Securing the Future of Asian Elephants in Manas National Park, India

Project ID 330809

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Project abstract	Asian elephant is in dire strait to survive in northeast India, including Manas primarily because of conflict with human resulting from human induced factors. Need of the hour is to understand and enhance knowledge on the conflict pattern and explore people's attitude for possibilities of co-existence that ensures elephant's future. This project has gathered information on spatial patterns of human elephant (HE) conflict besides understanding the attitude of affected people for better managing the HEC alongside strengthening local youths with capacity building training.

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ABSTRACT

Human elephant conflict (HEC) emerged as the biggest concern for the survival of elephants in India, especially in north east. Effective mitigation requires a detailed understanding on underlying spatial patterns as well as social issues that can predict conflict incidences. We studied HEC in the fringe areas of Manas National Park in north east India to identify the spatial drivers and social aspects, from 2009-2010. We followed objective based sampling method and collected data on conflict incidences beside interviewing local peoples during that period. Results suggested that predictors of human-elephant conflict are scale dependent. The 'distance from park boundary' was the only independent variable that predicted conflict incidents across multiple spatial scales; all other variables varied with spatial scale of analysis (1 km^2, 5 km^2, 10 km^2 and 20 km^2). We tested the data for non-independence of variables at different scales due to spatial autocorrelation. Therefore we conclude in preferring multiple spatial scales in studying drivers of human elephant conflict. Spatial drivers may also vary across different regions and therefore are more localised in influencing patterns. *No one size fits all method*: drivers are context-dependent and vary with scale; conservationists need to address these issues before using spatial models to try and mitigate HEC. Models need to be used in conjunction with social data for effective community-based HEC mitigation; our findings reveal that there are major differences within communities and benefits from PAs are not equitably distributed among them; solutions must take ethnicity, etc into account; they should try and identify the most vulnerable groups within the community (e.g. ethnicity; gender; low-income group; caste etc) who are likely to be disproportionately affected than those who are well off.

This study could serve as a heuristic model for achieving this in other Human Wildlife Conflict scenarios elsewhere.

INTRODUCTION

General concept of Human elephant conflict (HEC)

Wildlife–human conflict is a major threat to the survival of many species. Such conflict is of conservation and socio-economic significance, where potentially dangerous species that in addition to depredating resources, threaten human morbidity and mortality. Human–elephant conflict is a case in point. Elephants are mega-herbivores and commonly raid crops, causing economic losses, and death and injury to people (Sukumar 1989; Hoare 1995; O'Connell-Rodwell *et al*. 2000). While ivory poaching is a major threat to some elephant populations in Africa, it is of lesser importance in Asia, as only male Asian elephants carry tusks. Further, the frequency of tusked males varies among populations. Conflict between human and wildlife is a threat to local wildlife populations, a factor limiting species meta-population viability and a cause of anti-wildlife conservation sentiment that can undermine other, potentially unrelated conservation initiatives (Kiss, 1990; Sillero-Zubiri and Laurenson, 2001). Although of worldwide occurrence (Sukumar, 1991; Hoogesteijn *et al*., 1993; Cozza *et al*., 1996, Barnes, 1999; Mishra, 1997; Naughton-Treves *et al*., 1998), conflicts between humans and wildlife are most intense in the tropics, where wildlife competes directly with a rapidly increasing human demand over scarce land and resources. The case is more severe in case of large bodied mammals like the elephants across its range. The Human elephant conflict (HEC) has emerged as the biggest concern for the survival of the species in the recent past. Unprecedented human population growth in Asia has caused increasing conversion of natural habitat to human dominated landscapes, bringing elephants and humans into greater contact and conflict (Fernando *et al*, 2005). Confronted with the escalating human–elephant conflict, the historical respect and reverence for elephants in Asian cultures and societies, is rapidly eroding (Fernando *et al*, 2005). The most publicized form of HEC are crop damage by elephants, property damage and injury or death to people (Ngure, 1995; Lahm, 1996; Ekobo, 1997). Human–elephant conflict represents a widespread, complex, and intractable challenge to conservation and is the major threat to elephants across their range.

The Asian Elephant has been considered as one of the most suggestive cultural symbols of the people of Asia and it also stands for the need of safeguarding sufficient natural forest areas; however the survival of the species has been

Sign of wild elephant damaging a house in the villages

endangered due to a number of conservation issues (AERCC, 1998). Growing human population, demands for cultivable lands and alteration of forest habitat to human habitation and cropland resulted serious human-elephant conflict in Assam (Talukdar and Barman, 2003). The forest cover in north-eastern India is disappearing at an alarming rate. More than 1000 km^2 of forests are being destroyed annually (Choudhury, 1999). This has resulted increasing incidents of human-elephant conflicts (HEC) to alarming proportions in Assam in recent time (Monier, 2006; Talukdar, 1996, Talukdar and Barman, 2003). HEC refers to a range of direct and indirect negative interactions between people and elephants which potentially harm both. The most publicized are crop damage by elephants and injury or death to people (Ngure, 1995; Lahm, 1996; Ekobo, 1997). HEC is a closely related problem of elephant conservation scenario. The conflict problem is a cause for concern because it threatens to erode local support for conservation in areas where human life and property are at high risk of destruction by wild elephants (Williams and Johnsingh, 1997; Thouless, 1994; Lahm, 1996) Habitat destruction by men has threatened the survival of the Asian Elephant not only in the north-eastern India but throughout its range. Since the animal is basically a forest (including grassland)-dweller, which migrates regularly, its survival depends upon the continued existence of large stretches of forest cover as well as sufficient supply of water within it (Choudhury, 1999). The habitat of Asian Elephant has been catastrophically shrinking in recent decades. In India between 1972-75 and 1980-82, one-sixth of the forest cover was lost, or 1.3 million hectares every year (Choudhury, 1989). The ultimate cause of habitat destruction is, however, the very rapid growth of human population. Every year the already overburdened population of north-eastern India increases by more than half a million. As a very high percentage of this population lives in rural areas (c. 85%) with farming as the main occupation, the large-scale destruction of forest and wetland seems inevitable. Conflict between elephant and man is a major conservation problem. With the decrease in forest cover, the conflict is becoming more serious by the day (Choudhury, 1999). Elephant-Human conflict has been used as a tool for understanding elephant habitat utilization in fringe-villages.

