International Journal of Ecology and Environmental Sciences 48: 703-714, 2022
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijees.2022.6703

Impact and Mitigation of Human-Elephant Conflict around Kaziranga National Park, Assam, India

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ABSTRACT

In some areas, human-elephant conflict (HEC) is a key issue for conservation and sustainable rural development due to increasing habitat loss and resource competition, resulting from the climate crisis and increasing human population. This study explored perceptions and experiences of HEC by smallholder farmers in villages near Kaziranga National Park, India. Interviews were conducted with 140 households in 29 villages using a semi-structured questionnaire. Participatory risk mapping was also conducted in three villages to identify perceived risks and their severity. Respondents considered crop-eating as a considerable challenge to efficient and productive farming. HEC scored a risk index of 0.986, greater than wild buffalo and one-horned rhinoceros combined. HEC around Kaziranga National Park is mainly nocturnal and seasonal, with peak activity in winter. Mitigation was primarily traditional 'drive-away' methods of shouting and burning tyres. Villagers considered elephants an embodiment of the elephant God, Ganesha, which has conservation value. The government compensation policy was known to 40% of respondents and 75% of them believed it complex and inadequate based on their experience. Tolerance for HEC was evident; 94% of respondents expressed a desire to remain in their village. Affected farmers recommended solar-powered electric fencing and efficient compensation to reduce HEC impacts. Mitigation measures should engage farmers, build trust, and address perceptions of successful outcomes. Effective HEC mitigation is essential to achieve UN Sustainable Development Goals in affected regions as well as elephant conservation.

Key words: Asian Elephant, Conflict, Mitigation, Perception, Participatory, Risk Mapping

INTRODUCTION

India is home to an estimated population of 30,000 Asian elephants (*Elephas maximus)* (MOEF&CC 2019), approximately 60% of the global population of the species (Sukumar 2006). India has the third greatest amount of wildland area available to wild elephants, after Myanmar and Thailand (Leimgruber et al. 2003). The combined effect of climate crisis, increasing human population, habitat loss, habitat fragmentation, changes in rainfall patterns, and changes in land-use patterns reduce wildland available to elephants, and increase interactions between humans and elephants, resulting in escalated human-elephant conflict (HEC) in India (Choudhury 1999, Sukumar 2006, Kangaraj et al. 2019). HEC impacts elephant and human wellbeing and is a key constraint on agricultural productivity in affected regions (Hopker et al. 2020).

Nearly half a million families are affected by HEC in India annually (Rangarajan et al. 2010), and as vulnerable communities are often pushed to the fringes of settled land, poorer society members are disproportionately impacted by HEC. Conflict due to crop eating is one of the most critical issues in elephant conservation in Africa and Asia (Sukumar 1991, Hoare 2000, O'Connell-Rodwell et al. 2000, Madhusudan 2003, Sitati et al. 2003, Dublin and Hoare 2004, Osborn 2004, Fernando et al. 2005, Sifuna 2010, Sarker and Røskaft 2011, Gubbi 2012). Complete resolution of HEC is unrealistic; however suitable interventions could manage HEC at tolerable levels. Considering local context for any intervention is essential, as techniques effective in one location may not be in another (Hoare 2000). Social influences and perceived risks from wildlife increase the complexity of human-wildlife conflict (Dickman 2010).

Rising human populations increase resource competition between humans and animals . Elephants eat crops, grain stores and damage dwellings. People retaliate, guarding against HEC disrupts normal daily activities, and confrontations risk serious injury.

In 1990s, elephants in Northeast India had almost continuous distribution contacting populations in Bhutan, Nepal, Myanmar and Bangladesh (Choudhury 1999), but these populations are now discontinuously distributed. Assam is a prime conservation area for elephants, but loss and fragmentation of habitats in the last two decades have escalated HEC by isolating populations with limited resources (Choudhury 1999, 2004). Elephants frequently cross interstate boundaries, however, a large number of elephants remain in Assam during the rice cultivation period (Choudhury 1999). Elephants south of the Brahmaputra river in the Kaziranga National Park (KNP) use tea plantations and agricultural fields for movement and crop-raiding (Choudhury 1999). The growth and commercialisation of large tea plantations have been identified as a factor in increased HEC, threatening existing corridors (Sukumar 2006, Baskaran et al. 2011). A study in Sonitpur, Assam, suggested HEC increased dramatically after 1980 when forest cover dropped below 30-40% (Chartier et al. 2011). KNP also attracts elephants from the eastern Karbi plateau during the winter (Choudhury 1987) and remain in the area until the seasonal flood in July- August force them to return to high ground.

