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IMPACTS OF AGRICULTURAL LAND USE ON ELEPHANT CONSERVATION: A SYSTEMATIC REVIEW OF HUMAN-ELEPHANT INTERACTION

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ABSTRACT
Human-elephant conflict (HEC) is any negative interactions between humans and elephants, arising from competition for space and resources often resulting in detrimental impacts for both species. Interactions like this are among the major issues challenging both the conservation of wildlife and human livelihoods across the globe. Specifically in Asia, elephants frequently come into contact with humans due to habitat fragmentation, agricultural expansion, and a decline in natural food sources. These conflicts typically result in crop damage, destruction of properties, and human casualties. The systematic review summarizes several key impacts when wildlife begin to overrun anthropogenic zones. Several studies have revealed the main drivers for this conflict is the expansion of human settlements and agricultural fields across Asia, which has led to significant habitat loss for elephants, reduced availability of food, diminished landscape connectivity, and a notable decline in elephant populations compared to their historical size and overall range. The degradation of their habitat has progressively forced elephants to make closer contact with people, often resulting in severe conflicts between the two species. Because of this, different mitigation strategies were implemented across India and Nepal. The most common being the construction of physical barriers to divide the forest range area from the local community; electric fencing is the most used. Some studies focused on community-based management such as building awareness via awareness campaigns, sending patrol groups, and improving compensation schemes for crop damage. The results highlight the importance of sustainable coexistence in order to protect both wildlife and local communities.

Keywords:
Asian elephant, human-wildlife interactions, crop raiding, wildlife conservation, habitat loss.

INTRODUCTION

Human–elephant conflict has become a serious conservation and social issue in many parts of South Asia, particularly in India and Nepal, where human populations increasingly overlap with elephant habitats. Studies conducted in regions such as Chhattisgarh and the Western Ghats show that interactions between humans and elephants often lead to crop damage, property destruction, injuries, and fatalities (Baskaran, N. et al 2024; Roy, K. et al, 2025). These conflicts are closely associated with expanding agriculture, settlement growth, and habitat fragmentation, which push elephants into human-dominated landscapes (Ram et al., 2022). As a result, both human safety and elephant conservation are negatively affected, making it important to understand the patterns and causes of these interactions.

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Many studies show that human-elephant interactions are significantly influenced by the way people use the land and the landscape. For example, research conducted close to protected areas such as Buxa Tiger Reserve and Bardiya National Park revealed that the boundaries of farms and forests are high-risk areas where elephants frequently enter farms in search of food (Nad, C. et al., 2022; Prins, H. H. T. et al.,2021). Similarly, studies in areas like the Chure Terai Madhesh region and the Nilgiri Biosphere Reserve found that damaged habitats, the availability of crops at different times of the year, and how close farms are to forests are important predictors of when conflicts will happen (Roy, A. K. et al., 2022). These results indicate that the time and location of conflicts are influenced by environmental and landscape factors. The likelihood of conflicts between humans and elephants can be increased or decreased depending on how people use the land and the features of the landscape. In addition to ecological drivers, socio-economic factors also contribute to the severity of human–elephant conflict. Some studies reveal that marginal farmers often suffer the greatest losses because their livelihoods depend heavily on agriculture and they have limited resources to protect crops or recover from damage (Pant, G. et al., 2025). Research examining community attitudes further shows that people's perceptions of elephants and conservation efforts vary depending on their location, economic status, and personal experiences with conflict. Negative attitudes tend to increase when communities experience repeated losses or feel that support from authorities is insufficient, which can complicate conservation efforts and coexistence strategies (Basu-Roy et al., 2024)

OBJECTIVES

The main objective of the study is to conduct a systematic review and synthesize existing literature and research studies on human-elephant conflict in local communities of Asian countries to better understand the broader patterns and drivers of these conflicts. In addition, even with the increasing number of studies on human-elephant conflict in various regions, the results are frequently localized and concentrated on particular elements like crop damage, community perceptions, or fatalities. Therefore, this systematic review aims to examine the impacts of land-use and landscape changes on human–elephant interactions in India and Nepal by integrating evidence from multiple studies. Such understanding can help inform more effective management strategies and promote sustainable coexistence between humans and elephants.

METHODOLOGY

The study uses a systematic methodology structured into three main components: Input, Process, and Output (IPO). The Input stage involves collecting relevant and credible peer-reviewed articles from academic databases focusing on human–elephant conflict, including determinants such as land-use change, spatial patterns, fatalities, and mitigation strategies. The Process stage follows PRISMA 2020 guidelines, which include identifying, screening, selecting, and analyzing eligible studies based on predefined criteria, and organizing data according to key factors like land use, habitat fragmentation, and risk predictors. The Output stage provides a synthesized summary of findings, highlighting the major determinants of human–elephant conflict and the recommended mitigation measures, ensuring a clear and evidence-based interpretation of the selected studies.