Human wildlife conflict mitigation requires a detailed understanding on underlying spatio-temporal patterns and the attitudes of the people affected. Although spatial patterns are more difficult to identify (Sitati et. al., 2003) than the temporal patterns, conflict is generally highest in close proximity to protected areas that act as elephant refuges (Barnes, Asika & Asamoah-Boateng 1995; Bhima 1998; Parker & Osborne 2001). Hence to mitigate this form of human–

Photo: Naba Nath

An elephant herd crossing the Park

wildlife conflict more effectively, it is first necessary to understand the temporal and spatial factors that predict crop raiding, and the effectiveness of current guarding strategies (Sitati *et al.*, 2003; Sitati, Walpole & Leader-Williams, 2005). The most comprehensive published study of HEC, however, failed to identify any strong spatial correlates (Hoare 1999). Identifying these patterns is vital for developing integrated mitigation strategies.

Although any interaction between human animal is regarded as conflict, these may be crop damage, house damage, manslaughter etc. However, in this report we have considered only the crop raiding incidents as this is the most frequent form of human elephant conflict. The other cases mentioned here are incidental and may not have (?) elephants' behavioural inputs.

Few studies have looked to identify the spatio-temporal patterns of human wildlife conflicts ((Sitati *et al.*, 2003, Barnes, Asika & Asamoah-Boateng 1995; Bhima 1998; Parker & Osborne 2001) including carnivores (Stahl *et al.* 2002) and birds (Tourenq *et al.* 2001; Somers & Morris 2002). Studies suggested that area of cultivation, distance from Park boundary, human density exhibit considerable spatial predictability (Sitati *et al.*, 2003; Bal *et al,* 2011; Kumar and Singh, 2010). However, importance of grid scale was always ignored in such studies except Sitati *et al.*, (2003). Spatial predictors may vary at different scale and can cause significant errors in conclusions because of danger of non-independence caused by spatial autocorrelation (Koenig 1999).

Identifying social parameters of the affected people are important to develop mitigation planning. Elephants in general are regarded as a symbol of religion, power and prosperity in Indian culture (Groening & Saller, 1999; Lahiri-Choudhury, 1991). Hence, these cultural factors are also believed to be influential in sustaining peoples' tolerance to wildlife damage (Woodroffe, 2000). When experiences with a species are negative, however, attitudes toward the species and its conservation could potentially be affected (Mukherjee & Borad, 2004). Increasing human–elephant conflict, however, has led to a gradual erosion of positive cultural beliefs in many parts of India (Gureja *et al.*, 2002; Singh, 2002). Barua *et al.*, (2010) observed that exposure to wild elephants negatively affected intentions to conserve elephants, while specific concern for the elephant and direct involvement in conservation activities led to positive intentions while Bandara and Tisdell (2003) and Hazarika *et al.*, (2008) found a mixture of positive and negative attitudes towards elephants. Hence, effective use of the Asian elephant as a flagship may be contingent on mitigating human–elephant conflict, for which engagement with concerned local actors and initiation of participatory conservation frameworks need to be considered (Barua *et al.*, 2010). These studies however didn't look at the different aspects that may offset conflict loss although Sitati *et al.*, (2003) suggested tourism can be an important factor. However, how conflict differentially offsets different social groups are yet to be studied.

Asian elephants are confined to 13 Asian range countries, of which, India holds over 50% of the global population – approximately 24,000–28,000 distributed across 18 states of the country (Menon 2003; Sukumar 2003). Northeast India holds around 30% of the country's total elephant population (Bist 2002). Within this north-eastern countryside, the state of Assam is known as the key conservation region of Asian elephants (Stracy 1963; Gee 1964; Santiapillai & Jackson 1990; Choudhury 1991,1997; Bist 2002) with an elephant population of about 5200 as assessed in the year 2005 (Talukdar *et al.* 2006).