In this study, semi-structured questionnaires and participatory risk mapping techniques were used to investigate the attitude of local people to HEC, their response to HEC, their perception of their vulnerability to HEC in the villages around KNP and

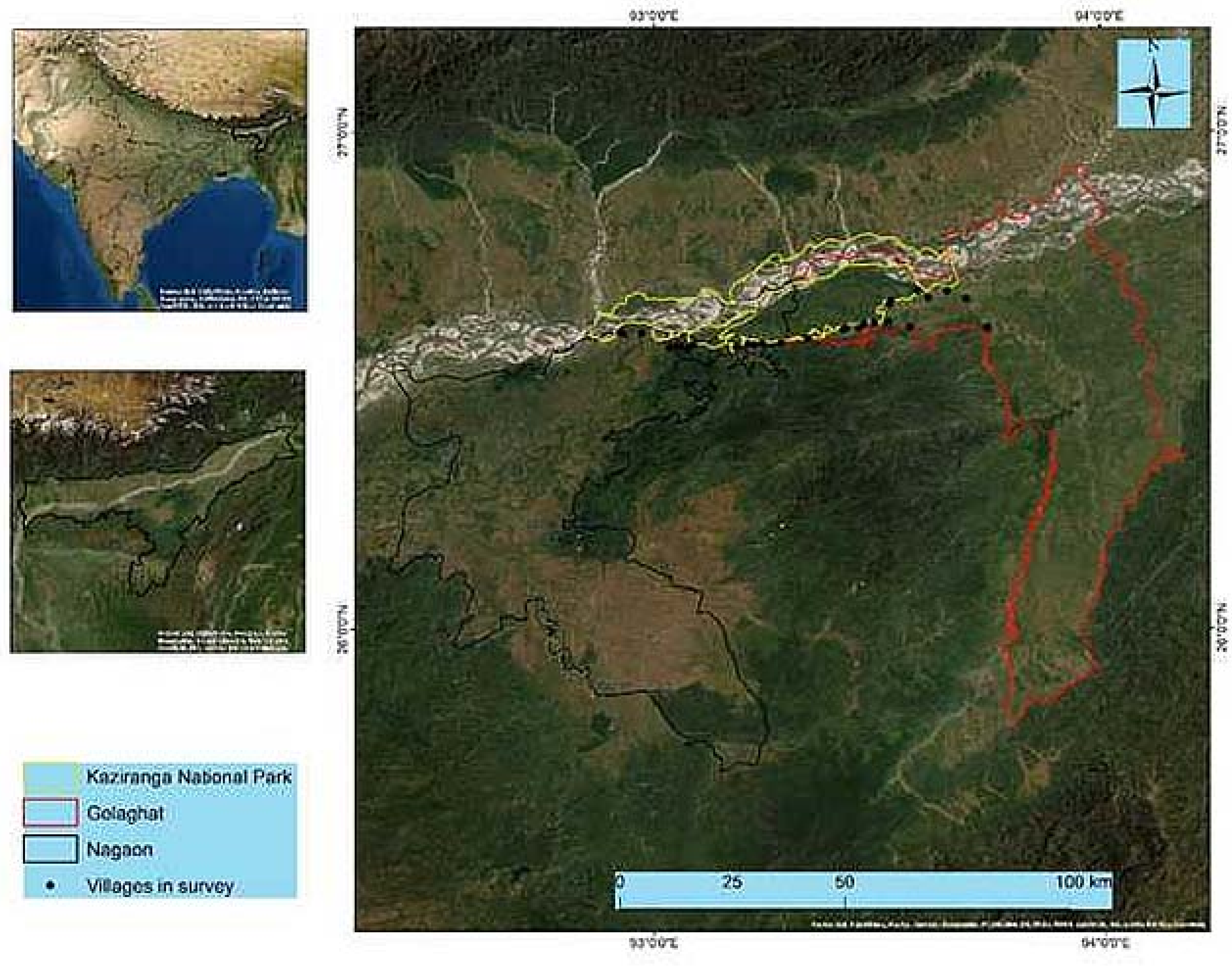

Figure 1. Map showing the location of Kaziranga National Park and study villages

factors affecting their tolerance for the conflict. A mixed method of qualitative and quantitative research was adopted for the study.

MATERIALS AND METHODS

Study area

The study was conducted in 29 villages of Golaghat and Nagaon districts in Assam, India (Fig. 1), at the southern border of the Kaziranga National Park (KNP), a UNESCO World Heritage Site. KNP is part of Kaziranga Tiger Reserve lying between 26.797750 to 26.471837 N and 92.594317 to 93.691783 E and spread over an area of 1055 km^2 Located in the floodplains of the Brahmaputra River, KNP is composed of grasslands, semi-evergreen forests tropical moist mixed deciduous forests, wetlands and sandy chaurs. *Bombax ceiba*, *Albizia procera*, *A. lucida*, *Careya arborea*, *Premna latifolia*, *Lagerstroemia parviflora* and *Dillenia indica* are common species of trees found in the KNP. Diverse climatic conditions and good rainfall support wide range of flora in KNP and which in turn provide refuge to diverse range of wild fauna at KNP which is famous for its one-horned rhinoceros (*Rhinoceros unicornis*). Apart from rhinoceros, it has Asian elephant, Eastern swamp deer (*Rucervus duvaucelii ranjitsinhi*), tiger (*Panthera tigris*), sambar deer (*Rusa unicolor*), Asiatic wild buffalo (*Bubalus arnee*), and hog deer (*Axis porcinus*) amongst 35 species of mammals recorded in the park.