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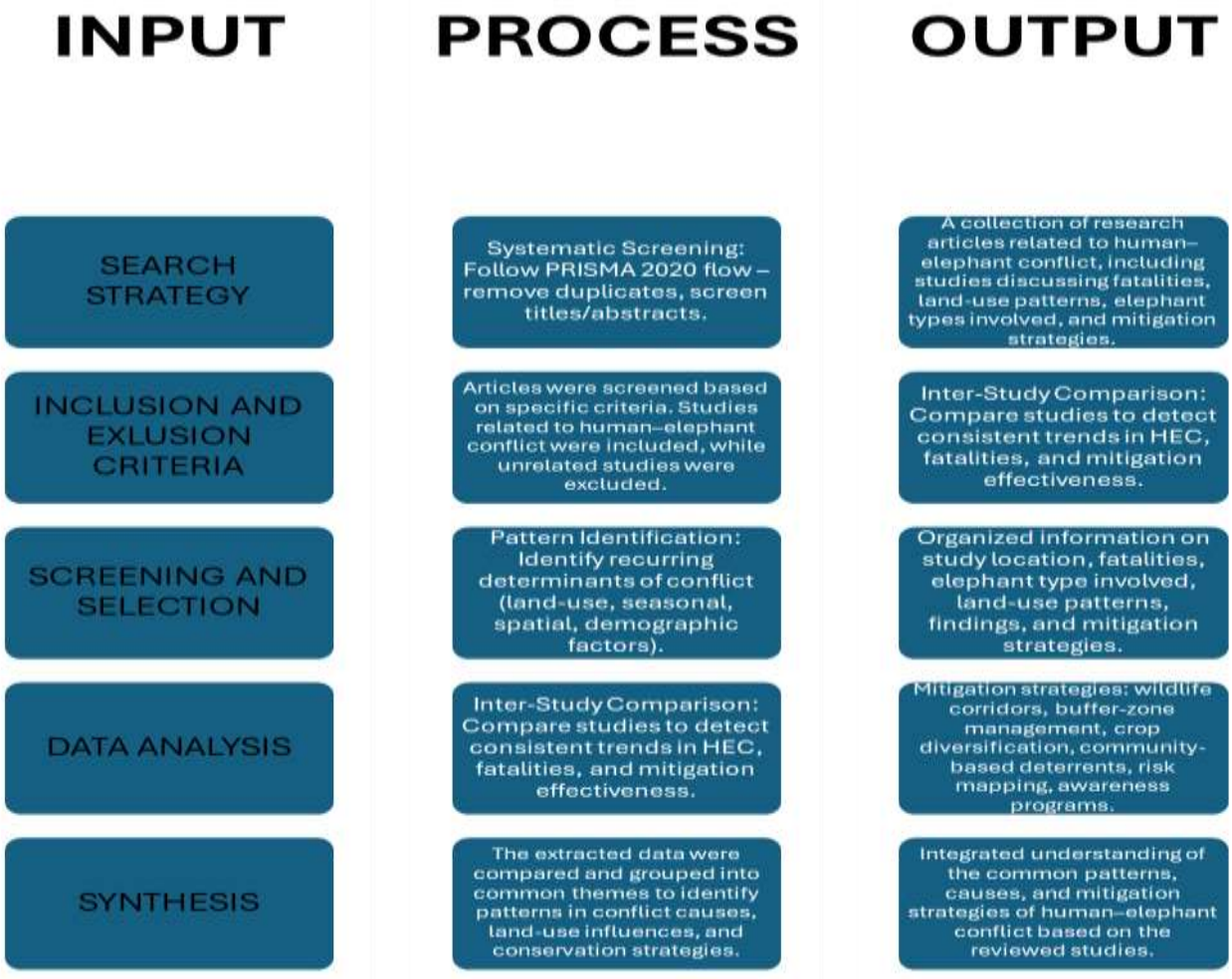

Figure 1. IPO Diagram of the Study

Search Strategy

A comprehensive literature search was conducted in PubMed, Google Scholar, and manually through the reference lists of selected studies. The search included publications from 2015 to 2026 and focused on keywords such as "human–elephant conflict," "Asian elephant," "land use," "fatalities," "mitigation strategies," and "land use." Boolean operators were applied to combine terms, ensuring both broad coverage and relevant results. Both human and animal studies reporting HEC patterns, fatalities, land-use factors, and mitigation strategies were included to identify all relevant determinants of conflict.