HEC in Manas

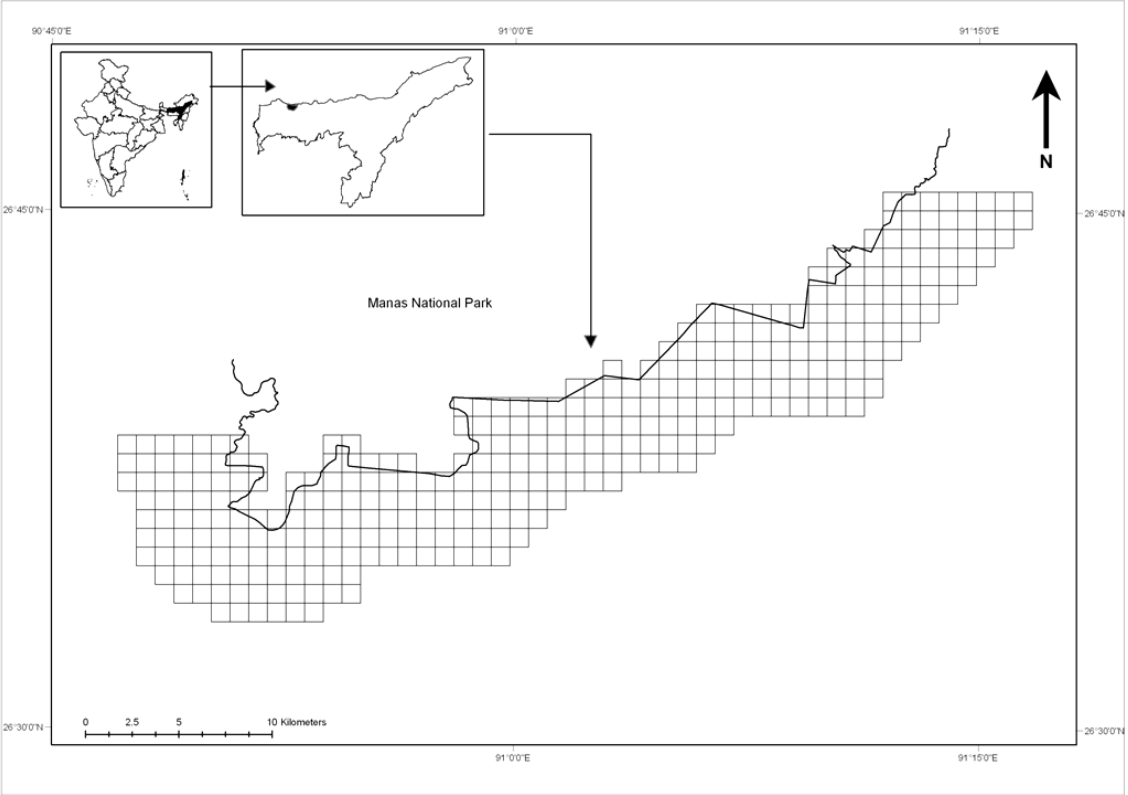
The elephants in Manas are widespread across the landscape as they once were. However in the recent years, their distributional range has been heavily fragmented and shrunk in the western part of the Tiger Reserve, primarily because of human activity. Continued fragmentation and habitat destruction may influence the viability of the remaining population in the landscape. Because of habitat loss and fragmentation, there are chances of the population may get isolated in small pockets and hence there will be constraints in demographic and genetic variables. Already the increased intensity in conflict in the fringe areas has suggested the impact of habitat loss.

Crop-raids by elephant and hog-deer are increasingly common, which unavoidably leads to continued ill-feeling amongst local people (Deb Roy, 1991). The present scenario on HEC has further deteriorated but nevertheless uncontrollable. Proper planning and research can considerably reduce human elephant conflict in Manas.

STUDY AREA

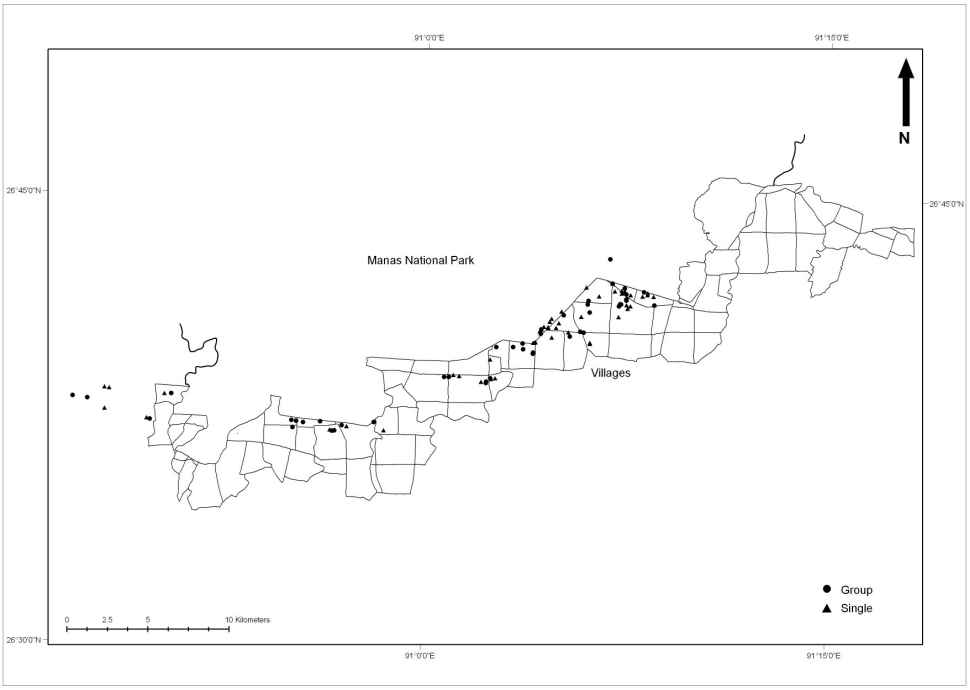
Manas National Park lying on the border between Assam and Bhutan, encompassing Indo-Gangetic and Indo-Malayan biogeographical realms which naturally provides great bio diversity. The Park lies on a gentle alluvial slope in the foothills of the Himalayas, where wooded hills edges with grasslands and tropical forest. The Park is home to a great variety of wildlife, including many endangered species such as the tiger, the pygmy hog, and the Indian rhinoceros and elephant.

