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Original Research Paper

Developing Innovative Approaches for Mitigating Human-Wildlife Conflicts in Protected Areas and Buffer Zones

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Key Words

Human-wildlife conflict, Protected areas, Buffer zones, Sustainable solutions, Community engagement, Conflict mitigation strategies.

Abstract

Conflicts between humans and wildlife (HWCs) are an emerging conservation challenge in buffer zones, as human encroachment into these areas affects ecosystems and threatens both wildlife and humans. This paper examines new approaches to address these conflicts, but it is oriented towards developing measures that create sustainable solutions that satisfy both conservation and local people. Its primary goal is to find solutions and strategies to curb the human-wildlife contact and increase community participation in the conservation activities. The study uses a mixed-methodology, including field surveys, stakeholder interviews, and a case study of areas with high HWCs. The findings indicate that a balanced approach combining technological interventions (e.g., wildlife tracking and early warning systems), community-based management, and enhanced policy frameworks will be essential to mitigate the situation. Also, it is important to develop a a positive attitude towardtowards wildlife conservation through education and community involvement to minimize conflicts. The paper provides a conclusion and recommendations, including habitat restoration, wildlife corridors, and compensation schemes, to mitigate the economic losses arising from such conflicts. These techniques, which, based on local contexts, represent an elaborate platform for reducingfor reducing HWCs within protected and buffer zones.

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Introduction

Human-wildlife conflicts (HWCs) pose a major challenge to wildlife conservation and are typically driven by habitat destruction, encroachment, and resource competition. As the human population increases, the areas occupied by wildlife are reduced, forcing wildlife into areas inhabited by humankind, which results in more interactions and conflicts. This may translate to crop destruction, carrion flies of livestock and even loss of human lives. These conflicts have been increased by the development of agricultural lands, infrastructure, and tourism in the vicinity of the protected areas (PAs) where wildlife explorers in search of food and water enter human-controlled landscapes.

Wildlife conservation is impossible without the use of so-called protected areas (PAs) and buffer zones, areas where species can exist without the threat of human interference. Nevertheless, with the encroaching human activities, the efficacy of these zones towards minimizing human-wildlife conflict is most of the time compromised. Buffer zones serve as an intermediate zone between human settlements and PAs to reduce tension between the two by creating a buffer against human intrusion. Although they have the potential, it is presently observed that in most cases, buffer zones are inadequate in the sense that they offer no solutions to the actual origin of human-wildlife conflict, simply because of a lack of resources, poor management, and the increasing demands of the human population around most buffer zones (Lamichhane et al., 2019; Lumacad & Swiatkowska, 2025).

Current conflict management methods, such as physical barriers or compensation for crop damage, have been observed to provide only a short-term remedy and fail to address the causes of HWCs (Gatti, 2025). To address this, we need to develop innovative, sustainable solutions that combine community-based approaches with advanced technologies. Indicatively, community-based interventions have proven effective in minimizing conflict by engaging local people in conservation processes (Branco et al., 2020). Similarly, artificial intelligence (AI) (Shetty & Nair, 2024) and deep learning can be used to offer innovative solutions to reduce conflicts by forecasting wildlife movement and detecting conflict zones before they arise in biodiversity hotspots (Ojija et al., 2025). In addition, the idea of ecological peace corridors, which are safe corridors through which the animals move through the fragmented habitats, presents an intriguing new way of reducing the conflict and increasing the connectivity to the conservation zones (Gayo & Ngonyoka, 2025).

This paper aims to discuss new methods for reducing human-wildlife conflict, especially in protected and buffer zones. The paper will seek to present sustainable solutions to enhance harmonious coexistence between people and wildlife in these critical conservation areas by using technology, community participation, and new conservation plans.

Literature Review

One of the challenges facing the use of protected areas (PAs) and their immediate surroundings is human-wildlife conflict (HWC), in which human activities such as farming and

residential development encroach on wildlife habitats. The growing scope and influence of these conflicts have been documented in previous studies, especially at the boundaries of PAs. For example, large insectivores like elephants and rhinos can destroy crops, whereas predators like tigers can feed on livestock, forcing local people to retaliate by killing them (KC et al., 2023). It is the effects of these wars on not only wildlife populations but also local communities, which are devastated by economic losses from crop destruction and livestock theft. The tension that arises does not facilitate the effective conservation and may have adverse effects on the local economy.