Inclusion and Exclusion Criteria

Studies were included if they were peer-reviewed, focused on Asian elephants in India or Nepal, and contained primary data on human–elephant conflict, fatalities, findings, land-use, or mitigation strategies. Excluded studies included reviews, editorials, conference abstracts, and any articles lacking primary data on HEC. This ensured that only high-quality and directly relevant studies were analyzed.

Screening and Selection

All identified studies were imported into a reference management system to remove duplicates. Titles and abstracts were screened for relevance, and full texts of potentially eligible studies were assessed to determine final inclusion. Any disagreements during screening were resolved through discussion among researchers to ensure consistent decision-making. This process ensured that the final set of studies met all criteria for relevance and quality.

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Data Extraction and Analysis

A standardized form was used to extract key information from each study, including author, year of publication, study location, elephant type, number of fatalities and injuries, land-use patterns, spatial and seasonal characteristics, major findings, and proposed mitigation strategies. The data were then categorized into four main themes: (1) Fatalities and attack patterns, (2) Land-use and habitat drivers, (3) findings, and (4) Mitigation and community interventions. Organizing the data in this way allowed for systematic comparison across studies and identification of recurring patterns and risk factors.

Synthesis of result

A qualitative synthesis was performed due to heterogeneity in study designs, populations, and measurement methods. Patterns of HEC were identified by comparing findings across all 10 studies. For example, Roy et al. (2025) and Ram et al. (2021) highlighted the influence of forest fragmentation and settlement proximity on fatalities, while Anoop et al. (2023) and Pant et al. (2015) emphasized the roles of crop type, male elephant behavior, and seasonal peaks in conflict events. The synthesis also summarized mitigation strategies, including the establishment of wildlife corridors, buffer-zone management, crop diversification, community-based deterrents, risk mapping, and awareness programs. Overall, this methodology allowed for a thorough understanding of the determinants of human–elephant conflict and provided evidence-based recommendations to support conflict reduction and coexistence between humans and elephants.

RESULTS AND DISCUSSION

Human–elephant conflict (HEC) is a widespread environmental issue across South and Southeast Asia, where increasing human activities overlap with natural elephant habitats. One of the main drivers of this conflict is the expansion of agricultural land and the fragmentation of forests, which reduce available resources for elephants and force them into human-dominated areas. As a result, interactions between humans and elephants have become more frequent, often leading to serious consequences such as human fatalities, crop damage, property destruction, and harm to elephant populations. Over the past decade, numerous studies have examined how land-use changes, particularly agricultural development, influence the relationship between humans and elephants. These studies provide important insights into the patterns, causes, and impacts of conflict, helping researchers better understand how environmental and human factors contribute to its occurrence. The key findings and major studies on human–elephant conflict and its drivers are summarized in Table 1.

Table 1. Summary of Selected Studies on Agricultural Land Use and Human-Elephant Interactions

	Location/ Country	Focus of the Study	Key Findings/ Results	Implication	Author(s)/ Year
1	Chhattisgarh, India	Examines how agricultural land-use change and habitat fragmentation influence human-elephant conflict and affect both elephant and human livelihoods	Agricultural expansion and habitat fragmentation significantly increase human-elephant conflict by forcing elephants into human-dominated landscapes	Implementing land-use planning, habitat restoration, and community-based conservation strategies to reduce human-elephant conflict and support elephant conservation	Roy, K. et al (2025)
2	Western Ghats, India	Analyzes how temporal and seasonal patterns of elephant movement are	Human-elephant interactions peak during specific seasons and night-time periods,	Adopting seasonal and time-specific mitigation strategies, such as increased	Anoop, N. R. et al (2023)