The Park suffered from insurgency related issues in the last decade of the last century which damaged a great deal of wildlife. The Park is still trying hard to come out from List of World Heritage Site in Danger, which was stamped in 1992, after it had been invaded by militants seeking political redress. Its infrastructure suffered great damage from 1988 to 1993, and political instability between 1990 and 1996 led to the destruction of hundreds of trees and animals, including some 50 % of the Park's rhinoceros and 30% of its tigers. The damage to the Park, estimated at more than two million US dollars, was confirmed by a joint monitoring mission of the Government of India with the UNESCO World Heritage Committee in January 1997.



The study area, fringe areas of Manas National Park, this constitutes 61 fringe villages. The area gridded in to 1 km^2 is shown here.

The Park is located at the foothills of the Bhutan Himalayas in Baksa and Chirang districts of Assam (26°35'-26°50'N, 90°45'-91°15'E). It spans on both sides of the Manas River and is restricted to the north by the international border of Bhutan, to the south by thickly populated villages and to the east and west by reserve forests. Altitude ranges from 50 m MSL on the southern boundary to 200 m MSL along the Bhutan hills (Sarma *et al.,* 2008). The Manas National Park occupies an area of 519 sq. km., which forms the core area of the Tiger Reserve (2837 sq. km). The Tiger Reserve stretches over a length of 150 km. as a continuous belt of forests along the foothills between the rivers Sankosh in the west to the river Dhansiri in the east. It is contiguous with Royal Manas National Park (1023 sq. km.) of Bhutan. The Manas National Park is located at the junction of Indo-Gangatic, Indo-Malayan and Indo-Bhutan realms and is a key conservation area in the *Jigme Dorji-Manas-Bumdeling* conservation landscape in the eastern Himalayan eco-region (Wikramanayake *et al.* 2001).



Village boundaries are shown here with the conflict incident places by group and single elephants during the study period (2009-2010)

There are 61 thickly populated fringe villages with not less than 30,000 inhabitants live on the fringe of the National Park, predominantly Bodo tribal people (Project Tiger, 2001). Surrounding forests, originally tribal lands used for grazing and tree products, have been logged by the timber and paper industries for a pittance, and immigrant farmers have illegally purchased the cleared land. This has so alienated the tribals that they prefer to see the jungle razed than let outsiders take it. This, and their growing numbers,

has forced villagers into using the protected forests. Denial of access has caused conflict and antagonism towards the National Park. Political pressure from this growing population, driven by feelings of deprivation and neglect, may become the greatest threat to the future of the Park (Deb Roy, 1991). In the recent years, increasing human population in the fringe areas had led to encroachment and illegal hunting and tree-felling within the Park. Even now, people residing in the buffer areas are in many ways dependent on the Park for their livelihood, such as livestock grazing, and fodder and fuel wood collection (Sarma *et al.,* 2008). Therefore, the urgent need of the hour is to regulate and control the anthropogenic pressure. Elsewhere there has been report of elephant mortality caused by anthropogenic pressure (Dunham, 2008).

House damage

Banana crop damage

Ricefield damage

Crop damage during day time

Different forms of human elephant conflict in Manas

STUDY OBJECTIVES

The aim of this study was seeking a sustainable solution to to save elephants and explore possibilities of co-existence with local people in the fringe areas of Manas National Park, Assam.

Following are the objectives of the study :

1. Establish the conflict history in the area.
2. Assess the degree of conflict and ascertain current trends in raiding intensity.
    - Is there a difference in crop-raiding incidents involving single (male) and female-led family groups?
    - What spatial factors (e.g. distance from PA, area under cultivation) influence crop depredation by elephants? Do these patterns vary with the scale of analysis?
    - Can spatially explicit predictive models of HEC could be derived from field monitoring and other available data?

3. To explore management options for different anthropogenic pressure involving locals.
    - What are peoples' attitudes toward elephants and conservation? Are these homogeneous or do they vary within the community?

4. To build capacity of conservation professionals, at all levels from village worker, to ranger to conservation and social scientists

METHODS

Research design

Initially, field personals were trained and three field persons were stationed at three different ranges of the Park. For every conflict incidents, data were collected by objective based sampling method.

Data collection

Spatial data

Data were collected on any conflict incidents including crop-raiding, house damage and human deaths and injuries from August 2009 to August 2010. To establish a reliable and independent conflict reporting system (Hoare & Mackie 1993; Hoare 1999a), a team of three community members were selected and trained to enumerate conflict incidents. This circumvents the problem of over exaggeration of reported conflict by farmers themselves (Siex & Struhsaker, 1999). Each enumerator was stationed at a different location within the three administrative ranges of the National Park, to offer widespread coverage of the area. Any crop-raiding incident within an enumerator's area was visited for verification purposes and to record the location in Universal Transverse Mercator (UTM) coordinates using a Garmin GPS12 satellite navigation unit (Garmin Corp., Ulathe, KA). Further details of the incident, such as elephant group size and composition (male groups vs. female-led family groups; cf. Sukumar & Gadgil 1988) and time of incident, were recorded from complainants on a standardized reporting form (Hoare 1999b). Incidents of human death and injury were similarly recorded.