There are 74 villages in the proximity of the Kaziranga National Park on its southern boundary with human population of 66,519 people, with 85% of the families as marginalised and landless farmers (Yadava 2014). The local population could be distinctly identified as Ahom, Mising, Karbi, Santhal, Nepalis and immigrant workers in tea gardens.

The main sources of income for the villagers are working as daily wage labourers, farming, skilled labour work like carpentry, and ecotourism. Nearly three-fourths of the houses in the fringe villages of the park are made of mud walls, bamboos and thatched roof and most of these are vulnerable to damage by wild elephants. Rice is the primary crop mainly using rainwater. Few framers grow mustard too. The soil and rainfall make rice as the first choice of crop.

Elephants in KNP display seasonal movement patterns, descending to the plains of KNP from the Karbi plateau as winter starts and ascending before the annual floods in July- August. KNP is inundated by floodwater from the Brahmaputra River annually.

Methodology

The study aim was to enhance our understanding of the local community's perception of HEC, and recommend suitable conservation measures. The data collection was aimed for both qualitative and quantitative analysis. Data was collected using a semi-structured questionnaire (Supplementary Information) between December 2016 and May 2017. Questions collected information on demographic and socio-economic backgrounds, agricultural practices, intensity and pattern of crop-raiding, characteristics of HEC, mitigation measures, access to institutional support and compensation, tolerance of HEC, and desired support for mitigating HEC. Questions were designed to understand the willingness to co-exist with elephants and identify interventions that the farmers perceived critical.

Our study framed questionnaire based on the theoretical framework of Fishbein and Ajzen's theory of reasoned action (Kurland 1995). The interviews were undertaken in Assamese by a local field worker. This work was designed, carried out, and reported according to the COREQ guidelines for qualitative research (Tong et al. 2007). Within the qualitative approach, an integration of relevant questions for deriving quantitative data to understand the impact of age, education and compensation policy on perceived risks were framed.

In each village, an initial household was randomly selected, after which every fifth household was approached. One adult resident was interviewed in each household. The nature, purpose and scope of the study were explained, and verbal consent recorded. Signed consent was inappropriate due to high level of illiteracy and local mistrust of signed documents. There were up to six interviews per village, and a total of 140 people were interviewed. Each interview took 12-16 minutes. Questions were asked slowly and responses recorded contemporaneously. The interviews were not recorded on any electronic device. The location of every village visited was recorded by GPS (Garmin

Etrex 10).

Participatory risk mapping meetings were undertaken in three villages to obtain data for qualitative analysis. The risk was defined as uncertain consequences and exposure to adverse situations (Smith et al. 2000). Participants were asked to identify risks first and then rank the risks, making it a two-stage effort of ordinal ranking. The selection was not random; participatory techniques have been reported to yield the best results when respondents are willing and talkative (Smith et al. 2000). Participants, selected from different socio-economic backgrounds to be representative of their communities, included teachers, farmers, labours and representatives of local governing bodies. A total of 30 people took part in the participatory risk mapping exercise, ten in each of the three meetings. The villagers indicated their rank for each risk by number of pebbles assigned to each risk. The response was recorded on a chart paper where the lead author moderated the exercise for the villagers to list the risks and then rank them. The qualitative narratives were guided by an understanding of social research's philosophical principles and theoretical assumptions (Moon and Blackman 2014).

Quantitative analysis

Questionnaire data were analysed using the chi-square test of association. Linear regression was used to investigate the relationship between reports of being charged by an elephant and distance from the KNP. Analyses were conducted using the R statistical computing program (R Core Development Team, 2018), statistical significance was considered at 95% confidence.

Risk maps were produced using the methodology described in similar studies (Smith et al. 2000, Quinn et al. 2003, Webber and Hill 2014). The formula $Sj=1+(r-1)/(n-1)$ was used to calculate the severity index for each risk, where r is the rank associated by each respondent for each risk and n is the total number of risks listed by the respondents. The mean value was calculated for all respondents, creating a score ranging from 1 to 2 wherein 1 indicated most severe, and 2 indicated least severe, as described by Smith et al. (2000). To create a more intuitive estimate of severity, a modified severity index was created using the formula $Sjm = (Sj^*-1)+2$ to create an index ranging from 0 to 1, with 0 being the lowest severity and 1 being the maximum severity. An incidence index (Ij) was created to indicate the proportion of respondents mentioning a particular risk, where 0 indicated not mentioned at all and 1 indicated mentioned by all. Risk maps were created by plotting the modified severity index values against the incidence index values to compare farmers' perceived risks of crop damage by wildlife and factors affecting financial returns. A risk index (Rj) was obtained for each perceived risk by multiplying the modified severity index by the incidence index.

