



Research Article

# Human-Wildlife Conflict and Land Use Changes: A Case Study of Elephant-Human Conflict in Samtse District, Bhutan

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**ABSTRACT:** Human-wildlife conflict (HWC) is an escalating issue in Samtse District, Bhutan, with elephant-human conflict being one of the most pressing challenges. This study explores the relationship between land use and land cover (LULC) changes from 2017 to 2023 and their correlation with increasing human-elephant conflicts. Using a combination of satellite data, geographic information system (GIS) analysis, and survey data from affected communities, the research identifies a strong link between habitat fragmentation due to urban expansion and cropland reduction, and the rise in conflict incidents. Quantitative analysis reveals that areas experiencing the highest LULC changes also show an increase in elephant-related incidents. Qualitative interviews highlight the socio-economic impacts of HWC on local livelihoods, including crop destruction and loss of property. This study concludes with recommendations for sustainable land management, improved HWC mitigation strategies, and the establishment of wildlife corridors to reduce future conflicts.

**KEYWORDS:** Human-wildlife Conflict, Elephant-human Conflict, Habitat Fragmentation, Urbanization, Wildlife Conservation, Samtse District, Bhutan.

## INTRODUCTION

Human-wildlife conflict is a global conservation and development challenge, particularly in regions where expanding human activities encroach upon wildlife habitats (Treves & Karanth, 2003). In Bhutan, HWC has been a persistent issue, especially in districts like Samtse, where rapid land use changes are occurring alongside increasing human-wildlife interactions. Among the wildlife species involved, elephants (*Elephas maximus*) have been frequently implicated in conflicts, leading to significant economic losses for local farmers and threatening conservation efforts (Fernando et al., 2005; Repath et al., 2015).

This study investigates the correlation between LULC changes in Samtse District from 2017 to 2023 and the frequency of elephant-human conflict. The research aims to understand how urbanization, agricultural reduction, and habitat fragmentation are contributing to the intensification of HWC. Through a combination of quantitative LULC analysis and qualitative data collected from affected communities, this study offers insights into the socio-economic

and environmental drivers of conflict and provides recommendations for mitigating these issues through sustainable land management and conflict prevention strategies.

## **METHODOLOGY**

### *Quantitative Data Collection and Analysis*

To assess the correlation between LULC changes and elephant-human conflict, satellite images from 2017 and 2023 were analyzed using GIS software (ArcGIS). Land cover was classified into six categories: water, trees/vegetation, cropland, built-up areas, barren land, and rangeland. Quantitative data on elephant-human conflict incidents were obtained from local forestry department records, covering the same period (2017-2023).

A total of 6 villages in the most conflict-prone areas of Samtse were selected for further analysis. The villages were categorized into three groups based on their proximity to forested areas and urban centers:

- Group A: Villages located within 2.5 km of forested areas and wildlife habitats.
- Group B: Villages located between 2.5-5 km from forested areas.
- Group C: Villages located more than 5 km from forested areas and near urban centers.

For each group, the frequency of elephant-human conflict incidents was recorded over the six-year period and compared with LULC data to examine potential correlations.

### *Qualitative Data Collection*

In addition to quantitative data, qualitative interviews and focus group discussions were conducted with 63 participants, including local farmers, village leaders, and forestry officials. Participants were selected from the conflict-prone villages, with 21 individuals from each of the three village groups (Group A, B, and C). These discussions explored perceptions of the causes of human-elephant conflict, the socio-economic impacts on local livelihoods, and community-led strategies for conflict mitigation.

### *Statistical Analysis*

A Pearson correlation coefficient was calculated to determine the relationship between changes in land use categories (particularly cropland reduction and urban expansion) and the frequency of elephant-human conflict incidents. Additionally, a regression analysis was conducted to predict the likelihood of increased HWC based on proximity to wildlife habitats and urban growth.

