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Research Article
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Human-Elephant Conflict Assessment Based on Compensation Records in Baksa District, Assam, India

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Abstract. In Northeast India, the demands of rising human populations compromise elephant habitats causing human-elephant conflict (HEC). We conducted a study of HEC in Baksa District, Assam, obtaining data from Baksa Forest Division records. HEC mostly occurred during the winter paddy ripening season and the summer fruit ripening season. HEC had a significant impact on villages that border elephant habitats. The majority of HEC incidents involved crop raiding and about 35% were house damages. To reduce HEC, effective mitigation measures such as early warning systems and solar fences, need to be implemented.

Introduction

Human-elephant conflict (HEC) refers to adverse interactions between people and elephants. HEC incidents include crop raiding, property damage, and fatalities affecting both humans and elephants. Although not a new phenomenon, HEC has been escalating across much of elephant range in India, with approximately two human fatalities per day attributed to it (Singh 2024). Loss and fragmentation of elephant habitat due to human activities have caused greater increase of human-elephant interactions and crop raiding (Liu *et al*. 2017).

Cultivations in areas with elephants are vulnerable to raiding, due to elephants' preference for crops (Sukumar 1991). Consequently, easily accessible crops exacerbate HEC (Gubbi 2012). Elephants frequently traverse human-dominated landscapes, including settlements, to reach crops, often resulting in damage to human property (Talukdar *et al*. 2023). Confrontations between humans and elephants during crop-raiding incidents, or human retaliatory actions, lead to injuries and fatalities on both sides.

India is home to the largest population of Asian elephants (*Elephas maximus*), composed of populations in the south, northeast, and north of the country distributed across 23 states (MoEFCC 2017). Assam in the northeast of India has a population of around 5,800 elephants (Piraisoodan *et al*. 2024). Key elephant habitats in Assam comprise protected areas such as national parks and wildlife sanctuaries, the area along the northern borders adjoining Bhutan and Arunachal Pradesh, and hills of the Karbi Anglang Plateau (Piraisoodan *et al*. 2024). Around 85% of Assam's elephant population is concentrated in 12 out of 43 Forest Divisions.

Assam is 78,438 km^2 in extent and has a population density of 398 persons/km^2 (Census of India 2011), which imposes significant pressure on natural resources, particularly forests. The state recorded a loss of 83.92 km^2 of forest and tree cover between 2021 and 2023 (Forest Survey of India 2023). Most of the remaining forests in the state are categorised as open or moderately dense, with minimal coverage of highly dense forests (Forest Survey of India 2023). These factors contribute to the intensification of HEC in the region.

HEC is prevalent along the periphery of elephant habitats in the state and habitat shrinkage has been identified as its primary cause (Talukdar *et al*. 2023). The districts of Baksa and Chirang in Assam are particularly prone to HEC (Talukdar *et al*. 2024). Residents in HEC-affected areas typically seek monetary compensa-

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tion from the government. Compensation claims made by victims are not always accurate and require verification by Forest officials before settlement. The locations of HEC incidents in compensation records are deemed reliable and useful for identifying HEC hotspots (Sengupta *et al*. 2020).

Methodology

Study area

Bodoland, officially known as the Bodoland Territorial Region, is an autonomous administrative region in Assam (Fig. 1). It comprises four districts situated on the northern bank of the Brahmaputra River, below the foothills of Bhutan and Arunachal Pradesh. The Bodoland Territorial Region is located between 26° 7′12″N latitude and 89°47′40″E to 92°18′30″E longitude. The area experiences four seasons in a year: pre-monsoon (March – May), monsoon (June–September), post-monsoon (October – November), and winter (December – February). The temperature drops to around 10°C in January and reaches a maximum of approximately 34°C during July and August (Bhattacharyya *et a*l. 2024). Baksa District is one of the administrative divisions within the Bodoland Territorial Region. The district covers a total area of 2,457 km^2 and has a population of 950,075 (Census of India 2011). It has extensive forests rich in flora and fauna. There were approximately 679 villages in the Baksa District.