The UTM coordinates of each incident were imported into the Arc GIS 9.3 and ERDAS Imagine 9.1 software package for manipulation prior to analysis. Separate layers were created for

Data collection in field

Data collection in field

crop raiding by male elephants, crop raiding by family groups. Data for seven independent variables that might determine the spatial pattern of HEC were collected and generated in the GIS lab. Digital road and river vector files derived from 1: 50,000 topographic sheets and satellite imagery were obtained from the National Remote Sensing Agency, Hyderabad. Digital polygons of village and forest cover were obtained from the same source and updated with ground surveys in 2008.

Social data

For the social data collection, trial interview was carried out in the fringe areas. Problem questions were thus identified, rephrased or re moved from the lists and additional questions added where more detail was deemed requisite. A questionnaire was then designed using that of Smith and Sutton (2008) as a template, but with modifications on the basis of responses from the initial semi-structured interviews to make the questionnaire more specific to the species and conservation issue at hand. Subsequent to these corrections, villages and market places were visited and people living therein interviewed. We interviewed people between May 2010 and October 2010. Where possible, the village head person was interviewed, to best represent the most 'influential' opinion at that location. From other groups, respondents were chosen randomly with respect to age and sex.

Interviewing local villagers

Data analysis

Spatial data

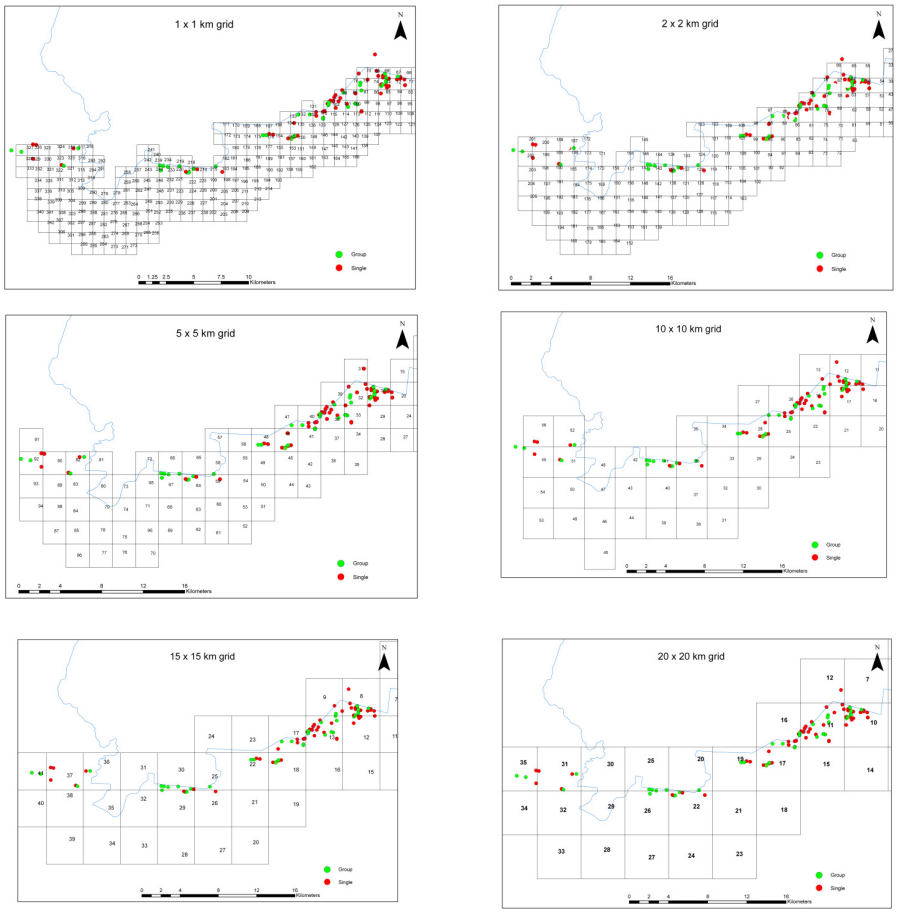
Analysis was carried out using SPSS v.16 (SPSS Inc., Chicago, IL) at various spatial scales (1 km^2, 10 km^2, 15 km^2). Spearman's rank correlations (ρ) were conducted to compare conflict incidents with other contexts (Hoare, 1999; Sitati *et al.*, 2003). As the intensity of conflict incidents exhibited highly skewed distributions among grid cells, it was not possible to use linear regressions to identify ecological correlates of crop-raiding. Instead, each conflict incident was binary coded into presence and absence for each grid cell, and analysis undertaken using multiple stepwise logistic regression (Manel, Williams & Ormerod 2001; Tourenq *et al.*, 2001), with entry and exit of variables determined by the Wald statistic with P-values of 0.05 and 0.1, respectively. The goodness of fit of the model was tested using a Hosmer and Lemeshow test.