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		associated with agricultural cycles and influence the timing of human-elephant interactions	closely aligned with crop availability and agricultural cycles	night-time monitoring and adjusting farming practices to reduce conflict risk	
3	Central Nepal	Investigates how land-use change, human population expansion, and resource competition drive human-elephant conflict in agricultural landscapes	Human-elephant conflict is primarily driven by land-use change, increasing human population density, and competition for limited natural resources	Promoting sustainable land management, habitat protection, and integrated policies that balance agricultural development with wildlife conservation	Pant, G. et al (2015)
4	Buxa Tiger Reserve, India	Identifies the underlying environmental, anthropogenic, and landscape-level factors that contribute to human-elephant conflict	Multiple interacting factors, including habitat degradation, human activities, and landscape configuration, collectively drive human-elephant conflict	Addressing underlying drivers of conflict through landscape-level planning, improved data use, and strengthened community awareness programs	Nad, C. et al (2022)
5	Chure Terai Madhesh, Nepal	Explores how people's attitudes toward human-elephant conflict are influenced by their socio-economic, demographic, and locational characteristics	People's attitudes toward elephants are significantly influenced by their socio-economic status, level of conflict exposure, and geographic location	Enhancing community education, improving compensation schemes, and involving local people in conservation decision-making to foster positive attitudes toward elephants	Ram, A. K. et al (2022)
6	Bardiya National Park, Nepal	Describes the nature, extent, and impacts of human-elephant conflict, including crop damage, property loss, and human casualties	Human-elephant conflict results in substantial crop loss, property damage, and occasional human casualties, severely affecting rural livelihoods	Strengthening conflict mitigation measures, rapid response systems, and compensation programs to reduce the impacts on affected communities	Prins H. H. T. et al (2021)
7	Nilgiri Biosphere Reserve, India	Examines how landscape features such as forest cover, proximity to settlements, and agricultural areas predict the occurrence of human-elephant conflict	Areas with fragmented forests, proximity to settlements, and agricultural expansion are strong predictors of human-elephant conflict hotspots	Using spatial planning and predictive mapping to identify high-risk areas and guide land-use decisions that minimize conflict	Baskaran N. et al (2024)

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8	Buxa Tiger Reserve, India	Assesses how human-elephant conflict disproportionately affects marginal farmers and increases their economic vulnerability	Marginal farmers experience disproportionately higher economic losses from elephant damage compared to more affluent households	Providing targeted financial support, fair compensation, and alternative livelihood options for vulnerable farmers affected by elephant damage	Nad & Basu-Roy (2024)
9	Bardiya National Park buffer, Nepal	Evaluates how communities in buffer zones adapt to and manage human-elephant interactions to promote coexistence	community-based strategies and local adaptation measures can reduce conflict and improve human-elephant coexistence	Strengthening community-based management approaches and collaboration among stakeholders to promote sustainable human-elephant coexistence	Sagar, P. et al (2024)
10	Terai and Chure regions, Southern lowland Nepal	Analyzes the patterns, causes, and risk factors associated with elephant attacks on humans	Elephant attacks on humans are more likely to occur in specific high-risk areas and times, often linked to human activities in elephant habitats	Improving risk awareness, monitoring systems, and limiting human activities in high-risk areas to reduce elephant attacks on humans	Ram, A.K. et al (2021)

As shown in Table 1, across the 10 studies, agricultural expansion consistently increases contact between humans and elephants by reducing and fragmenting natural habitats. This pattern is observed across different geographical contexts indicating a strong level of agreement among studies (Roy et al., 2025; Pant et al., 2015; Nad et al., 2022). The convergence of results strengthens the reliability of the conclusion that landscape transformation is a primary driver of conflict. Temporal patterns further refine the understanding of when conflicts are most likely to occur. Several studies demonstrate that interactions are closely linked to agricultural cycles, with peaks during crop maturation and harvesting periods (Anoop et al., 2023). Night-time activity also emerges as a recurring factor as elephants tend to enter farms when human presence is reduced. These consistent temporal trends suggest that conflict events are not random but follow predictable patterns that can inform more precise mitigation strategies.
Spatial characteristics of landscapes also play a critical role in shaping conflict distribution. Areas with fragmented forests, expanding agricultural frontiers, and close proximity between wildlife habitats and human settlements are repeatedly identified as high-risk zones (Baskaran et al., 2024; Nad et al., 2022). This indicates that not only the presence of agriculture but also its configuration within the landscape influences conflict intensity. Such findings highlight the importance of incorporating spatial planning and habitat connectivity into conservation efforts.
Socio-economic dimensions are equally significant in determining both the impacts of conflict and community responses. Marginalized farmers experience greater economic losses and are more vulnerable to the effects of crop damage and property destruction (Nad & Basu-Roy, 2024; Prins et al., 2021). In addition, local attitudes toward elephants are influenced by lived experiences, economic capacity, and access to compensation or support systems (Ram et al., 2022). These factors collectively shape tolerance levels and willingness to participate in conservation initiatives.
The summary also identifies commonly recommended intervention strategies across studies. Community-based management, adaptive farming practices, and targeted mitigation measures such as monitoring systems and compensation schemes are frequently cited as effective approaches (Sagar et al., 2024; Ram et al., 2021). However, the variability in outcomes across different settings suggests that no single solution is universally

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applicable. Instead, interventions must be context-specific and responsive to local ecological and socio-economic conditions. While the included studies provide valuable insights, certain limitations must be acknowledged. The concentration of research in specific regions, particularly India and Nepal, may limit the broader applicability of the findings. Additionally, differences in study design and the lack of long-term data constrain the ability to assess sustained outcomes of mitigation strategies. Addressing these gaps in future research would improve the robustness and generalizability of evidence in this field.