Current conflict management mechanisms are physical barriers, compensation programs, and community-based programs (Reddy & Thomas, 2024). Physical barriers, such as fences, are used to exclude wildlife, especially in human settlements; however, they can be expensive to maintain and might limit wildlife movement (Johnson et al., 2018). Compensation programs that compensate farmers on a loss basis are also intended to decrease retaliatory killings, which are, however, criticized for their short-term results and insufficiency in offering long-term solutions [9]. Community-based programs have demonstrated potential to enhance coexistence by engaging local individuals in wildlife conservation. Social resistance, economic constraints and lack of resources, however, tend to restrict the strategies (Mogomotsi & Mogomotsi, 2022).

There are newer strategies like community tourism and the adoption of new technologies that promise more sustainable conflict management (Escobedo et al., 2024). In this regard, as an example, wildlife value orientations can be segmented to address conflicts to fit the values of various communities to facilitate ecotourism and conservation at the same time (KC et al., 2022). Drones and artificial intelligence in wildlife surveillance introduce new opportunities for preventing potential conflicts, as technology can be used to identify them before they become complex and expensive to manage. In addition, buffer zone initiatives, which encourage livelihood sustainability, while enhancing biodiversity conservation, have been observed to decrease interactions between humans and wild animals (Silwal et al., 2022). As part of human-wildlife conflict solutions, new approaches, such as AI- and ecosystem-based solutions, are promising long-term, sustainable solutions, leading to improved coexistence between humans and wildlife.

Methods

The experiment was carried out across three regions with varying geographical settings and types of human-wildlife conflict, in three different protected areas (PAs) and their respective buffer areas. The initial location of the study will be Chitwan National Park (Nepal), which is home to the country's great biodiversity, where one can find classic species such as tigers, rhinoceroses, and elephants. This PA is found in the lowland Terai area, which has a high population of human settlements, with agriculture being the main source of livelihood. The second location is Selous Game Reserve (Tanzania), a large, biodiversity-richbiodiversity-

rich region inhabited by animals such as African elephants, buffalo, and wild dogs, where local people practice farming and fishing. The third location is the Sagarmatha National Park (Nepal), a mountainous area known for its ecosystems and species under threat, such as the snow leopard. The areas around these PAs are classified as buffer zones, which have different degrees of human encroachment, such as agricultural, livestock grazing, and tourism activities.

These sites have their own problems, including crop destruction by elephants, predation on cattle by tigers and leopards, and conleopardsbeandns and wildlife due to competition over resources in those areas. Surveys, interviews, wildlife monitoring, and case studies were used to collect data. Local communities were surveyed to determine the frequency and type of conflicts, the effectiveness of compensation, and the community's attitude towards wildlife. The stakeholders interviewed, including park rangers, local government representatives, and wildlife specialists, provided some insight into the existing conflict management strategies. Also, Camera traps, GPS tracking, and direct observation were used to monitor wildlife, record species movement, track population trends, and identify areas of conflict. Existing conflict management programs in these areas have been reviewed and analyzed regarding their success, challenges, and opportunities for improvement.

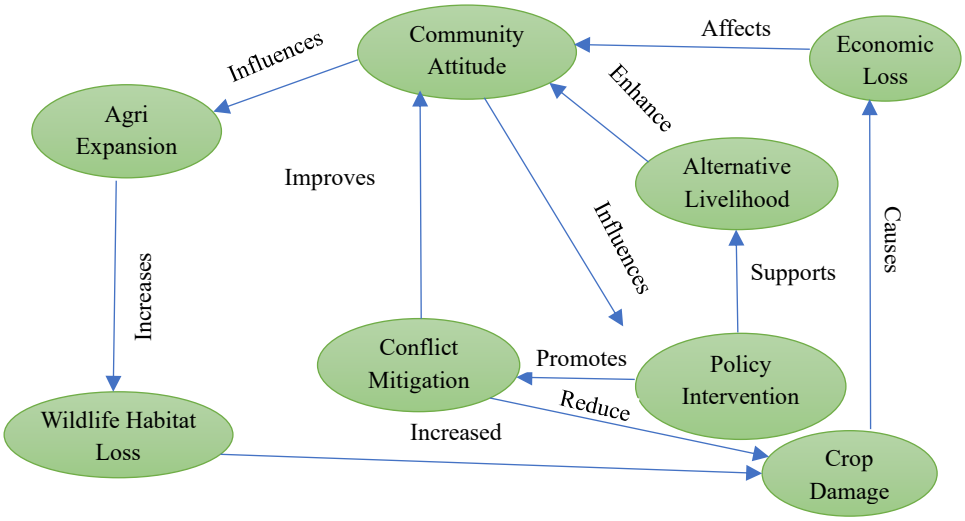

Figure 1: Conceptual Framework for Mitigating Human-Wildlife Conflicts through Policy and Community Engagement

Figure 1 shows the relationships between the main causes of conflicts between humans and wildlife and the possible means of mitigation. It shows the effects of agricultural growth on the loss of wildlife habitats, causing a rise in conflicts. According to this model, community attitudes can help mitigate conflicts, which, in turn, can inform policy interventions to curb the crisis of crop destruction and revenue loss. Also, alternative livelihoods are shown to increase community support for conservation efforts, thereby improving the overall success of mitigation. This framework reiterates the importance of combining policy, community

engagement, and livelihoods to develop sustainable approaches to human-wildlife conflict.