The independent variables chosen were

a. Area of cultivation: The size of the cultivation where crop raiding has occurred can likely be an influential variable attracting elephants.
b. Distance from Park boundary: This is always a major variable that determines elephants raiding pattern.
c. Area of woodland: This variable was determined using GIS at different grid cells at different scales.
d. Area of waterbody
e. Area of grassland
f. Distance to river
g. Distance to road

When analyzing spatial data, there is a danger of non-independence caused by spatial autocorrelation (Koenig, 1999) whereby adjacent cells share similar values in the dependent variable. This effect can reduce the degrees of freedom in the analysis and thus increase the chances of Type 1 errors (Legendre & Legendre, 1998), whereby correlation coefficients appear more significant than they actually are. Spatial autocorrelation was tested for in the dependent variables by calculating Moran's I statistic (Cliff & Ord, 1981) using the Crimestats v.3.3 software package (N. Levine & Associates, Annandale, VA). The significance of Moran's I was examined using a Z-test. As caution is needed in the interpretation of significance of correlation coefficients where spatial autocorrelation occurs, we conducted the analyses at coarser resolutions (10km^2, 15km^2) at which spatial autocorrelation was less likely to be significant.

At the 1km^2 scale, 342 grid cells were available for the study area, whilst the number of grid cells decreased to 56 for 10km^2 and 41 for 15km^2 resolution grids.



The anayses were carried out at multiple scales (1 km^2, 5 km^2, 10 km^2, 15 km^2 and 20 km^2) to identify the drivers of HEC in the study area. Different scale resulted in different variables suggesting the effect of scales in identifying HEC drivers

Social data

We interviewed 297 people with different occupation, out of which farmers comprised the most 54.88% (n=163), followed by tourism/Protected area affiliated (i.e. patrolling locals) 12.12% (n=36), and others (business / service) 24.92% (n=74) of the study sample.

The interviewed community :

- Community: Bodos comprised a majority of the respondents (60.27%; n=179), followed by Assamese (32.32%; n=96), Bengali (5.73%; n=17), Nepali (1.01%; n=3) and Adivasi (0.67%; n=2).
- These were later regrouped as tribals / Non-tribals

- Involved / Not-involved in environmental activities = 51.2% (n=152) said they were involved in some environment-related activity, whilst 48.8% (n=145) said they were not.
- Distance from PA boundary ranged from 0 to 4km from Manas National Park (median = 100m); these were recorded into near (<100m) and far (>101m). Out of these, 51.5% (n=153) of respondents were from villages near the park, and 48.5% (n=144) were from villages further away.
- In the 89 villages sampled during the study, number of conflict incidents in different villages ranged from 0 to 13; conflict was not reported from 54 villages (n=0); this does not mean there is no conflict in these villages – rather conflict did not occur during our study period; we regrouped villages as (1) conflict present and (2) conflict absent during the study area.

To compare differences between different social groups we used a Fischer's Exact test.

Elephant population in Manas

In the year 1981, the Forest Department estimated about 1200 elephants in the Manas Tiger Reserve comprising an area of 2837 sq km (Census report, 2008). Again in 2002, department census revealed the presence of 500 elephants in the Park (Census report, 2008). Now the Park holds more than 780 elephant (Census report, 2008). Recent census by the department reported an estimated population of approximately 780 elephants in the Park with a density of 1.68 per km^2 in the year 2008. However, there is room for error in census activity by the department as the field persons often face trouble in counting or even identifying age and sex. The field guards often have a tendency to exaggerate the numbers.

Das (2011) during his PhD work, estimated a population of 895 ± 112.4 at a density of 1.79 elephants/km^2 during January 2007 to November 2009. This study followed dung density and decay rate estimation process to assess the population, which is the first attempt in north east India. Historically, the direct count method was followed and hence the study carried out by Das (2011) gained added importance to find out the effectiveness of this method. Additionally, this method not only provide the population status but also give an idea how many elephants has utilized the Park during the study period.

RESULTS

Spatial analysis

A total of 137 conflict incidents (n=137) were reported during the study period. This included 15 incidents of house-damage, 2 incidents of physical injury and 120 incidents of crop-raiding. Elephants raided a number of crops including paddy *Oryza sativa*, pumpkin *Cucurbita maxima*, coconut *Cocos nucifera*, and sesame *Sesamum indicum*. Conflict occurred throughout the year, but intensified during early winter (October-November) just prior to the paddy harvest. The size of crop-raiding elephant groups varied from 1 to 10 (median=1), with 57 incidents involving single elephants and 40 involving female-led family groups. The identity of elephants for 23 incidents could not be ascertained. Only the incidents involving 57 single elephants (n=57) and 40 female-led family groups (n=40) were considered in the final analysis in order to minimize variability and uncertainty in the dataset.

Conflict incidents were highly clustered at the 1km^2 scale, exhibiting spatial autocorrelation for both single (Moran's I= 0.04, p=0.000) and group crop-raiding (Moran's I=0.07, p=0.000). At the 10km^2 scale, crop-raiding showed spatial autocorrelation for single elephants (Moran's I=0.08, p=0.001), but not for groups (Moran's I=0.03, p=0.1). Crop-raiding did not show spatial autocorrelation at coarser 15 km^2 resolution for both single elephants and groups (Moran's I=0.05 and 0.02 respectively, p>0.05). The significance of correlation coefficients at higher spatial resolutions (1 km^2 for both single and groups, 10 km^2 for single elephants) are presented in order to make comparisons with other studies and to discuss implications of scale. However, this is likely to cause non-independence in the regression models and we treat them with extreme caution (Blamford *et al.*, 2001; Sitati *et al.*, 2003).