Overall, the findings of this review emphasize that human-elephant conflict is a complex issue shaped by interacting environmental and social factors. A comprehensive approach that integrates land-use planning, ecological conservation, and community engagement is necessary to effectively reduce conflict. The consistency of evidence across studies supports the need for coordinated strategies that balance agricultural development with wildlife conservation.

Fatalities Associated with Human-Elephant Conflict

Table 3.1. Human Fatalities and Injuries Associated with Human-Elephant Conflict (HEC) in India and Nepal

	Location/ Country	Study Period	Causes / Drivers of Conflict	Fatalities	Injuries	Total Casualties	Author(s)/Year
1	Chhattisgarh, India	2000-2023	Agricultural expansion, habitat fragmentation, and road expansion	737	91	828	Roy, K. et al (2025)
2	Western Ghats, India	2009-2018	Temporal/seasonal patterns, crop availability, and lack of natural forage	400	—	400	Anoop, N. R. et al (2023)
3	Central Nepal	2008-2012	Land-use change, population expansion, and resource competition	21	4	25	Pant, G. et al (2015)
4	Buxa Tiger Reserve, India	2009-2019	Habitat degradation, landscape configuration, and shrinking natural habitats	98	54	152	Nad, C. et al (2022)
5	Chure Terai	2001-2020	Habitat	274	138	412	Ram, A. K. et

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	Madhesh, Nepal		fragmentation, agricultural expansion, and socio-economic vulnerability				al (2022)
6	Bardiya National Park, Nepal	2000-2007	Movement between park and agriculture, and wilderness-cultivation boundary proximity	26	16	42	Prins H. H. T. et al (2021)
7	Nilgiri Biosphere Reserve, India	2009-2019	Forest cover fragmentation, proximity to settlements, and decline in grass biomass	396	222	618	Baskaran N. et al (2024)
8	Buxa Tiger Reserve, India	2009-2019	High vulnerability of marginal farmers in enclave forest and corridor villages	98	54	152	Nad & Basu-Roy (2024)
9	Bardiya National Park buffer, Nepal	2019-2023	Human settlements/fields creeping closer to forest boundaries	12	0	12	Sagar, P. et al (2024)
10	Terai and Chure regions, Southern lowland Nepal	2001-2020	Attacks outside protected areas, high-risk human activities, and proximity to forest edges	274	138	412	Ram, A.K. et al (2021)
TOTAL				**1,964**	**525**	**2,489**	

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Table 3.2. Human Fatalities and Injuries Associated with Human-Elephant Conflict (HEC) in India and Nepal

	Location/ Country	Study Period	Causes / Drivers of Conflict	% Fatalities	% Injuries	Author(s)/Year
1	Chhattisgarh, India	2000-2023	Agricultural expansion, habitat fragmentation, and road expansion	89.01%	10.99%	Roy, K. et al (2025)
2	Western Ghats, India	2009-2018	Temporal/seasonal patterns, crop availability, and lack of natural forage	100%	—	Anoop, N. R. et al (2023)
3	Central Nepal	2008-2012	Land-use change, population expansion, and resource competition	84.00%	16.00%	Pant, G. et al (2015)
4	Buxa Tiger Reserve, India	2009-2019	Habitat degradation, landscape configuration, and shrinking natural habitats	64.47%	35.53%	Nad, C. et al (2022)
5	Chure Terai Madhesh, Nepal	2001-2020	Habitat fragmentation, agricultural expansion, and socio-economic vulnerability	66.50%	33.50%	Ram, A. K. et al (2022)
6	Bardiya National Park, Nepal	2000-2007	Movement between park and agriculture, and wilderness-cultivation boundary proximity	61.90%	38.10%	Prins H. H. T. et al (2021)
7	Nilgiri Biosphere Reserve, India	2009-2019	Forest cover fragmentation, proximity to settlements, and decline in grass biomass	64.08%	35.92%	Baskaran N. et al (2024)
8	Buxa Tiger Reserve, India	2009-2019	High vulnerability of marginal farmers in enclave forest and	64.47%	35.53%	Nad & Basu-Roy (2024)

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			corridor villages			
9	Bardiya National Park buffer, Nepal	2019-2023	Human settlements/fields creeping closer to forest boundaries	100%	0.00%	Sagar, P. et al (2024)
10	Terai and Chure regions, Southern lowland Nepal	2001-2020	Attacks outside protected areas, high-risk human activities, and proximity to forest edges	66.50%	33.50%	Ram, A.K. et al (2021)
TOTAL				**78.91%**	**21.09%**	