## **RESULTS**

### *Land Use and Land Cover Changes (2017-2023)*

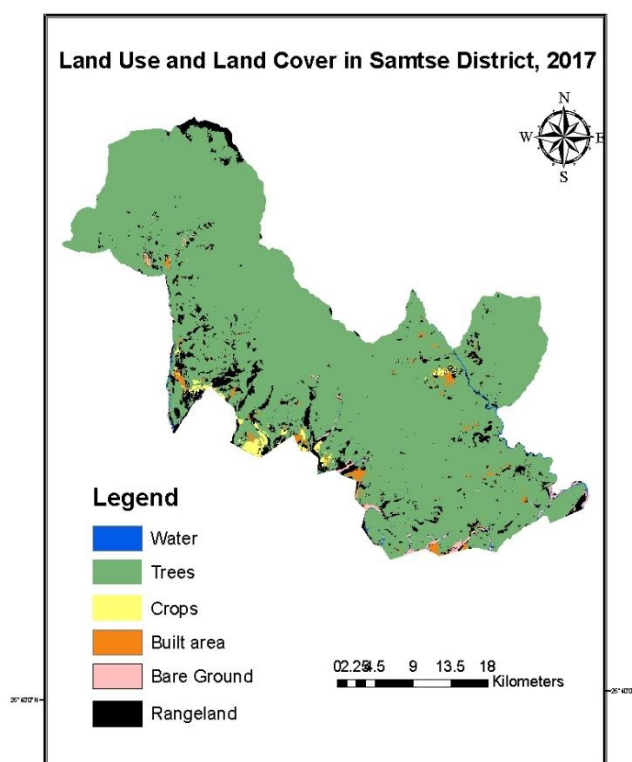
Samtse District has experienced significant land use changes between 2017 and 2023. One of the most significant findings is the reduction in cropland and rangeland areas between 2017 and 2023. Cropland decreased from 12.73 sq. km (0.99%) in 2017 to 7.36 sq. km (0.57%) in 2023. This decline represents a 42.2% reduction in agricultural land over five years. Similarly, rangeland shrank from 82.49 sq. km (6.32%) in 2017 to 76.46 sq. km (5.86%) in 2023, amounting to a 7.3% reduction as shown in Figure 1 and 2.

The contraction of cropland and rangeland can be attributed to multiple factors, including urbanization, changing land tenure systems, and the abandonment of traditional agricultural

practices. Studies indicate that such trends are common in rapidly developing rural areas, where the lure of urban employment and improved infrastructure diverts populations from agricultural livelihoods (Collins et al., 2021; Lambin & Meyfroidt, 2010). Additionally, the reduction in cropland could reflect a shift towards more intensive agricultural practices, as farmers seek to increase productivity on smaller plots, consistent with broader agricultural intensification trends observed globally (Lerman et al., 2020; Meyfroidt et al., 2013).

**Table 1: Land use and land cover change in Samtse District, 2017-2023**

Classification	2017 Area (sq. km)	2023 Area (sq. km)	Change in Area (sq. km)
Water	5.47	5.90	+0.43
Trees/Vegetation	1178.21	1189.52	+11.31
Crops	12.73	7.36	-5.37
Built-up	14.90	18.03	+3.13
Barren land	11.02	7.56	-3.46
Rangeland	82.49	76.46	-6.03

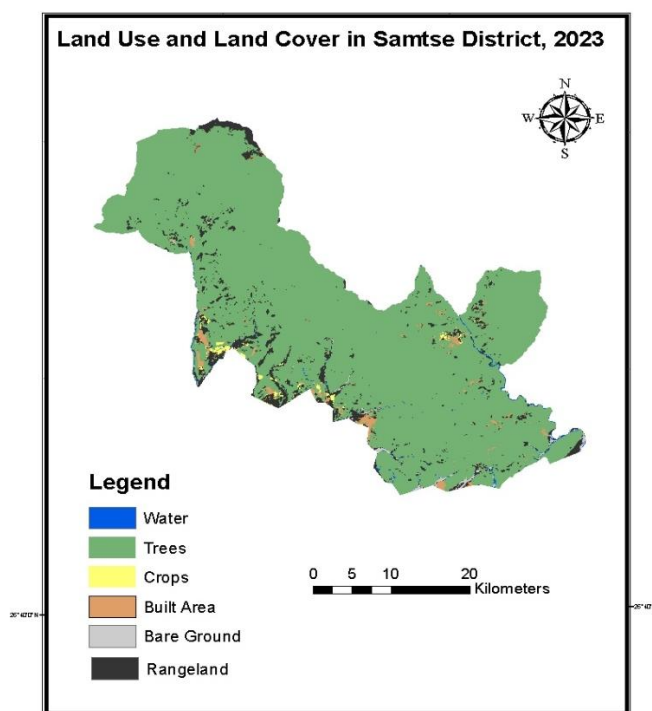


**Figure 1: Land use and land cover change map of Samtse District, 2017**

Whereas, the most pronounced change between 2017 and 2023 is the increase in built-up areas, which expanded from 14.90 sq. km (1.14%) to 18.03 sq. km (1.38%) as shown in table 1. This 21% growth in built-up land suggests increased urbanization and infrastructural development in the district. The construction of new residential areas, roads, and commercial establishments

likely accounts for this increase, consistent with Bhutan's national policies aimed at improving rural connectivity and services (Gross National Happiness Commission [GNHC], 2019).