At 1km^2 resolution, crop-raiding by both single elephants and female-led family groups was negatively correlated with distance from park boundary (Spearman's ρ= -0.242, p<0.001; Spearman's ρ= -0.274, p<0.001) (Table 1). Crop-raiding for groups was also negatively correlated with the area of waterbody (Spearman's ρ= -0.114, p<0.05) at this spatial scale. The best predictor of the occurrence of crop-raiding in logistic regressions at this spatial scale was distance from park boundary for both single elephants (β= -0.883, Wald=17.215, p<0.001) and groups (β= -1.028, Wald=15.732, p<0.001). Area of grassland (β=4.100, Wald=4.221, p<0.05) also predicted crop-raiding by female-led family groups. The overall r^2 for the models were lower than those at higher spatial scales (Nagelkerke r^2=0.229 for single and Nagelkerke r^2=0.312 for groups respectively) (Table 2).

Crop-raiding was also significantly negatively correlated with distance from park boundary at a 10 km2 spatial resolution for both single elephants (Spearman's ρ= -0.449, p<0.01) and groups (Spearman's ρ= -

0.437, p<0.01). Moreover, for groups crop-raiding was also correlated with total area of woodland (Spearman's ρ=0.300, p<0.05) and grassland (Spearman's ρ= 0.384, p<0.01). Logistic regressions at this spatial scale indicated that distance from park boundary was the best predictor for both single (β= -1.748, Wald=4.986, p<0.05) and female-led groups (β= -2.148, Wald=5.457, p<0.05). However, only the area of grassland (β=4.343, Wald=4.702, p<0.05) was an additional independent variable that predicted conflict-occurrence for groups.

At a 15 km^2 spatial scale, crop-raiding was negatively correlated with distance from park boundary for single elephants (Spearman's ρ= -0.341, p<0.05), but not for groups (Spearman's ρ= -0.283, n.s.). Further, crop-raiding by single elephants was negatively correlated with distance from roads (Spearman's ρ= -0.389, p<0.05). The best predictor of conflict in the logistic regressions was again distance from park boundary (β= -0.591, Wald=4.545, p<0.05 for single elephants and β= -0.440, Wald=4.052, p<0.05 for groups) (Table 2).

Variables	*1 km^2*		*10 km^2*		*15 km^2*	
	Single	*Group*	*Single*	*Group*	*Single*	*Group*
Total area of cultivation	0.23	-0.039	0.183	0.182	0.239	0.201
Total area of woodland	0.044	-0.020	0.175	0.300*	0.267	0.238
Total area of water body	-0.079	-0.114*	-0.04	0.052	-0.029	-0.077
Total area of grassland	0.079	0.073	0.225	0.348**	0.176	0.144
Distance to Park boundary	-0.242***	-0.274***	-0.449**	-0.437**	-0.341*	-0.283
Distance to road	-0.048	-0.028	-0.178	-0.304*	-0.389*	-0.231
Distance to river	0.013	0.150	-0.08	-0.15	-0.119	-0.059

Table 1. *Spearman's rank correlations for associations between seven variables and either male elephant crop raiding or family group crop raiding in 1 km^2 (n=342), 10 km^2 (n = 56) and 15 km^2 (n = 41) grid cells. *P < 0·05, **P < 0·01, ***P < 0.001*

Variables	1 km^2						10 km^2						15 km^2					
	Single[1]			Group[2]			Single[3]			Group[4]			Single[5]			Group[6]		
	B	Wald	Sig.	B	Wald	Sig.	B	Wald	Sig.	B	Wald	Sig.	B	Wald	Sig.	B	Wald	Sig.
Total area of cultivation	1.274	1.182	0.277	0.019	0.000	0.987	0.639	2.135	0.144	0.509	1.168	0.280	-0.359	1.931	0.165	-0.198	0.766	0.381
Total area of woodland	2.158	0.987	0.320	0.573	0.054	0.816	-0.038	0.001	0.971	0.361	0.132	0.717	0.721	0.423	0.515	0.572	0.362	0.547
Total area of water body	-3.944	0.776	0.378	-2.423	0.357	0.550	-5.978*	4.820*	0.028*	-5.842	3.532	0.060	-5.278	2.232	0.135	-0.936	0.329	0.566
Total area of grassland	2.847	2.272	0.132	4.100	4.221	0.040*	2.969	3.621	0.057	4.343*	4.702*	0.030*	0.422	0.163	0.687	0.481	0.344	0.557
Distance to Park boundary	-0.883	17.215	0.000*	-1.028	15.732	0.000*	-1.748*	4.986*	.026*	-2.148*	5.457*	0.019*	-.591*	4.545*	0.033*	-.440*	4.052	0.044
Distance to road	-0.686	0.578	0.447	-1.565	2.189	0.139	0.424	0.048	0.826	-1.330	.375	0.540	-3.020	4.225	0.040	-1.304	1.965	0.161
Distance to river	0.508	0.122	0.727	3.623	2.657	0.103	2.585	1.272	0.259	5.029	3.266	0.071	1.826	1.595	0.207	1.997	2.355	0.125

Table 2. *[1]Nagelkerke R^2=0.229, Hosmer-Lemeshow Test p=0.616; [2]Nagelkerke R^2=0.312, Hosmer-Lemeshow Test p=0.722; [3]Nagelkerke R^2=0.646, Hosmer-Lemeshow Test p=0.385; [4]Nagelkerke R^2=0.676, Hosmer-Lemeshow Test p=0.634; [5]Nagelkerke R^2=0.547, Hosmer-Lemeshow Test p=0.869; [6]Nagelkerke R^2=0.355, Hosmer-Lemeshow Test p=0.988*