From Chhattisgarh, India we see a disturbing glimpse of just how serious HEC can be. From 2000 to 2023 there were 828 reported HEC events. However, the major cause of this massive number of events were agricultural expansion, habitat fragmentation, and roads that have caused the habitat of wild elephants to fragment. 737 of these incidents were fatal, compared to only 91 non-fatal events. The ratio is more than 8 to 1 in favor of fatal attacks. This ratio indicates that encounters in this region are extremely unlikely to result in only a minor injury, but instead, there is virtually no buffer zone for the local populations. The distribution of deaths varies by district, with Jashpur leading the pack with 152 recorded deaths, and Dharamjaigarh a close second with 135 deaths. On the other hand the ratio in Surajpur and Korba are much smaller (though still greater than 1), with fatalities still dominating over injuries in all forest divisions (Roy et al. 2025).In the Western Ghats, at Wayanad plateau the research points directly to HEC as a result of agricultural activities taking over elephant habitats. Here researchers point to farming plantations as replacing traditional elephant habitats thus forcing the elephants into closer contact with humans, thereby forcing elephants into human-dominated landscapes in order to find food. India faces an incredible crisis where between 400 people and 100 elephants die from these encounters each year. In central Nepal at the buffer zones of Chitwan National Park and Parsa Wildlife Reserve, between 2008 and 2012 researchers observed 25 deaths and 21 non-fatal incidents. Although property damage was reported as the most common issue in this region, resource competition as a result of changing land uses caused considerable amounts of deaths and injuries.The Buxa Tiger Reserve (BTR) in West Bengal has had problems with HEC between 2009 and 2019. During this period 152 deaths were reported that occurred as a result of loss of habitat and therefore closer contact between elephants and people. This increase in deaths compared to deaths between 2001 and 2008 indicates that elephants, as natural corridors disappear, are coming into more and more aggressive contact with people. In the CTML in Nepal the story is not any different. In the last 20 years (2001-2020), there have been 10,798 documented encounters, with 412 documented human deaths as a result of these encounters. This is again over twice as many deaths as injuries, again with close contact being the main cause (Ram et al., 2022).In Nepal's buffer zone between Bardiya National Park and the Khata corridor the negative effects of marginal populations come into play again. Between 2000 and 2007, elephants from the Bardia National Park move into farm fields in order to satisfy needs as a result of the boundary between agriculture and wildlands approaching closely. These particular attacks occurred mostly at peak harvesting season when humans were in the fields. In Southern India, at the Nilgiri Biosphere Reserve (NBR), 618 deaths occurred during this time, indicating forest fragmentation and the reduction in natural grasses. These 618 deaths are part of the 618 recorded casualties and that is why we see such a great loss in HEC incidents (Baskaran et al., 2024).Among marginal farmers in corridor villages at the BTR and surrounding area, there have been 98 deaths and 54 injuries between 2009 and 2019. These farmers do not have the necessary resources to prevent elephants from raiding their crops and they are essentially easy targets. At the Bardia-Banke complex in Nepal, there have been 12 encounters resulting in 12 deaths and 0 injuries. This

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clearly indicates the severity of the human-elephant conflict in this region. Finally in Southern Nepal, in the lowlands of the Terai and Chure region, there have been 274 deaths and 138 injuries during the last 20 years (2001-2021). In this region, over 2/3 of all HEC events were fatal, and most of these attacks occurred very close to the forest boundary (Ram et al. 2021). These studies show how, over the years and at different geographical scales, the room for peaceful coexistence is shrinking and that human-elephant conflict is a grave threat with injuries growing at such an extreme pace (Prins et al., 2021 and Sagar et al. 2024).

Elephant Species Involved in Conflict

The reviewed studies indicate that different elephant types contribute to human–elephant conflict (HEC), including solitary male elephants, mixed herds, and smaller male groups. These elephants interact with human environments primarily in search of food, water, or movement corridors. However, the type of elephant involved often influences the severity and frequency of conflicts. Across several studies, solitary adult male elephants (bulls) were identified as the most common individuals responsible for direct attacks on humans. Male elephants tend to roam alone, especially after separating from their natal herd. Their independent movement increases the likelihood of encountering human settlements, agricultural fields, or forest edges. These solitary bulls may also display more aggressive behavior, particularly during the musth period, when testosterone levels rise and aggression increases. Research suggests that solitary males account for a large proportion of fatal encounters because they often raid crops at night and react aggressively when disturbed.

Some studies also reported herd-related conflicts, particularly when family groups consisting of females and calves enter agricultural areas. Herds generally move together while searching for food, especially crops such as rice, maize, and other agricultural products that provide high nutritional value. When these groups enter villages or farmlands, conflicts often involve crop damage, property destruction, and occasional injuries to people who attempt to chase them away. In addition, certain studies observed small groups of male elephants, sometimes referred to as all-male groups. These groups may form in landscapes heavily modified by human activities, where young males associate with each other to navigate human-dominated environments. Although these groups may raid crops collectively, their encounters with humans are often less predictable compared with herd movements.