RESULTS

Demographic and socio-economic profile of farmers

The interview covered 140 farmers, 38 female and 102 males (Table 1). Out of the 140 farmers, 81% owned their farms, and 19% were landless; 110 farmers interviewed (79%) farmed within 2 km of KNP. All respondents cultivated rice. In addition, 69% also cultivated mustard, 42% grew vegetables, and 8% of farmers grew fruit as commercial crops.

Problem animals and perceived impact of crop raiding

All respondents reported crop-eating by elephants. Many respondents reported crop-eating by other species: wild pig (*Sus scrofa*) 64%; greater one-horned rhinoceros (*Rhinoceros unicornis)* 47%; and hog deer (*Axis porcinus*) 38%. Fewer respondents (15%) mentioned rhesus macaque (*Macaca mulatta*), Asiatic wild buffalo (*Bulbus arnee*), and rose-ringed parakeet (*Psittacula krameri*). About 95% of the farmers considered elephant to cause the most damage to their crops, only 5% believed that wild boar caused the most damage.

During the participatory risk mapping meetings, respondents (n=30) listed a series of different risks they perceived to affect their financial returns from agricultural activities (Figs. 2 and 3). Poor road network, lack of education/awareness, and inadequate veterinary care were perceived as the top three risks, damage by wild animals ranked fourth. One farmer's opinion of the basis of community risks:

> "All our problems arise from lack of education and awareness".

Table 1. Demographic profile of respondents in the survey

	Group	Respondents	
		Number	%
Age	18-30	34	24
	31-40	26	19
	41-50	32	23
	Above 50	48	34
Caste	Scheduled Castes (SC)	48	34
	Scheduled Tribes (ST)	23	17
	Other Backward Class (OBC)	15	39
	General Caste	14	10
Education	Illiterate	96	69
	Primary School	20	14
	High School	19	13
	College	5	4

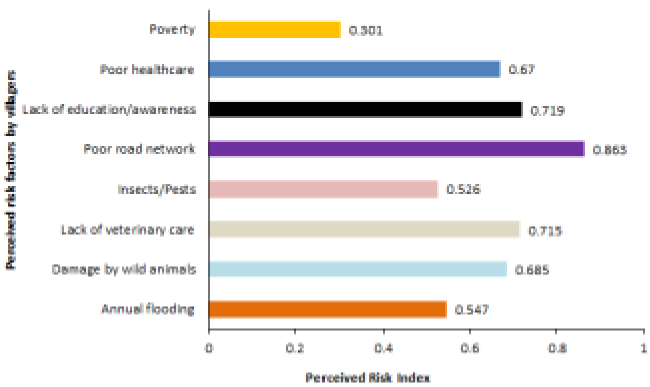

Figure 2. Perceived Risk Index for the risks identified by the villagers during participatory risk mapping

Considering crop eating by wild animals, elephants scored the highest perceived risk index, 0.983, and were considered the main problematic species (Table 2 and Fig. 4). One farmer, inspecting his green rice saplings, remarked:

> "Almost half of the standing crop in my field gets damaged by Baba (farmers address elephants as Baba or father). I also know that half of the crop belongs to him. It is difficult for my family when the crop loss goes beyond 50%. The compensation for the crop lost is not easy to access."

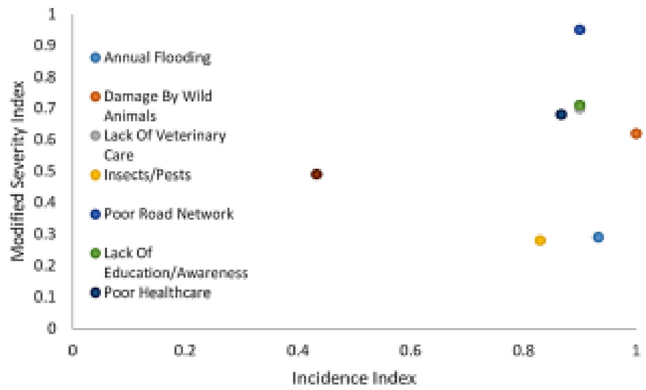

Figure 3. Risk map view depicting farmers' perception of identified risks affecting their financial returns

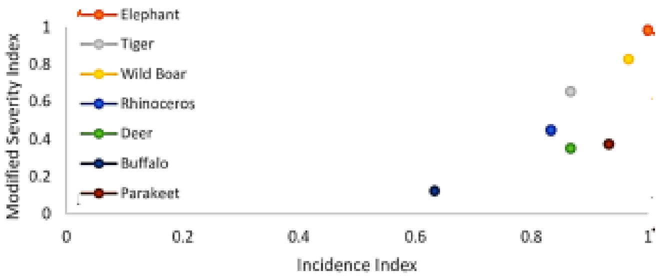

Figure 4. Risk map view depicting farmers' perception of damage caused by elephants proportional to other wild animals

The intensity of elephant attacks

The intensity of elephant attacks experienced in villages reflects in the incidents of being charged,