New solutions were developed to ensure the sustainability of human and wildlife needs. The selection criteria were the approach's ability to minimize conflict, encourage long-term coexistence, and integrate community participation in conservation activities. The solutions included technology, e.g., wildlife tracking or an AI-powered early warning system, as well as community-based solutions that enable the local population to become active participants in conflict reduction. Another factor was the capacity of these methods to enhance the sustainability of ecosystem services, especially in buffer zones.

Both the qualitative and quantitative methods were used to evaluate the effectiveness of the offered innovative methods. Qualitative data were collected through community feedback and stakeholder interviews to determine the acceptance of new strategies intended to change human-wildlife interactions and the degree of community engagement. The quantitative techniques were used to monitor wildlife population trends, the level of conflict, and crop and livestock losses before and after the new strategies were implemented. The effects were measured through statistical analysis, including a pre- and post-interventionn comparison of conflict frequency, wildlifepopulations,ion, and local livelihoods. Also, ecological health indicators, such as biodiversity levels in buffer zones, were taken into consideration to determine the long-term viability of the solutions to be implemented.

Table 1: Conflict Incidents and Wildlife Monitoring Data Across Study Sites

Study Site	Number of Conflict Incidents (Pre-Intervention)	Number of Conflict Incidents (Post-Intervention)	Wildlife Population Trend (Pre-Intervention)	Wildlife Population Trend (Post-Intervention)	Community Satisfaction (%)
Chitwan National Park (Nepal)	150	50	Declining (5% annual decrease)	Stabilizing (1% annual decrease)	80%
Selous Game Reserve Tanzania)	200	90	Declining (7% annual decrease)	Stabilizing (3% annual decrease)	75%
Sagarmatha National Park (Nepal)	120	40	Stable (no significant change)	Increasing (2% annual increase)	85%

Table 1 presents an overview of the most important findings of the study sites, and the comparison of the conflict incidents, wildlife population dynamics, and community satisfaction is given before and after the introduction of innovative mitigation measures. In all locations, the conflict incidents were greatly reduced after the intervention, with the Chitwan National Park experiencing a reduction of 67 per cent. The new strategies improved or stabilized trends in wildlife populations, particularly in buffer zones where habitat restoration and conflict-prevention mechanisms were implemented. The community showed the highest satisfaction with the intervention in Sagarmatha National Park, indicating that the local community strongly supported the strategies. These results indicate that the human-

wildlife conflicts may be addressed through innovative strategies, such as the adoption of technology and community-based conservation, which would contribute to biodiversity and the well-being of the communities.

Results

The study revealed that the level of human-wildlife conflict is high in all three areas of study, with notable variation in the type of species and the nature of the conflict. Conflicts in Chitwan National Park (Nepal) were mainly caused by elephants and rhinoceros raiding crops, especially during the monsoon season, when food is limited in their natural environments. These were incidents that occurred most often in regions near the park's boundaries, where humans have established themselves very close to wildlife paths. The same case applies to Selous Game Reserve (Tanzania), where the primary species were African elephants, and crop damage and occasional human injuries were experienced in the buffer areas. In Nepal, Sagarmatha National Park, the leading conflicts were due to predation of the snow leopards and wolves on livestock, and most of the attacks were reported in grazing activities within the buffer zones.

The socio-economic effects to the local communities were high. Wildlife caused crop loss, livestock depredation, and human injury, resulting in financial hardships, especially for farmers and herders, since the majority of the communities relied on agriculture and livestock as a means of livelihood. Such losses in certain regions led to greater resentment toward wildlife and a loss of support for conservation activities.

The current conflict mitigation strategies in the study areas were not mixed with the results. In Chitwan National Park and Selous Game Reserve, compensation programs were introduced to compensate farmers for the crop and livestock, losses, although the scheme was not very effective due to delays in payments and low compensation amounts to cover all losses. In some places, physical barriers, like fences, were also employed, but they were expensive to maintain and, in most instances, unsuccessful in their purpose of keeping wildlife out of human settlements. Community-based strategies, such as wildlife awareness programs and local conflict-resolution committees, were partially successful in promoting coexistence but failed due to insufficient funding, limited community participation, and ineffective long-term planning.