Conflict Hotspots of HEC and Mitigation Implications

Utilization of land resources for both agricultural and residential purposes has led to increasing human–elephant conflict occurrences near the wildlife boundary where elephants reside. The reviewed studies show that conflicts are more common in areas where elephant habitats overlap with agricultural lands, settlements, and fragmented forests. One of the most common settings is the forest–agriculture interface, where farms and villages are located near forest boundaries. In these areas, elephants are attracted to crops because they provide easy and high-energy food, leading them to enter farms, especially at night, which results in crop damage and encounters with farmers. Another key factor is habitat fragmentation and land-use change. The expansion of agriculture, roads, and settlements reduces the size and connectivity of forests, forcing elephants to move through human-dominated areas in search of food and migration routes. As a result, conflicts are more likely to occur near forest edges, roads, crop fields, and human settlements, while areas with larger and continuous forests tend to have fewer conflict incidents. Because of these negative encounters with elephants, locals often view them as a nuisance or threat as not only do they pose serious damage to crops and properties but casualties and fatalities as well. This often creates a negative attitude towards the conservation of these megaherbivores, locals frequently resorting to retaliatory killings out of anger. To avoid such detrimental effects from these interactions, conservation scientists have been studying the drivers of human-elephant conflict to produce sustainable solutions that would both preserve wildlife and support local communities and compensate for the damage caused by raiding elephants.

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Table 4. Summary of Conflict Hotspots of HEC and Mitigation Implications Implemented in the Reviewed Articles

	Study Location	Conflict Hotspots	Detrimental Effect	Mitigation Implication	Author(s)/ Year
1	Chhattisgarh, India	Forest fragmentation, expanding agriculture, roads	Human fatalities and injuries	Early warning systems	Roy, K. et al. (2025)
2	Western Ghats, India	Forest–agriculture matrix	Crop damage	Crop protection measures	Anoop, N. R. et al. (2023)
3	Central Nepal	Agricultural settlements near forest areas	Human casualties, crop and property damage	Community awareness	Pant, G. et al. (2015)
4	Buxa Tiger Reserve, India	Forest converted into farmland	Biodiversity loss, crop and property damage	Habitat management	Nad, C. et al. (2022)
5	Chure Terai Madhesh, Nepal	Fragmented forests with human settlements	Crop and property loss, human casualties	Land-use planning	Ram, A. K. et al. (2022)
6	Bardiya National Park, Nepal	Small-scale farming near protected areas	Crop and property damage	Compensation programs	Prins H. H. T. et al. (2021)
7	Nilgiri Biosphere Reserve, India	Settlement expansion and degraded habitats	Human casualties, crop and property damage	Conflict monitoring	Baskaran, N. et al. (2024)
8	Buxa Tiger Reserve, India	Agriculture in buffer zones	Crop damage	Community participation	Nad & Basu-Roy (2024)
9	Bardiya National Park buffer, Nepal	Farming and settlements in buffer zones	Elephant attack, crop damage	Buffer zone management	Sagar, P. et al. (2024)
10	Terai and Chure regions, Southern lowland Nepal	Villages and farmland near forests	Human fatalities	Safety guidelines	Ram, A.K. et al (2021)

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The table summarizes how human settlements influence human–elephant conflict based on the ten reviewed studies. Most of the studies show that changes in land use near elephant habitats increase the chances of encounters between humans and elephants. Several studies, such as those by Roy et al. (2025), Ram et al. (2022), and Baskaran et al. (2024), highlight that forest fragmentation, settlement expansion, and infrastructure development reduce the natural habitat available for elephants. As forests become fragmented and roads or villages expand into these areas, elephants are forced to move through human-dominated landscapes. This increases the likelihood of elephants entering villages or farms, which often leads to crop damage, property destruction, or even human fatalities.

The table also shows that agriculture located near forests or protected areas plays a major role in attracting elephants. Studies such as Anoop et al. (2023), Pant et al. (2015), and Prins et al. (2021) explain that farms located close to forest boundaries provide an easy food source for elephants, especially during crop-growing and harvesting seasons. Similarly, research conducted in buffer zones of protected areas, such as in Bardiya National Park and Buxa Tiger Reserve, indicates that farming activities and human settlements in these zones increase the frequency of human–elephant interactions. Overall, the findings suggest that land-use changes such as agricultural expansion, settlement development, and habitat degradation are major factors that contribute to the increasing occurrence of human–elephant conflict in many regions.