Table 2. Perceived risk index of problem species of wildlife as stated by the villagers

	Severity Index	Modified Severity Index	Incidence Index	Risk Index
Asian elephant (*Elephas maximus*)	1.017	0.983	1	0.983
Wild boar (*Sus scrofa)*	1.172	0.827	0.967	0.800
Tiger (*Panthera tigris*)	1.346	0.653	0.867	0.566
Rose-ringed parakeet (*Psittacula krameri)*	1.625	0.375	0.933	0.349
Greater one-horned rhinoceros (*Rhinoceros unicornis*)	1.553	0.446	0.833	0.372
Hog deer (*Axis porcinus*)	1.647	0.352	0.867	0.305
Wild buffalo (*Bubalus arnee*)	1.877	0.123	0.633	0.077

challenges to agricultural or non-agricultural properties, and psychological stress. Most (64%) respondents said they had been charged by a crop-raiding elephant, with 16% reporting that elephants caused a human fatality in their village in the last ten years. A further 14% acknowledged cases of psychiatric morbidity or chronic stress in their village attributable to HEC. 20% of respondents who reported human fatalities in their village also reported psychiatric morbidity related to HEC, compared with only 6% of respondents that reported no human fatalities in the last ten years. An elephant's risk of being charged was negatively associated with distance from the KNP (R^2=0.84, $p<0.05$).

Most (77%) respondents indicated they had suffered non-agricultural property losses due to HEC, including damage to houses, household goods, and water pumps. The highest non-agricultural loss due to HEC was reported by respondents classified as Scheduled Tribes and Other Backward Castes (87% of each category), followed by Scheduled Castes (75%) and general castes (29%). There was a significant difference in the perceived number of attacks among various castes (χ^2= 25.757, $p<0.01$, n=140).

Timing and seasonality of HEC

All respondents reported elephants to come to crop fields at night but 24% also experienced crop-loss in the evening. A smaller proportion (9%) believed elephants would damage crops at any time, day or night. Many respondents (65%) believed that full moon made no difference in crop-loss incidents; 27% thought less crop-loss occurred around a full moon. About 80% of farmers interviewed reported that elephants also cross their fields when there is no crop in the field. About 93% believed the maximum intensity of crop-raiding occurred during winter.

Differences were observed in methods used to detect elephants and alert other farmers. Most (75%) said they detected elephants approaching their fields by hearing, while 30% said that, in addition to hearing, they could also see the elephants approaching. Only 68% of under 30-year-olds thought they could hear elephants coming, compared to 88% of villagers over 50 years old. About 50% of farmers said that elephants approached silently, making early detection difficult.

Shouting was the most common method (92%) for informing other farmers about elephants approaching agricultural fields (Fig. 5). As education and economic levels of respondents increases, more and more people now inform neighbours about the presence of elephants. Shouting to inform neighbours was less commonly reported among educated respondents (Fig. 6).

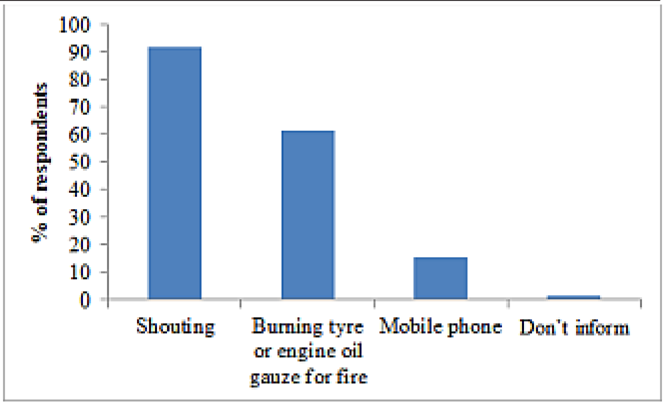

Figure 5. Methods used to inform others

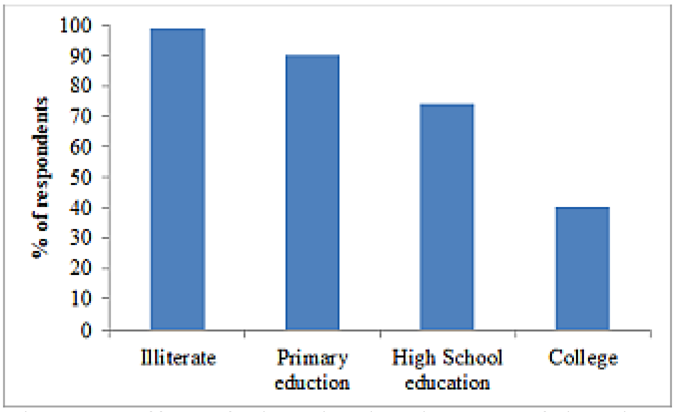

Figure 6. Effect of education level on use of shouting as a technique of passing information to neighbours about elephants approaching agricultural fields. Number of respondents in each category: Illiterate n = 90, Primary n = 20, High School n = 19, College n = 5

Farmers' understanding of crop-eating behaviour

Repeated crop-eating by the same group of elephants was reported by 82% of farmers. A group of elephants adopts visiting certain areas of fields regularly and the group is thus often sighted by villagers and villagers identify the herd with its group formation. While 23% of farmers believed elephants preferred ripe crops, 71% of the farmers in the study area observed elephants engaged in crop-eating at any stage of the crop.