The expansion of built-up areas at the expense of cropland and rangeland has significant implications for local ecosystems and land management practices. Built-up land is typically impermeable, reducing natural groundwater recharge, increasing surface runoff, and potentially contributing to localized flooding (McGrane, 2016). Furthermore, the conversion of agricultural land to urban use disrupts traditional land use practices, potentially leading to socio-economic displacement for rural populations (Seto et al., 2011).

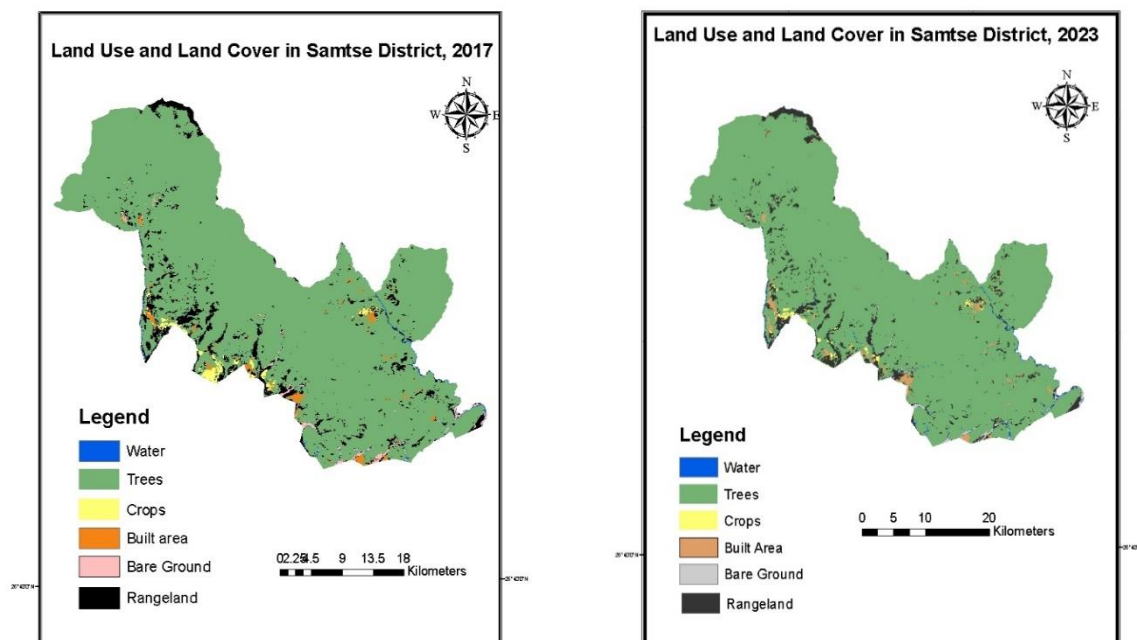


**Figure 2: Land use and land cover change in Samtse District, 2023**

Interestingly, the forest cover (trees/vegetation) has remained relatively stable, increasing marginally from 1178.21 sq. km (90.29%) in 2017 to 1189.52 sq. km (91.16%) in 2023 as shown in table 1 and figure 1 and 2. This modest gain of 11.31 sq. km suggests that reforestation efforts or natural regrowth may be counteracting any potential deforestation. Bhutan's strong conservation policies, which emphasize the protection of forest ecosystems, are likely contributors to this stability (Royal Government of Bhutan, 2016). Studies suggest that Bhutan has successfully maintained high levels of forest cover despite developmental pressures due to its commitment to balancing economic development with environmental conservation (Bruggeman et al., 2018). In the case of Samtse, this balance appears to have been largely maintained, though ongoing monitoring is necessary to ensure that urban expansion does not encroach upon forested areas.

