukumar, 1989; Lahiri - Choudhury, 1999).

According to data from the Ministry of Environment, Forest and Climate Change, India is home to approximately 30, 000 wild elephants, representing around 60% of the global Asian elephant population (Project Elephant, 2017). These elephants are concentrated in 14 of India's 28 states, with the largest populations found in the southern and northeastern regions of the country. States like Karnataka, Assam, and Kerala are known for their significant elephant populations and the concomitant HEC issues they face (Baskaran et al., 1995; Karanth & Gopal, 2005).

However, the problem of human - elephant conflict is not evenly distributed across India. Certain regions, such as the state of Odisha, have been particularly hard hit by the crisis, with devastating consequences for both human and elephant communities. In Odisha, the elephant population is estimated at around 1, 976 individuals, the second largest in the country after Assam (Elephant Census, 2017). Yet, this relatively large elephant population is compressed into an increasingly fragmented and diminished habitat, leading to frequent and often violent encounters with the state's growing human population (Nath & Sukumar, 1998; Pradhan & Rout, 2013).

Scenario of Human Elephant conflict in Keonjhar, Odisha

The human - wildlife conflict, particularly involving elephants, is on the rise in Champua, Barbil, and BJP range of Keonjhar district due to increased mining activities. The disturbance caused by mining by SAIL in the Karo - Karampada Elephant Corridor has disrupted the movement of elephants in this region, which is influenced by the River Baitarani, rail corridors, road networks, and rapid mining and industrialization.

Efforts are being made to reduce animal depredation and human - animal conflicts with the help of modern technology. The two elephant corridors, Karo - Karampada and Telkoi - Pallahara, will be restored with dense forest cover to provide safe passage for elephants. Habitats for tigers, leopards, and antelopes will be managed to facilitate their natural reintroduction, aiming to regain the region's past glory. The human resources involved in wildlife management will receive adequate training to handle the situation more professionally.

Elephants from Jharkhand state are migrating to the Keonjhar Division and becoming residents, leading to damage to agricultural crops in surrounding paddy fields. Encroachment for habitation and agricultural practices is taking place on a large scale in the B&JP Range and Ghatagaon Range of the Division.

The data on elephant and human deaths due to conflicts in the Keonjhar Division from 2018 - 19 to 2021 - 22 (until December) is provided in the following tables:

Table 1: Elephant Death for the year from 2018 - 19 to 2021 - 22 (December) in Keonjhar Division

Year	Number of cases	Major cause of death
2018 - 19	2	Due to shock arising from septicemia and train death
2019 - 20	6	Road accident, health issue
2020 - 21	8	Due to Electrocution and health issues
2021 - 22	6	Due to Electrocution and health issues