The Bodo community forms the largest ethnic group in the region, accounting for approximately 12 million people (35% of the population), followed by the Bengali-speaking Muslim community, which represents the largest minority group (Census of India 2011). The district's economy is predominantly agricultural, with limited urbanisation and industrial development. Majority of the population rely on agriculture for their livelihood. Paddy is the principal staple crop, cultivated in both the summer (June–July) and winter (October–November) seasons; however, winter paddy is more widely cultivated (Kalita & Baruah 2021). Tourism in the region is managed by the Department of Bodoland Tourism, with Manas and Raimona National Parks serving as the primary centres of tourist attraction.

Data collection and analysis

Six years of data (2015–2020) were obtained from the Baksa Forest Division records, covering HEC incidents in the whole of Baksa District. For each HEC incident documented, the following data were extracted; complainant's name, village, location, type of conflict, date and time of the incident and the compensation amount disbursed. Additionally, for crop damages; the extent, and for property damage; the type of household and the extent, for human casualties; name of the victim, age, sex, location and probable cause of the incident, for injuries; whether minor or major. Villages with 11 to 50 HEC incidents over the study period were categorised as highly affected and those with more than 50 incidents as severely affected. HEC incidents were classified into six categories based on the type of loss caused by elephants, as crop losses, house damage, human injuries, combined damage to houses and crops, human fatalities and injury or death of livestock.

Results and discussion

Types of HEC incidents

A total of 1,182 HEC incidents were reported between 2015 and 2020. The largest proportion of incidents were crop losses (N = 709), accounting for 59.98% (χ^2 = 2125.19, d.f. = 5, p<0.0001), followed by house damage (N = 382, 32.32%), human injuries (N = 43, 3.64%), combined damage to houses and crops (N = 30,

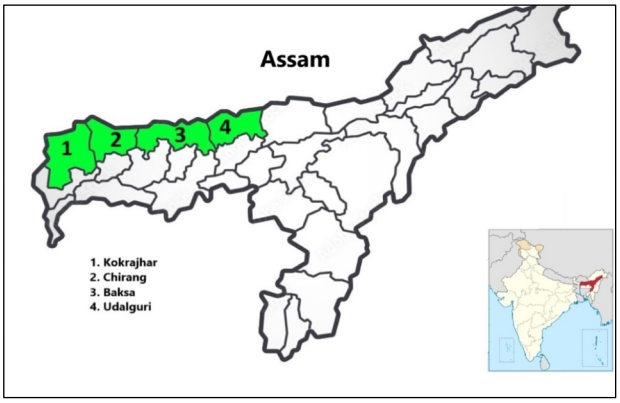

Figure 1. Map showing the Bodoland Territorial Region of Assam, India.

2.54%), human fatalities (N = 10, 0.84%), and injury or death of livestock (N = 8, 0.68%) (Fig. 2).

The main agricultural crop was paddy, and the high prevalence of its raiding underscored its role as the primary driver of HEC. Other incidents of HEC may have arisen secondary to crop raiding. Our findings are consistent with studies conducted in other areas of Assam, such as Manas National Park (Nath *et al*. 2015), Swang Reserve Forest and its adjacent areas in Nagaon District (Baishya *et al*. 2021), and Patharia Hills Reserve Forest in Karimganj District (Talukdar *et al*. 2023). Similarly, studies from other regions of India with different primary crops have also reported crop raiding as the main cause of HEC. For example, Gubbi (2012) found that finger millet, maize, and cotton were mostly raided by elephants in Nagarahole National Park in Karnataka (India), while Patil & Patil (2019) reported that coconut palms were the most frequently damaged crop in Sindhudurg District of Maharashtra, India.