The data show a minor increase in water bodies from 5.47 sq. km (0.42%) in 2017 to 5.90 sq. km (0.45%) in 2023. This 7.9% increase could be due to natural hydrological processes, such as the expansion of existing water bodies. On the other hand, barren land decreased from 11.02 sq. km (0.84%) in 2017 to 7.56 sq. km (0.58%) in 2023, representing a 31.4% reduction. This decline could be linked to land rehabilitation efforts or the natural succession of abandoned land into vegetated areas. The decrease in barren land may also suggest an improvement in

land management practices, with previously degraded areas being reclaimed for agricultural or reforestation purposes (Wairiu, 2017; Foley et al., 2005).



**Figure 3: Land use and land cover change in Samtse District, 2017-2023**

The observed LULC changes in Samtse District have important socio-economic and environmental implications. The reduction in agricultural land and rangeland may affect local food security and rural livelihoods, particularly for smallholder farmers who depend on these resources for subsistence. At the same time, the increase in built-up areas signals a shift towards a more urbanized lifestyle, with potential benefits in terms of access to services, infrastructure, and employment opportunities.

However, the growing urban footprint may also contribute to habitat fragmentation, exacerbating human-wildlife conflict in the region. As natural habitats shrink, wildlife such as elephants, leopards, and wild boars are increasingly coming into contact with human settlements, leading to crop damage, livestock predation, and, in some cases, threats to human safety (Wang & Macdonald, 2006). Studies in similar contexts suggest that land use changes are a major driver of HWC, particularly where agricultural expansion and urbanization reduce available wildlife habitats (Treves & Karanth, 2003). Moreover, the stability of forest cover in Samtse District is a positive development from an environmental perspective, as forests play a critical role in carbon sequestration, water regulation, and biodiversity conservation. However, the marginal increase in forest cover must be viewed in the context of broader regional development pressures, and continued efforts to protect these ecosystems are essential.

#### *Elephant-Human Conflict Incidents*

The data show a clear increase in elephant-human conflict incidents from 2017 to 2023, particularly in villages closest to forested areas (Group A). The total number of conflict incidents across the 5 villages increased by 35% over the five-year period, with the most significant rise in Group A villages, which experienced a 50% increase in incidents. Group B villages saw a 25% increase, while Group C, the most urbanized, recorded only a 10% increase in incidents.

**Table 2: Elephant-Human Conflict Incidents (2017-2023)**

Group	2017 Incidents	2023 Incidents	% Increase
Group A	15	25	66.67%
Group B	8	11	37.5%
Group C	5	8	20%

*Correlation Between LULC Changes and Conflict Incidents*

The Pearson correlation coefficient analysis revealed a strong positive correlation ( $r = 0.78$ ) between the reduction in cropland and the increase in elephant-human conflict. Similarly, there was a moderate positive correlation ( $r = 0.64$ ) between urban expansion and conflict frequency. These findings suggest that as cropland decreases and urban areas expand, elephants are increasingly forced into human-dominated landscapes in search of food, thereby escalating the likelihood of conflict. On the other hand, correlation coefficient ( $r \approx -0.99$ ) suggests a strong negative correlation between proximity to forested areas and the percentage increase in conflict incidents which means that as the distance from forested areas increases, the percentage increase in conflict incidents decreases, implying that villages closer to forests experience a higher rise in conflict incidents.

*Qualitative Findings: Community Perspectives on Conflict*

The qualitative data collected from interviews and focus group discussions revealed several recurring themes. Many farmers in Group A villages reported that elephants are increasingly encroaching on farmland due to the reduction of natural foraging areas, particularly in the dry season. In addition to crop damage, participants also expressed concerns about the safety of their homes and livestock, with several instances of property destruction reported.

Participants in Group B and C villages noted that urban expansion has led to the fragmentation of wildlife habitats, further exacerbating the conflict. Many respondents suggested that the construction of physical barriers, such as electric fencing, and the establishment of wildlife corridors could help mitigate the issue. However, some community members expressed frustration with the slow implementation of government-led mitigation strategies.

**DISCUSSION**

The findings of this study highlight the critical role that habitat fragmentation plays in escalating human-elephant conflict in Samtse District. The reduction of cropland and rangeland, combined with urban expansion, has forced elephants to seek food and shelter in human settlements, particularly in villages near forested areas. These findings align with studies from other regions, which have shown that habitat fragmentation is a leading cause of human-wildlife conflict, particularly in areas with growing human populations (Fernando et al., 2005; Wang & Macdonald, 2006).