The table also presents the mitigation implications and conservation strategies, each study highlights different approaches that can help reduce conflicts between humans and elephants. These strategies include early warning systems, crop protection measures, community awareness, habitat management, and land-use planning. For example, some studies recommend monitoring elephant movement and using early warning systems to alert communities before elephants enter villages. Other studies emphasize the use of physical protection methods such as fences, watchtowers, and community guarding to prevent elephants from damaging crops. Education and awareness programs are also highlighted to help local communities understand elephant behavior and learn safe practices when living near elephant habitats.

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Furthermore, we acknowledge the researchers whose foundational studies on wildlife conservation, agricultural land-use patterns and human-elephant interactions provided the essential framework for our review. Their studies have helped us in gathering necessary data for the study.

CONCLUSION

The present systematic review collects the available information about HEC in key Indian and Nepalese areas, illustrating HEC as a multifaceted issue influenced by a myriad of ecological, spatial, and socioeconomic factors. The distribution of conflicts indicated that the intensity of HEC was particularly high in areas that border areas with increasing agricultural activity and habitats that are characterized by high biodiversity, such as the Chure Terai Madhesh Landscape, Nilgiri Biosphere Reserve, Buxa Tiger Reserve, and Chhattisgarh. The fragmentation

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of these areas, the proximity of these habitats to water bodies, and the rise of anthropocentric pressure intensified the levels of interaction. The high toll on humans resulting from this HEC was apparent. There were a reported 2,489 incidents of conflict across all the collected papers, which resulted in the loss of 1,964 lives (78.91%) and 525 injured (21.09%). This means that while conflicts occur with a high probability of casualties, there is an even higher chance of them being fatal. High-risk areas such as the forest edges and agricultural fields in such locations clearly put human lives at risk. Factors such as habitat alteration, pace of land-use change, and human actions in specific localities influenced the varying impact of these events at different scales. In essence the elephants themselves are an integral part of the conflicts. Solitary males were responsible for most deaths on account of individual behaviour and the elephant's capricious nature and charge behavior when in musth. Incidents where larger herds caused damage usually entailed agricultural destruction and property damage. Inconsistent interactions were more frequently observed between small male groups. The use of land in the context of HEC was seen to be one of the most critical influencing factors. An increase in agriculture, settlements, and infrastructure led to a drastic decrease in the connectivity between habitats and increased the extent of fragmentation. This resulted in elephants entering human settlements. Forest-agriculture interfaces are inherently conflict prone areas where clashes will more frequently occur due to attraction of nutrient rich crops such as maize and rice, especially at certain times of year. A great number of conservation outcomes and ways to diffuse the conflicts which can exist between ecology management strategies and community strategies are documented in the articles reviewed. This included early warning systems, physical barriers, crop protection techniques, conflict monitoring, and habitat restoration/corridor conservation. Nonetheless, it is the community-based strategies such as education, compensation, and local involvement in conservation processes that truly help combat negative feelings of humans towards elephants and thus coexist. It appeared that reliance solely on response strategies was insufficient, and therefore the use of a planning approach on a wider, landscape level was deemed necessary. The prevailing issues of conflict, especially with the impact of unsustainable land-use changes and habitat fragmentations and the subsequent threat to human life, finances, and the conservation of this species, were confirmed. A harmonious balance that incorporates conservation methods that emphasize ecology with social justice can ensure human coexistence with these majestic beings and that human lives are protected.

Recommendations

The first measure is the enhancement of land-use planning in sites surrounding forest reserves and established elephant corridors. Land use, particularly the expansion of agricultural fields and settlements along forest edges, should be controlled by local governments and the relevant authorities, and clearly defined buffer zones between the forest and farming settlements can prevent elephants from entering agricultural fields.

Secondly, the rehabilitation and preservation of elephant corridors are very crucial. Numerous papers examined within this study indicated that it is mainly fragmentation and disconnection of elephant corridors that push them to traverse across human environments. Reviving degraded forests and reconnecting fragmented habitats, may facilitate safer passage of elephants and prevent them from entering the fields to seek food.

Thirdly, the compensation schemes for crop damage and property loss could be strengthened and improved. Proper and fair compensation can make farmers have more positive attitudes toward wildlife, and thereby increase their support for conservation efforts. The provision of adequate economic assistance can help ease the financial pressure for the farmers and mitigate the intolerance to elephants.

Lastly, promoting alternative crop cultivations in critical sites should be adopted in the conservation schemes. Changing the type of crops, e.g. To crops that are less palatable to elephants, can minimize the incidents of crop raiding. And furthermore, integrating traditional agricultural methods that coexist with wild animals can assist to achieve both food production and species conservation.

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