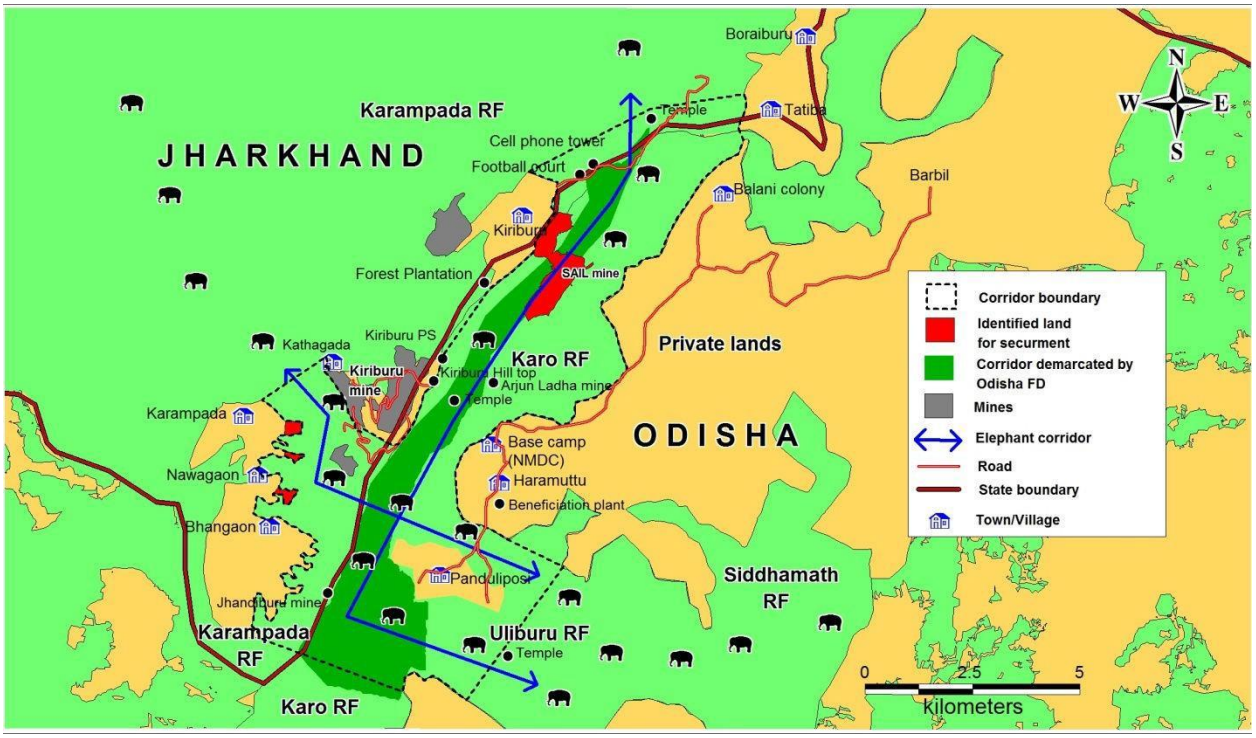
Source: Wildlife Division, Keonjhar

Table 2: Human death data for the year 2018 - 19 to 2021 - 22 (December) by Elephant

Year	Number of cases	Major cause of death
2018 - 19	7 (M - 4, F - 3)	Elephant attack
2019 - 20	8 (M - 2, F - 6)	Elephant attack
2020 - 21	4 (M - 3, F - 1)	Elephant attack
2021 - 22	10 (M - 8, F - 2)	Elephant attack

Source: Wildlife Division, Keonjhar

The management practices adopted in the Division include deploying anti - depredation squads, elephant trackers, anti - poaching squads, fire - fighting squads, and protection squads. Regular checking and fencing of transmission lines are carried out to prevent accidental electrocution of animals. Bird deflectors are provided on earthing conductors to prevent bird - hitting. Crop protection machans are constructed for farmers to protect crops. New technologies like early warning systems and drone cameras are being used to monitor elephant movements and forest fires. Habitat improvement through tree planting, increasing food availability in forests, and maintaining natural salt licks are ongoing efforts to mitigate the human - elephant conflict in the region.



Source: Wildlife Division, Keonjhar

Drivers of Human - Elephant Conflict in Keonjhar, Odisha

The roots of the human - elephant conflict in Odisha, as in many other parts of India, can be traced to a complex interplay of ecological, economic, and social factors that have emerged over time. Understanding these underlying drivers is crucial for developing effective, long - term solutions to the problem.

Ecological Factors

1) Habitat loss and fragmentation: One of the primary drivers of HEC in Odisha is the steady erosion and fragmentation of the state's elephant habitats. As human settlements, agricultural lands, and infrastructure have expanded, they have encroached on the traditional migratory corridors and foraging grounds of elephant populations. This has forced elephants to venture into human - dominated areas in search of food and resources, leading to more frequent and intense conflicts (Sukumar, 1989; Nath & Sukumar, 1998).
2) Diminishing resource availability: The degradation and depletion of natural resources within elephant habitats, such as water sources and forage, has exacerbated the conflict. As these vital resources become scarce, elephants are compelled to venture out of their traditional ranges and into human - occupied areas, further heightening the potential for clashes (Bist, 2002; Pradhan & Rout, 2013).
3) Climate change: Emerging research suggests that the impacts of climate change, such as altered rainfall patterns and increased droughts, may be contributing to the heightened HEC in Odisha and other parts of India. These environmental stressors can disrupt the availability of food and water for elephants, driving them to seek sustenance in human - dominated landscapes (Srinivasaiah et al., 2019; Gunawardene et al., 2021).