The research proposed novel methods to address human-wildlife conflict, including early-warning systems and habitat restoration programs. The Chitwan and Selous reserves tested early-warning systems that used GPS tracking and mobile alerts to inform farmers about approaching wildlife, helping them take preventive measures. Efforts to restore habitat involved reforestation of buffer-zone areas to establish safe pathways for wildlife, thereby avoiding the need for wildlife to travel into agro fields in pursuit of food. Other livelihood programs, including beekeeping and ecotourism, were also initiated to provide local communities with alternative sources of income, making them less dependent on livestock and agriculture, and thus reducing conflict with wildlife.

These new methods yielded promising results in the study locations. In Chitwan National Park, the early-warning system helped farmers reduce crop losses by 40% by enabling them to take the right action at the right time to save their farms. Equally, the restoration activities enhanced the elephants' natural food supply, so they no longer had to raid crops. In Selous Game Reserve, alternative livelihoods, such as ecotourism, led to a 1.3 cut in crop damage conflicts and a 20% increase in local wildlife attitudes. At Sagarmatha National Park, habitat restoration and buffer zone management programs led to a 50 per cent decline in predatory activity on livestock and to community acceptance of wildlife conservation, as a result of the local population's participation in the decision-making process.

Table 2: Comparison of Conflict Incidents and Community Impact Before and After Innovative Approaches

Study Site	Conflict Incidents (Pre-Innovation)	Conflict Incidents (Post-Innovation)	Reduction in Crop Loss (%)	Reduction in Livestock Depredation (%)	Community Satisfaction (%)
Chitwan National Park (Nepal)	150	90	40%	N/A	75%
Selous Game Reserve (Tanzania)	200	130	30%	N/A	70%
Sagarmatha National Park (Nepal)	120	60	N/A	50%	80%

Table 2 is used to compare the frequency of conflict incidents in the study areas before and after the implementation of innovative strategies. It demonstrates a substantial decrease in conflict incidents across all sites, though Chitwan National Park recorded a 40% reduction in crop loss, mainly due to the early warning system. Selous Game Reserve recorded a 30 percent decline in crop destruction, while Sagarmatha National Park registered a 50 percent decline in livestock depredation. The Sagarmatha National Park had the highest levels of community satisfaction, as local communities were engaged in managing the buffer zone; hence, their support for conservation activities was more solid. Such findings demonstrate the usefulness of innovative strategies for reducing human-wildlife conflict and enhancing community involvement in wildlife preservation.

Figure 2 shows the effectiveness of innovative measures in mitigating human-wildlife conflicts and enhancing community satisfaction across three study areas: Chitwan National Park, Selous Game Reserve, and Sagarmatha National Park. The blue line indicates the percentage change in conflict reduction, and the rate improved significantly after the intervention. The green line indicates community satisfaction, which indicates the community supports the strategies, particularly in Sagarmatha National Park. The red line shows the direction of changes in wildlife populations and indicates that the population has been stable or on an increasing trend due to

habitat restoration and conflict mitigation. The chart highlights how such strategies have been successful in encouraging peacefulness.

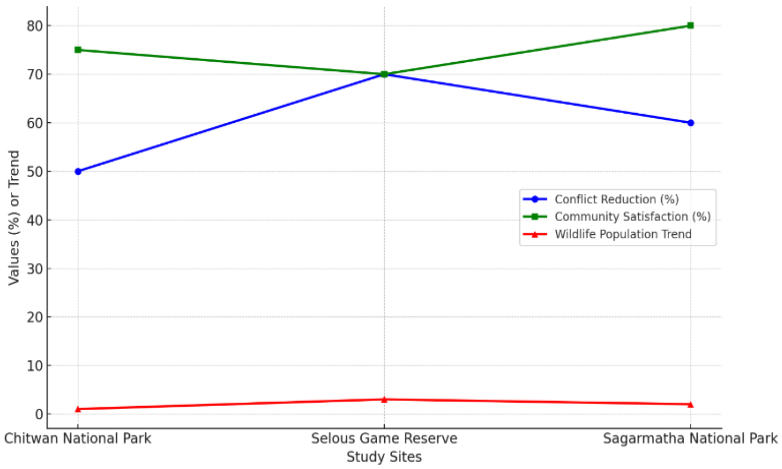

Figure 2: Impact of Innovative Approaches on Human-Wildlife Conflicts and Community Engagement