Compensation policy and farmers' access to it

Table 3. Villagers' opinion related to their resolve to face elephants

	Respondents' answers (%)		
	Yes	No	Don't know
Do you think that HEC could be stopped?	13	78	9
Has the human elephant conflict declined in the last ten years in your area?	19	78	3
Do you think elephants will eventually get used to all the mitigation methods?	39	46	15
Do you have access to a watchtower (called *tongi* in local language)?	73	27	0
Do villagers patrol the fields all night when crop is ripe?	84	16	0
Is there a crop loss compensation policy in place from the government?	40	60	0
If yes, then is the procedure complicated and takes time?	75	25	0
Will you continue to live in the same village?	94	4	2

Only 40% of respondents were aware of the Forest Department compensation policy for damages caused by HEC, and 75% of farmers who knew about the compensation policy considered the procedure complicated (Table 3). One third of the farmers (33%) who were aware of the compensation policy said they would attempt to utilise it should their crop be damaged by elephants. About 65% were undecided whether they would approach the Forest Department for compensation for crop loss. Only 19% of the farmers interviewed had received compensation in the past.

Mitigating HEC

Shouting (n=138) was the most commonly employed method to chase away elephants, followed by burning tyres (n=131) (Fig. 5). Chilli powder, whistles, thunder flashes and tobacco, were not reported to be used by any respondent. One farmer's response to the use of chilli for HEC mitigation:

> "The chilli we grow sells by counts not by weight. It fetches very good value. It would be very expensive for us to burn the chilli as a deterrent."

Another farmer was sceptical about the feasibility of using a fence of honey bees:

> "Our Kaziranga bees are small, make less noise and sleep at night. And even if they wake up, they won't produce as much sound to deter elephants. They are tiny actually".

Most respondents (73%) had access to a watchtower (*tongi*) which they used to observe for elephants approaching their fields. The majority of farmers believed that fencing the Park (83%) or fencing their farms (81%) would reduce HEC. Removal of problematic elephants through killing or translocation was supported by only 4% and 9% (n= 140), respectively.

The majority of farmers (82%) said they did not torture or abuse elephants while the elephants are in the crop field, even in locations where sharp tools were observed in the field and 10% farmers accepted having sometimes abused elephants while the elephants are in crop fields. About 8% of the farmers were unsure if they had abused elephants in their agriculture fields (Table 4). Education level would not appear to have any impact on farmers non-involvement in abusing of elephant in their fields; 80% of illiterate participants, 85% of primary school educated and 84% of high school-educated stated they would not abuse elephants while elephants are in fields. Early harvesting of crops was commonly reported as a strategy to minimise crop losses due to HEC.

Thoughts of abandoning agriculture varied between different caste groups and educational backgrounds. Overall, 10% had often thought of leaving agriculture due to HEC. Among educated respondents, only 38% had never considered stopping farming (Table 4). Only 10% of respondents from scheduled castes had thought of abandoning agriculture. In the general caste category, 47% of farmers said the idea of abandoning agriculture had occurred to them.

There was a significant association ($p<0.04$) between having experienced being charged by an elephant and entertaining thoughts of abandoning agriculture. However, there was no association found between having experienced being charged and

Table 4. Perception of HEC based on education and age as observed through the interview

Statement as made by farmers	% of respondents based on			
	Education		Age	
	illiterate	literate	< 30 yrs	> 30 yrs
Idea of abandoning agriculture never comes to me	77	38	62	66
Killing elephants will reduce HEC	0	13	0	10
I sometimes physically abuse elephants while chasing them away	9	11	3	12
I'll continue to live in the same village despite HEC	93	86	91	84

having abused elephants (p = 0.654). The latter could be attributed to traditional respect for elephants in rural Assamese society as narrated by a villager during a participatory risk mapping meeting:

> "Neither elephants nor we wish to confront each other. We both want to avoid confrontation. While we guard our crops, sometimes, we face each other and we, the farmers, are at greater risk than the elephant when it happens."

Solar-powered fencing of farms and adequate compensation for crop loss were ranked the top two mitigation tools by respondents. The majority of farmers (86%) expressed a desire for their farms to be solar fenced (Fig. 7), but only 31% believed that solar-powered electric fences worked as deterrence against crop-raiding by elephants. Maintenance was identified as a concern, and farmers commented that elephants find it easier to cross locations where solar-powered electric fences are broken. Adequate compensation would strengthen the resolve of many respondents (66%) to mitigate HEC. Alternative strategies discussed: 30% of farmers wished to receive a supply of firecrackers, 59% wanted the Forest Department to patrol border areas of KNP all night. Only 28% of the farmers said they wanted alternative livelihood training, and 68% of those willing to learn alternative livelihood skills also wanted to continue being farmers. Only 4% of respondents wanted to stop farming altogether.