Economic Factors

1) Agricultural expansion: The rapid expansion of agriculture, both in terms of land area and intensification of cultivation, has been a major factor in the escalation of HEC in Odisha. As more land is converted to croplands, it encroaches on elephant habitats, bringing the two species into closer and more frequent contact (Lahiri - Choudhury, 1999; Nath & Sukumar, 2005).
2) Infrastructure development: The construction of roads, railways, and other major infrastructure projects in Odisha has also contributed to the fragmentation of elephant habitats and the disruption of their traditional migratory routes. This can force elephants to traverse human - occupied areas, increasing the likelihood of conflicts (Raman, 2012; Pradhan & Rout, 2013).
3) Resource extraction: The extraction of natural resources, such as timber and minerals, has led to the degradation and loss of elephant habitats in Odisha. This, in turn, has compelled the animals to venture into human settlements in search of food and shelter, exacerbating the HEC crisis (Santiapillai & Jackson, 1990; Khisha et al., 2021).

Social Factors

1) Human population growth: The rapid growth of Odisha's human population, which has more than doubled since 1981, has placed immense pressure on the state's natural resources and elephant habitats. As more people settle in previously undisturbed areas, the potential for human - elephant encounters has increased dramatically (Census of India, 2011; Bist, 2002).
2) Lack of awareness and capacity: Many local communities in Odisha lack adequate awareness and knowledge about elephant behavior, ecology, and conservation. This can lead to more risky interactions and a failure to adopt appropriate mitigation strategies. Additionally, the capacity of local authorities and agencies to effectively manage HEC incidents is often limited (Nath & Sukumar, 1998; Bist, 2002).
3) Retaliatory killings: In response to crop raids, property damage, and human casualties, some local communities in Odisha have resorted to retaliatory measures, such as killing elephants or destroying their habitats. This not only exacerbates the conflict but also poses a significant threat to the conservation of the species (Sukumar, 1989; Bist, 2002).

Impacts of Human - Elephant Conflict in Odisha The consequences of the human - elephant conflict in Odisha are far - reaching, affecting both human communities and the elephant population itself. These impacts can be broadly categorized into the following areas:

Livelihood and Economic Impacts

The most immediate and tangible impact of HEC in Odisha is the damage to agricultural crops and property, which can have devastating consequences for the livelihoods and economic well - being of local communities. Crop raiding by elephants can wipe out entire harvests, leaving farmers and their families struggling to make ends meet. Additionally, the costs associated with repairing or rebuilding damaged infrastructure and homes can further strain household budgets and community resources (Nath & Sukumar, 1998; Pradhan & Rout, 2013).

Threats to Human Life

Perhaps the most tragic consequence of the human - elephant conflict in Odisha is the loss of human life. As encounters between elephants and humans have become more frequent, the number of fatalities has risen dramatically. Between 2014 - 2019, the state recorded over 1, 160 human deaths due to elephant attacks, making it one of the deadliest regions for HEC in India (Project Elephant, 2019).

Impacts on Elephant Welfare and Conservation

The human - elephant conflict in Odisha also poses a serious threat to the long - term conservation and welfare of the state's elephant population. Incidents of retaliatory killings, accidental deaths, and habitat destruction have all taken a toll on the elephants, with 274 elephant fatalities recorded between 2014 - 2019 (Project Elephant, 2019).

Environmental and Ecological Impacts The human - elephant conflict in Odisha also has broader environmental and ecological implications. The destruction of elephant habitats and the disruption of their migratory patterns can have cascading effects on the overall health and biodiversity of the state's forests and ecosystems (Sukumar, 1989; Nath & Sukumar, 2005).

Mitigation Strategies and Policy Interventions In response to the escalating human - elephant conflict in Odisha, a range of mitigation strategies and policy interventions have been implemented at the state and national levels. These efforts aim to address the various drivers of the conflict and mitigate its impacts on both human communities and elephant populations.

Habitat Management and Restoration

One of the key strategies for addressing HEC in Odisha has been the focus on habitat management and restoration. This involves efforts to protect, maintain, and, where possible, expand the existing elephant habitats in the state (Santiapillai & Jackson, 1990; Bist, 2002).

Crop and Property Protection

In addition to habitat management, strategies have also been developed to protect agricultural crops and property from elephant damage. These include the installation of physical barriers, the use of early warning systems, and the promotion of elephant - resistant crop varieties (Baskaran et al., 1995; Pradhan & Rout, 2013).

Conflict Mitigation and Response

To address the immediate challenges posed by human - elephant encounters, various conflict mitigation and response strategies have been implemented in Odisha, such as the establishment of rapid response teams and the development of standard operating procedures (Karanth & Gopal, 2005; Raman, 2012).

Awareness and Capacity Building

Recognizing the importance of community engagement and education, several initiatives have been undertaken to raise awareness and build the capacity of local stakeholders in Odisha to address the HEC challenge (Nath & Sukumar, 1998; Bist, 2002).