A total of 382 houses were damaged, and an additional 30 houses were damaged along with crops. Property damage commonly occurred when elephants attempted to access harvested paddy stored inside or outside the houses, when raiding banana plants in home gardens, or when moving through human settlements to reach agricultural fields.

Our findings indicate that HEC is closely linked to the maturity of the paddy crop and the ripening of summer fruits as HEC incidents were high at these times. Although the summer season aligns with the rainy season during which elephant habitat conditions are considered favourable, elephants appeared to preferentially raid jackfruit and banana. Since these fruit trees are typically cultivated in home gardens, such incidents often led to property damage.

The records indicated that 43 injuries and 10 fatalities of people occurred during the study period. Based on the government records, Mohan (2024) reported that 383 people and 89 elephants lost their lives from HEC in Assam between 2019 and 2024 giving a ratio of human: elephant deaths of 4.3:1. The Baksa Division re-

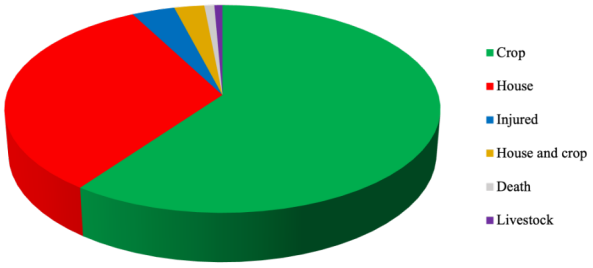

Figure 2. Number of HEC incidents in Baksa District of Assam from 2015-2020.

cords an average of 0.070 human deaths per year per 100 km^2 due to HEC, which is lower than the state (Assam) average of 0.089. In comparison, several other Forest Divisions reported much higher human mortality rates, including Udalguri at 0.854, Goalpara at 0.801, Tinsukia at 0.169, Nagaon at 0.141, Kamrup at 0.120 and Sonitpur at 0.092 (Talukdar *et al*. 2024). These higher values collectively contribute to an increase in the state's overall average.

Temporal distribution

HEC intensity exhibited significant variation across years (χ^2 = 49.88, d.f. = 4, $p < 0.001$). It was highest in 2017 and lowest in 2018 (Fig. 3). Incidents were highest during June–July and October–November (Fig. 4). The peak in October–November coincided with the late autumn to early winter period, when paddy matured. Elephants entered the crop fields at night to feed on the ripening paddy. Studies such as those by Das *et al*. (2012), Nath *et al*. (2015) and Talukdar *et al*. (2023) corroborate that the peak period of HEC aligned with the crop maturity season in late autumn and early winter. Another notable period of HEC occurrence in Baksa was during

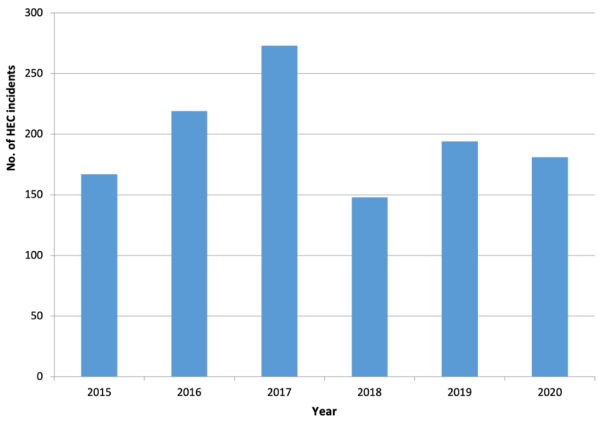

Figure 3. Annual number of HEC incidents in the Baksa District.