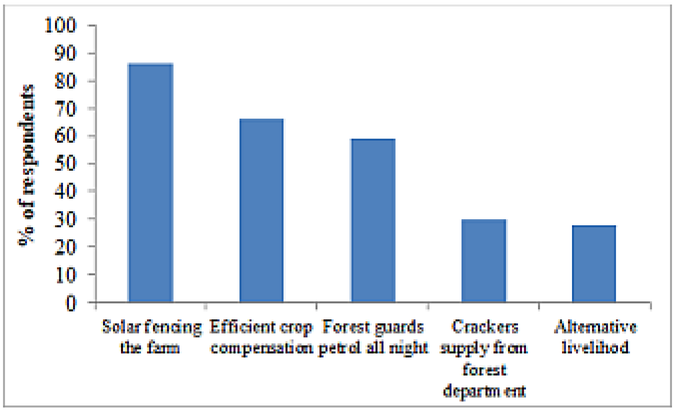

Figure 7. Villagers' expectations from Forest Department for mitigating HEC in the study area

Role of the Forest Department

The Forest Department, a major conservation stakeholder, is active in mitigating HEC in the Kaziranga landscape. The study found 66% of surveyed farmers said the Forest Department helped them in guarding their crops, but only 25% of respondents said that the forest guards patrolled the area all night. A 30-year-old man in a village 150 meters away from the border of KNP stated:

> "Forest guards help us in patrolling our farms, but they do not stay with us all night. I think elephants know when the forest guards vanish and then they suddenly appear from the darkness. Forest guards have guns and elephants know gunshot sound".

Most farmers (84%) reported villagers actively guarded crops all night to stop elephants raiding and that crop guarding mainly remained a male responsibility (85%). Patrolling was considered helpful in mitigating HEC by 96% of respondents.

DISCUSSION

The results show the impact of HEC on affected communities, with all 29 villages reporting HEC a major issue. Our study also highlights the importance of effective HEC mitigation for achieving United Nations Sustainable Development Goals in affected regions. The study revealed a seasonal and nocturnal pattern of crop-eating, with peak crop-eating occurring when rice crops ripened in winter. This contrasts a study in Manas National Park, Assam, where the peak crop-eating occurred during July-August (Nath et al. 2009). This could be attributed to flooding in KNP around July and August when many elephants return to the Karbi plateau (Choudhury 1987), reducing the number of elephants in the KNP area until their return in early winter.

A large part of the elephant population of northeast India resides in Assam during the rice cultivation period, contributing to this seasonal raiding pattern. Elephants in the study area use tea plantations to move around that are frequently contiguous with rice fields (Choudhury 1987). Unlike some observations that elephants preferred ripened crops (Sukumar 1991, Nath et al. 2009, Gubbi 2012), the respondents in this study believed that elephants came to eat crop of any stage of growth.

Farmers identified poor road network and lack of education as bigger risks for financial returns than annual flooding or crop eating. This contrasts with Webber and Hill (2014), who found farmers considered crop damage by wild animals the most critical risk in Uganada around Budongo Forest Reserve. Farmers accept crop losses of up to 50% to HEC as normal. This shows how commonplace crop raiding is in the region. The impact of HEC on food security and rural prosperity, and the magnitude of the other challenges faced by these farmers need to be studied. Poor road network and lack of education were perceived to be bigger risks than HEC, and this needs to be taken into account when planning the economic development of these villages.

Older farmers were more likely to accept the possibility that elephants suffered physical abuse during confrontations; however, this does not necessarily indicate older villagers were less tolerant of HEC. Cumulative interaction over many years has produced higher chances of confrontation and interaction with elephants. The finding that 82% of respondents do not abuse elephants should be considered cautiously. The Indian Wildlife (Protection) Act, 1972 confers the highest protection to elephants (Schedule 1, Part 1). Respondents describe their belief that elephants are the embodiment of Lord Ganesha, and this could also explain why few farmers report having abused elephants during HEC. Wild boars were mentioned by most of the respondents but were regarded as less problematic than elephants. Wild boars are small, hide under crop cover, and go unnoticed, unlike elephants that are almost always observed.

Mitigating HEC through a compensation policy is an important mechanism to support farmers. Poor communication of the compensation policy to farmers was observed in the study area. Farmers believed the process of reporting a loss, getting the loss assessed and finally receiving compensation was complex. These findings are similar to other studies that found compensation schemes inadequate, challenging and complex to access, and incur additional costs (Ogra and Badola 2008, Jadhav and Barua 2012). Improvements are necessary, either to assist farmers in utilising compensation schemes or simplifying the schemes themselves. Informal discussion with farmers revealed that the failure of one farmer to receive compensation discouraged neighbours from reporting losses for compensation. A Community Liaison Officer whose remit specifically included the scheme could ease the process of compensation.