Policy and Regulatory Frameworks

At the policy level, the Government of Odisha, in collaboration with the central government, has implemented various legislative and regulatory measures to address the human - elephant conflict, including the Odisha Elephant Reserve and Corridor Notification and the Odisha Elephant - Human Conflict Mitigation Policy (Pradhan & Rout, 2013; Project Elephant, 2019).

Persistent Challenges and Emerging Issues

Despite the various mitigation strategies and policy interventions implemented in Odisha, the human - elephant conflict in the state continues to pose significant challenges. Some of the persistent issues and emerging concerns include:

1) **Inadequate Funding and Resources:** The implementation of comprehensive HEC mitigation strategies in Odisha is often hindered by a lack of sufficient financial and human resources. Habitat restoration, community engagement programs, and emergency response systems require sustained investments that are often lacking. Without adequate funding, wildlife agencies and local authorities struggle to effectively monitor, manage, and respond to HEC incidents. This resource gap undermines the long - term viability and impact of HEC interventions (Baskaran et al., 1995; Raman, 2012).
2) **Competing Land - use Priorities:** The tension between conservation and development priorities remains a persistent challenge in Odisha, as the state grapples with the competing demands for land and resources. The expansion of infrastructure, extractive industries, and agricultural lands has continued to encroach on elephant habitats, despite efforts to secure and protect these critical areas. Balancing the needs of human economic development with the imperative of elephant conservation has proven difficult, requiring difficult trade - offs and compromise (Santiapillai & Jackson, 1990; Lahiri - Choudhury, 1999).
3) **Limited Stakeholder Coordination:** Effective Human - Elephant Conflict (HEC) management in Odisha demands a robust level of coordination and collaboration among diverse stakeholders, including government agencies, NGOs, and local communities. Regrettably, the absence of seamless communication and integration among these entities has occasionally impeded the implementation and effectiveness of mitigation strategies. Siloed approaches and the lack of a comprehensive, multi - stakeholder framework have weakened the impact of HEC interventions. Moreover, poor coordination among departments such as electricity, mining, and veterinary services has exacerbated the challenges. Additionally, community - based and traditional institutions, which often possess valuable knowledge and insights into local dynamics, are frequently overlooked. Recognizing and involving these institutions could enhance the relevance and effectiveness of HEC management initiatives, fostering greater community engagement and ownership of conservation efforts. (Nath & Sukumar, 1998; Karanth & Gopal, 2005).
4) **Human - Elephant Conflict Hotspots:** Certain regions within Odisha have emerged as persistent "hotspots" for human - elephant conflict, where the frequency and intensity of encounters have remained stubbornly high. These localized conflict zones often have unique ecological, economic, and social dynamics that require tailored, site - specific interventions. Addressing the complex challenges of these HEC hotspots has proven difficult, as the one - size - fits - all strategies have often fallen short. Moreover, understanding the changing behavior of elephants is crucial for developing effective mitigation measures. Sensitizing local communities to cooperate with elephants' behavior can significantly reduce conflict instances and promote coexistence. Therefore, a nuanced approach that considers the specific characteristics and needs of each hotspot is essential for mitigating human - elephant conflicts effectively in Odisha. (Pradhan & Rout, 2013; Khisha et al., 2021).
5) **Climate Change and Environmental Stressors:** Emerging research suggests that the impacts of climate change, such as altered rainfall patterns and increased droughts, may be exacerbating the human - elephant conflict in Odisha. These environmental stressors can disrupt the availability of food and water for elephants, driving them to seek sustenance in human - dominated landscapes and heightening the potential for conflict. Understanding and addressing the linkages between climate change and HEC will be crucial for developing long - term, sustainable solutions that account for these evolving environmental factors (Srinivasaiah et al., 2019; Gunawardene et al., 2021).
6) **Not Timely Undertaking Elephant Census:** The irregularity in conducting elephant census poses a significant challenge in understanding the population dynamics and devising appropriate conservation strategies. With the last census conducted in 2017, there

is a lack of up - to - date information on elephant numbers and distribution, hindering effective conservation planning and management.

7) **Poor Corridor Management**: Inadequate management of elephant corridors exacerbates human - elephant conflicts. Elephants require large areas to roam freely, and corridors serve as crucial pathways for their movement between fragmented habitats. Poorly managed corridors lead to increased instances of human - elephant encounters, habitat destruction, and conflicts, further threatening both human livelihoods and elephant populations.