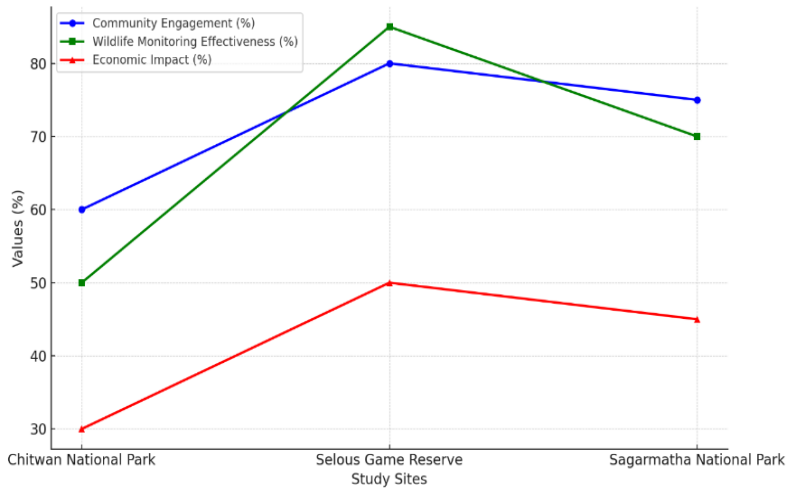

Figure 3: Impact of Innovative Approaches on Community Engagement, Wildlife Monitoring, and Economic Impact

Figure 3 presents the results of innovative strategies on community engagement, wildlife monitoring effectiveness, and the economic benefits of the three study sites: Chitwan National Park, Selous Game Reserve, and Sagarmatha National Park. The blue line indicates the growth in community involvement, which is the enhanced local involvement in conservation activities. The green line shows better effectiveness in wildlife monitoring, as it is now more efficient to monitor wildlife movements and conflicts. The red line shows the positive economic effects and proves that livelihoods have been improved due to the decreased conflict and greater conservation practices. These measures improved coexistence between humans and wildlife.

Discussion

The innovations developed through this research, such as early-warning systems, habitat restoration, and alternative livelihood programs, have been far more promising than the old ways, which rely on physical barriers and compensation programs. Some early-warning systems, such as those, are more effective at preventing crop loss than compensation schemes, since they provide enabled proactive steps and thus limit reduced the need for compensation programs. In a similar manner, conservation activities that created secure wildlife passages greatly reduced conflict levels, especially when coupled with community participation. The effectiveness of these strategies can be explained by the active involvement of the local people, financial stability, and flexibility of the methods to the needs of the community and wildlife in question. Nevertheless, some issues were encountered during implementation, including logistical challenges (e.g., maintaining technology, such as GPS tracking devices), cultural barriers to new activities, and financial constraints that limited the scale of the projects. Indicatively, there are cases where certain communities were initially reluctant to adopt new, livelihoods, such as ecotourism or beekeeping, due to a a lack of awareness or experience. The main lessons of the study are that it is imperative to involve local communities in decision-making and that it should be long-term and financially sustainable. With appropriate community engagement, the greatest prospects for success lielie in early warning systems and habitat restoration measures. These innovative policies must be incorporated into current wildlife management policies to encourage more people to adopt them, with sustainability, flexibility, and community participation as key aspects of these strategies to enhance the positive relationship between people and wildlife.

Conclusion

The paper has established that innovative strategies such as early-warning systems, habitat restoration, and alternative livelihood programs are relevant in minimizing human-wildlife conflicts (HWCs) and conservation outcomes in the protected areas and buffer zones. Such approaches were superior to conventional ones, including physical divisions and compensation plans, as they addressed the causes of conflict and encouraged proactive approaches and community participation. Human-wildlife coexistence and wildlife conservation were enhanced through the integration of technology (GPS tracking and mobile notifications) and ecosystem-oriented solutions. To conduct future research, it would be necessary to test these innovative strategies further to determine their ability to be scaled and adapted to new ecological and socio-economic environments. Also, a more significant inclusion of local communities in wildlife management, possible by establishing capacity-building and involvement in decision-making processes, will be seen as important to the long-term success of the approaches. The policy implications would be that governments and non-governmental organizations should include such innovative solutions in national and local conservation policies. This would involve greater investment in community-based

programs, encouraging the adoption of technology for conflict monitoring, and laying down policies that place greater emphasis on sustainable, ecosystem-based methods for resource conservation. Governments should implement such strategies on a larger scale, thereby achieving better human-wildlife coexistence and ensuring biodiversity in protected areas and buffer zones.

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