Most reported mitigation techniques were farm-based active deterrence for short term HEC mitigation. Chilli powder, whistles, thunder flashes and tobacco, were not reported to be used, and there is scope for investigation around KNP of these alternative mitigation measures. '*Tongis*' (lookout points) are the primary method used to protect crops. The majority of the respondents had access to a tongi which they shared with 4-5 families from adjoining fields. Facilitation of co-operation between households using a tongi could maximise its effectiveness in HEC mitigation while reducing the burden on individual farmers.

Respondents favour physical barriers for HEC mitigation using solar-powered fences. With scarce resources for allocation, solar power fence installation at landscape level would be an expensive venture, potentially negatively affecting conservation. Some villages on the southern boundary of KNP are located within the elephant corridor. Respondents reported that elephants crossed their fields even when there was no crop, requiring site-specific mitigation measures. Physical fencing in functional corridors would further fragment the habitat which is documented to be undergoing rapid shrinkage and fragmentation due to linear structures (Talukdar and Barman 2003, Choudhury 2004, Kushwaha and Hazarika 2004, Fernando et al. 2008, Kumar et al. 2010). Mitigation measures must be designed carefully, considering landscape-level movements of elephants as well as community needs. Temporary fencing, present only when rice crops are in the fields, could be tried with the community involved in establishing and maintaining the fence.

Farmers depended on hearing approaching elephants rather than observing them. Shouting by a neighbouring farmer often alerted other farmers, and 139 of 140 respondents employed a means of informing their neighbours about elephants approaching, indicating that crop guarding is a community effort. Mobile phone technology could be utilised more effectively to inform neighbours about impending risks and is already commonly used by educated farmers. It would be helpful to equip *tongis* with solar-powered mobile phone charging points.

Farmers attitudes and actions indicate tolerance and resilience to HEC. It should be possible to design appropriate local mitigation measures which support both conservation and community objectives. The Forest Department and NGOs should develop alternative livelihood programmes for local young people and mitigation measures in consultation with farmers. Ensuring that villages inhabitants benefit from ecotourism should be prioritised, with part of the income from ecotourism dedicated to meeting the expenses incurred by HEC mitigation.

CONCLUSION

Crop fields around KNP are visited by elephants during winter months of rice growing season, mostly at night. Villagers facing the crop eating elephants know that living close to the forest has its own risk in the form of crop eating by wild animals, mainly elephants. Frequency of elephants charging is perceived to be declining as distance of villages increase from park boundary. Mitigation measures adopted by the villagers are often of short-term in nature, targeting crop raiding when elephants approach the agriculture field. Traditional methods of using sound and light to chase away the elephants and guarding crops at night using lookout points in the fields are mainstay of mitigation measures.

Villagers consider early harvesting of their crop as a method to reduce the loss. Villagers also regard elephants as the embodiment of Lord Ganesha and have very high respect for elephants. This feeling of respect for elephants and tendency to adopt early harvesting of crop can be used for mitigation of HEC and conservation of the species. Farmers perceive compensation for crop loss complex, delayed, poorly communicated and inadequate. Compensation policy needs to be simplified and communicated to the farmers. Guarding the boundaries by the forest guards at night protecting crops from elephants raiding them is perceived as helpful by the farmers but they find it inadequate. Villagers perceive poor road network and illiteracy as bigger risks for their financial returns than HEC in the villages around KNP and they need to be factored by the administrators while developing local area plans.

We propose the following recommendations:

1. Recruit a full-time Community Liaison Officer to facilitate access to HEC compensation.

2. Study and map the distribution and functionality of elephant corridors around KNP.

3. Facilitate community co-ordination to locate *tongi* for maximum effectiveness, and assist community cooperation in distributing crop guarding duties.

4. Involve the local community in designing HEC mitigations.

5. The Forest Department and NGOs should support local communities in developing alternative livelihood programmes.

6. Collect continuing data to assess the effectiveness of HEC mitigation and livelihood intervention.

7. Further research should be conducted to explore the perceptions of forest personnel.

Despite perceiving HEC as a complex and regular event, most of the farmers in the villages around KNP are willing to continue in the same village, trying out combinations of mitigation measures. This could be an indication of their tolerance and resilience to HEC as most of the farmers refrain from physically abusing the elephants

ACKNOWLEDGEMENTS

The authors are grateful to the Commonwealth Scholarship Commission for the funding of this study. A special note of thanks to Kaziranga National Park authority for discussions on human-elephant conflict in the study area. The guidance by Professor Anna Meredith in conceptualising this study is sincerely appreciated. The authors would also like to thank the farmers of the KNP region, without whose help and time this study would not have been possible.

Authors' contributions: All authors contributed equally

Conflict of interest: Authors declare no conflict of interest

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Received:20th March 2022
Accepted:30th August 2022