2. Limitations of the study

A major limitation of such study is reliance on compensation data as it might not reflect actual intensity of conflict (Karanth et al., 2018). All the victims of HEC might not have claimed compensation and there could also be instances where damage due to other wildlife are reported as damage from elephants. These instances can lead to a false estimation and mislead the interpretation outcome. Also, compensation schemes vary on factors like; economic status of the country, political scenario, degree of awareness, literacy and sometimes also gender, religion etc. (Agarwala et al., 2010; Karanth et al., 2012, 2013, 2018; Manral et al., 2016; Johnson et al., 2018), which could restrict voluntary reporting by victims. To overcome this, future studies can include surveys to compare the actual scenario with the estimations obtained from the hotspots as well as in the least/not affected regions. The absence of HEC spatial locations was another limitation, which might have led to some spatial error in estimating hotspot zones, resulting in a small degree of variation on the ground level.

3. Conclusion

The human - elephant conflict in Odisha presents a multifaceted challenge requiring a comprehensive and collaborative approach to address. The escalating crisis has far - reaching impacts on human livelihoods, elephant welfare, and the broader ecological balance of the region. Despite the implementation of various mitigation strategies and policy interventions, persistent challenges and emerging issues continue to undermine the effectiveness of these efforts.

Analyzing spatial patterns of human - elephant conflict (HEC) and identifying high - risk areas is crucial for policy formulation, HEC management, and planning. This approach provides valuable context for understanding the risks associated with identified hotspots, enabling efficient resource allocation and streamlined mitigation measures. Additionally, finding hotspots for different types of HEC aids in devising streamlined compensation policies, while expanding the scope of mitigation measures.

For instance, prioritizing human casualty hotspots over property or crop damage hotspots when mitigation funds are scarce maximizes the effectiveness and minimizes the cost of HEC management. Furthermore, forest administrations can develop location - based strategies and determine suitable locations to implement mitigation plans such as early warning systems, bio or non - lethal fencing, and restoration of wildlife habitats and corridors. The formulation of spatial baseline data on HEC hotspots contributes to the improvement of regional databases, catalyzing larger analyses and collaborations.

This study makes several recommendations based on its outcomes. It underscores the importance of access to a detailed long - term dataset for a more dynamic analysis. Therefore, upgrading and strengthening HEC data collection protocols by adding geolocation and other relevant information is crucial. Additionally, periodic reviews and validation of data collection procedures through ground - level surveys are necessary.

As a proactive conflict management strategy toward coexistence, spreading awareness about compensation and insurance schemes is important. This not only increases the reporting rate of HEC incidences by victims but also advocates for government collaborations with the forest division in promoting community - based initiatives such as village response teams in vulnerable regions.

Effective land - use planning, considering the consequences on elephant movement behavior, should precede any mining or industrial projects. The hotspot map developed in this study can serve as a baseline for such land - use planning activities and can be used by wildlife authorities to prioritize areas for promoting elephant conservation initiatives.

Future mitigation plans should focus on assessing elephant habitat utilization and reconfiguring their movement pathways to avoid further encounters with human society. Additionally, there is scope for future research in determining the significant factors affecting HEC distribution and potential inequalities in HEC by examining the socio - demographic status of people living within high - risk zones compared to those outside.

To achieve long - term, sustainable solutions, it will be crucial to address the fundamental drivers of the conflict, including habitat loss and fragmentation, resource scarcity, economic pressures, and social dynamics. This will require a concerted effort among policymakers, wildlife experts, local authorities, and community stakeholders to develop and implement innovative, context - specific strategies that balance the needs of both human and elephant populations.

Ultimately, resolving the human - elephant conflict in Odisha, and indeed across India, will be a crucial test of the country's ability to balance its development aspirations with the imperative of conserving its natural heritage and biodiversity. The stakes are high, but the potential rewards - in terms of safeguarding human lives, protecting elephant populations, and preserving the ecological integrity of the region - make the effort worthwhile and necessary. It is imperative to adopt a collaborative approach rather than a confrontational one while dealing with elephants, as continued habitat destruction threatens their existence, leaving future generations with only stories and images of these magnificent creatures.

In conclusion, addressing the human - elephant conflict requires a concerted effort from all stakeholders, emphasizing

the importance of sustainable coexistence between humans and elephants for the well - being of both communities and ecosystems.

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