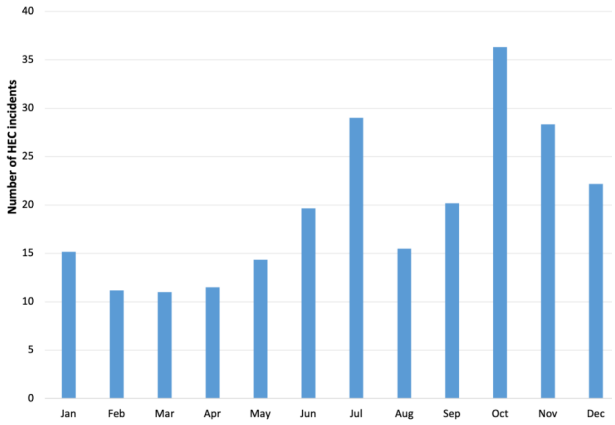

Figure 4. Average number of monthly HEC incidents in the Baksa District.

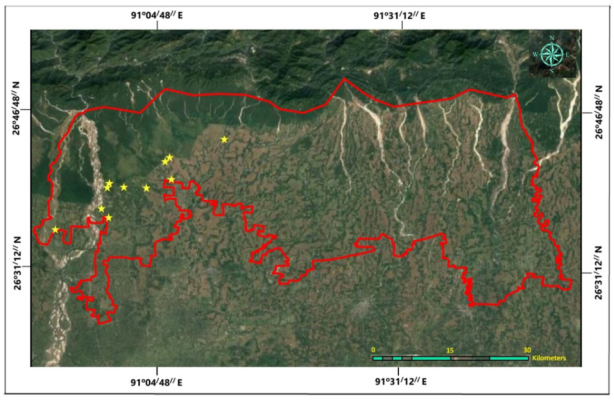

Figure 5. Villages in Baksa District commonly affected by HEC. The dark-green-shaded regions denote the Manas landscape.

July, coinciding with summer, when summer paddy began to mature. Houses and crops in home-gardens were also frequently damaged by elephants in summer, when jackfruit ripened. Home-gardens were generally not raided during the winter, possibly because mature paddy crops were widely present, unlike in summer when they were limited to a few fields. Winter fields were also often located away from human dwellings, reducing the likelihood of human-elephant encounters.

Spatial distribution of HEC

HEC incidents occurred in 105 villages between 2015 and 2020, representing 15.46% of the total 679 villages in the district. However, the actual proportion of the villages is considerably lower because many of the villages listed in the compensation records are parts of larger official villages, and these smaller units were recorded to accurately identify the victims.

The HEC affected villages were situated along the southern border of the Manas landscape, as indicated by the green-shaded areas in Figure 5. Notably, over two-thirds (70.39%) of these incidents were in 16 villages. Among them, five villages were severely affected (Fig. 6) and 11 villages highly affected (Fig. 7). Many villages (n = 46) only experienced single conflicts between the study periods. The severely affected villages were Bhuyanpara, Bansbari, Raghabbil, Karebari and Barengabari while the highly affected villages were Madanguri, Pakriguri, Chukrungbari Pathar, Daoraibari, Kumguri, Kagrabari, Gyatigoan, Katajhar Pathar, Kokilabari, Khusratari and Mayanagpara. In villages such as Bhuyanpara, Bansbari, and Raghabbil HEC incidents were recorded during both the summer and winter seasons in all years. The areas with severely and highly affected villages require special attention and targeted measures to mitigate the conflict.

The average crop area damaged by elephants in the study area was 0.85 acres, ranging from 0.33 to 2.47 acres (± 0.79), which is relatively small compared to the 1.28 acres reported by Talukdar *et al*. (2023) in the Patharia Hills Reserve Forest of Assam and 2.77 acres reported by Gubbi (2012) around Nagarhole National Park of Karnataka. Kalita & Baruah (2021) found that most farmers in Baksa District possessed less than 1 hectare (2.47 acres) of land. Also, elephants in our study area, did not remain in a crop field for long while raiding. Therefore, most fields were not completely damaged, pos-