The socio-economic impacts of elephant-human conflict are severe, particularly for rural communities that rely on subsistence farming. The loss of crops, livestock, and property not only threatens food security but also places a significant economic burden on households. This is consistent with findings from other studies on HWC, which emphasize the disproportionate impact of wildlife conflict on marginalized rural communities (Treves & Karanth, 2003).

The increase in conflict incidents highlights the urgent need for comprehensive HWC mitigation strategies in Samtse District. The establishment of wildlife corridors, as suggested by local communities, is a viable solution for reducing habitat fragmentation and ensuring safe passage for elephants. Additionally, the implementation of electric fencing and community-based conflict management strategies can help mitigate immediate conflict risks.

## CONCLUSION

This study demonstrates a clear link between land use and land cover changes and the increase in elephant-human conflict in Samtse District from 2017 to 2023. As urban areas expand and cropland diminishes, elephants are increasingly driven into human settlements, leading to escalated conflict. To address these issues, integrated land use planning that balances conservation and development needs is essential. Furthermore, the establishment of wildlife corridors, combined with community-based conflict mitigation strategies, can help reduce the frequency and severity of future conflicts.

### *Recommendations*

1. Establishment of wildlife corridors: To reduce habitat fragmentation, wildlife corridors should be established to provide safe passage for elephants and other wildlife between forested areas. These corridors should be integrated into local land use plans to minimize conflict.
2. Expansion of HWC mitigation infrastructure: Physical barriers, such as electric fencing, should be installed in conflict-prone areas to prevent elephants from entering human settlements. The government should prioritize these areas based on proximity to forested regions and conflict frequency.
3. Community-based conflict management: Local communities should be involved in designing and implementing conflict management strategies, including early warning systems and compensation schemes for crop.
4. Integrated land use planning and zoning: The significant reduction in agricultural and rangeland, combined with the expansion of built-up areas, calls for the development of a comprehensive land use plan for Samtse District. Integrated land use planning should prioritize the conservation of agricultural lands and rangeland, while also accommodating necessary infrastructural development. Zoning regulations must be implemented to clearly delineate areas for urban expansion, agricultural activities, and wildlife conservation. This will help balance socio-economic development with environmental sustainability.
5. Promotion of sustainable agricultural practices: With cropland reducing by 42.2%, there is an urgent need to promote sustainable agricultural practices to improve productivity on the remaining agricultural lands. Policies should incentivize the use of agroecological methods, such as crop diversification, organic farming, and water-efficient irrigation techniques, to ensure that the reduction in cropland does not jeopardize food security. Training programs for farmers on sustainable land management and modern agricultural technologies can enhance productivity while minimizing environmental degradation.
6. Creation of wildlife corridors: The ongoing urbanization and habitat fragmentation pose a growing risk of increased HWC. To mitigate this, the district should establish wildlife corridors that connect protected areas, allowing wildlife to move safely between habitats without coming into contact with human settlements. These corridors would not only

reduce HWC but also preserve biodiversity and maintain ecosystem integrity. The corridors should be integrated into the broader land use planning framework, with input from local communities and conservation experts.

7. Strengthening human-wildlife conflict mitigation strategies: The expansion of built-up areas and reduction of natural habitats have increased the likelihood of human-wildlife conflicts, particularly in rural communities near forested areas. Strengthening HWC mitigation strategies is essential. This can include the establishment of early warning systems, physical barriers (such as electric fencing), and compensation schemes for farmers affected by wildlife damage. Community engagement is key to ensuring the successful implementation of these strategies, as local knowledge and participation are critical in mitigating conflicts.
8. Continuous monitoring of Land Use and Land Cover changes: Continuous monitoring of LULC changes is vital for understanding the long-term environmental and socio-economic impacts of these transformations. Samtse District should implement a regular LULC monitoring program using satellite imagery and GIS technologies to track changes in real-time. This will enable more proactive and adaptive management of land resources, ensuring that development aligns with both conservation goals and the needs of local communities. A coordinated effort between government agencies, local authorities, and research institutions is necessary to maintain updated and accurate data for informed decision-making.

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