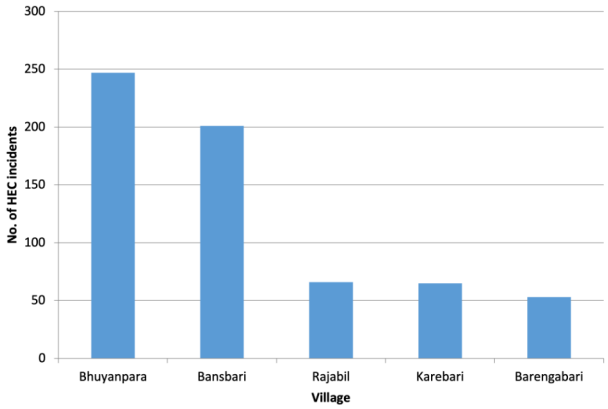

Figure 6. Severely HEC-affected villages in Baksa District.

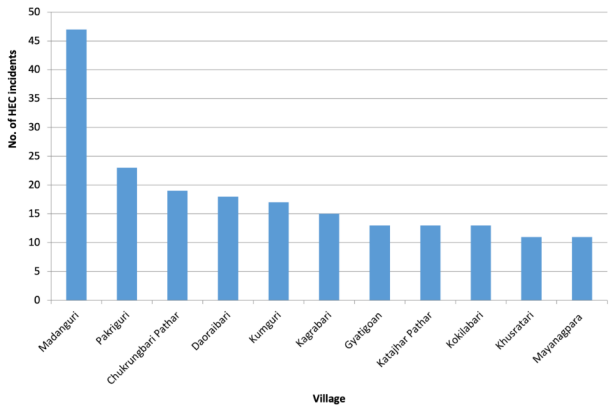

Figure 7. Highly HEC-affected villages in Baksa District.

sibly resulting in a smaller area of damage compared to other regions.

Compensation

Compensation amounts showed significant variation over the years, as they were determined by the number and type of incidents.

On average, those affected by crop-raiding received 4,407 INR (50 USD), compensation for house damage averaged 4,451 INR (50 USD), and for injuries, 12,319 INR (140 USD) (Table 1). The highest total compensation was allocated to crop loss, benefitting 709 persons, with individual payments ranging between 1,500 (17 USD) and 17,000 INR (193 USD), and a total disbursement of 2,974,900 INR (33,823 USD).

Property damage, including houses, remained a pressing issue in the study area. The total compensation paid for house damage was 1,696,000 INR (19,343 USD), with an additional amount of 173,500 INR (1,979 USD) allocated for damages to 30 houses caused by raiding harvested crops (Table 1).

Claims for livestock injury or death due to HEC were the least frequent. Compensation for eight livestock injuries totalled 33,500 INR (382 USD), with individual payments ranging from 2,500 to 9,000 INR, depending on the livestock's size and type (Table 1).

Compensation for human injuries ranged from 5,000 to 30,000 INR depending on the severity of the injury. In total, 455,800 INR (5,198 USD) was paid to 43 injured individuals, with an average payment of 12,318 INR (140 USD) (Table 1).

For 10 human fatalities, a total of 2,200,000 INR (25,091 USD) was disbursed as compensation for ten deaths between 2015 and 2020 in the Baksa District. Until 2017, the compensation amount for a human death was 100,000 INR (1,140 USD), which was then increased to 400,000 INR (4,562 USD).

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Table 1. Annual compensation (INR) paid in the Baksa Forest Division.

Year	Crop (n=709)	House (n=382)	House and crop (n=30)	Livestock (n=8)	Injury (n=43)	Death (n=10)	Total
2015	10,900	417,500	127,000	2,500	54,000	200,000	811,900
2016	211,000	244,000	46,500	0	50,000	0	551,500
2017	1,776,000	699,000	0	22,000	143,000	1,600,000	4,240,000
2018	67,000	18,500	0	0	56,800	0	142,300
2019	678,000	313,000	0	9,000	120,000	400,000	1,520,000
2020	232,000	4,000	0	0	42,000	0	278,000
Total	2,974,900	1,696,000	173,500	33,500	465,800	2,200,000	7,543,700

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