Social analysis

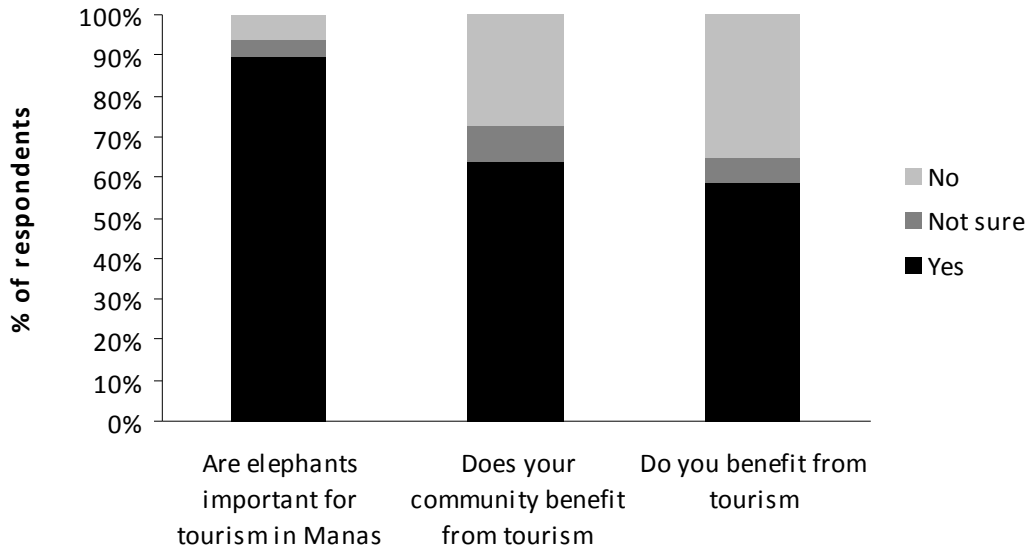
We interviewed 297 people from the fringe area (male = 292; female = 5, mean age = 40.22 ± 10.11). Of these, 161 individuals were farmers, 36 were employed in the park or in local ecotourism and the remaining 100 had other occupations or were unemployed. The number of male respondents was high as we took households as the sampling unit, and men are the general spokespersons in the community. This constraint in questionnaire-based sampling in the region is reflected in other studies as well (Barua *et al*., 2010). Further, 179 respondents were from the local Bodo tribal community. Overall people had positive attitudes towards elephants, with 89% (n=265) saying that elephants should exist in Manas, and 69% (n=206) saying that they liked living near elephants. Attitudes toward Manas National Park were also positive with 90.6% (n=269) saying they liked living near the park. Eighty-eight percent (n=262) felt they benefitted from the park being there. Benefits mentioned include natural resources (84.18%, n=250), firewood (70.71%, n=210) and tourism / park-related employment (48.15%, n=143).

A majority of the respondents (91.6%, n=272) thought there should be more animals in the reserve. However, only 11.1% (n=33) of these respondents said they would like more elephants in the area. Nearly all respondents said that elephants came to their village (92.6%, n=275), but only 59% (n=174) said they faced problems of crop-raiding or property damage. The difference between actual and perceived number of conflict incidents was significant (Wilcoxon Signed Rank Test; Z= -11.390, p=0.000) with respondents quoting far higher numbers of conflict than what actually occurred in the villages during our study period.

Most people (53.87%, n=160) felt that the government forest department was responsible for crop loss and property damage by elephants, and shunned individual responsibility in this matter (3.37%, n=10) (Cochran's Q=5.632, df=5, p=0.000). This may be because a large number of respondents said that the elephant was government property (46.13%, n=137). Similarly, there was a belief that the government should take responsibility for guarding fields from elephants (83.16%, n=247), and this was significantly higher than individual (57.91%, n=172) and community (41.08%, n=122) responsibility (Cochran's Q=3.574, df=3, p=0.000). Further, people felt that the responsibility of conserving elephants was on the government (64.65%, n=192), with community responsibility (40.07%, n=119) coming second (Cochran's Q=4.046, df=3, p=0.000).

Difference between conflict present / conflict absent was not significant for any item (possibly because this does not mean there is no conflict in other villages; rather it may be homogenous; also level of conflict might not necessarily influence people's perceptions)

Perception on tourism



Most of the respondents (89.2 %; n=265) believed that elephants are important for tourism in Manas, while few (6.1%; n=18) said no to elephants importance. Majority of the community ((63.3%; n=188) also believed that they have been benefitted by the tourism, while few others (27.3%; n=81) believed there is no community benefit from tourism. At individual level, only 58.2%; n=173 of the respondents have benefitted from tourism, while 35.0%; n=104 of respondents have not benefited from tourism in Manas. When asked about what sort of benefits, 'Indirect economic benefits' (21.21%; n=63) was the highest followed by 'Direct economic benefits' (13.47%; n=40) and 'Knowledge, education and awareness' (4.38%; n=13). Overall 81 individuals in total, said they received some form of direct or indirect benefit.

Furthermore, there were differences among different groups on the tourism perception -

	Group	***Yes % (n)***	***No % (n)***	***Sig.***[1]
Are elephants important for tourism in Manas?	Farmer	91.4% (138)	8.6% (13)	0.142
	Non-farmer	96.2% (127)	3.8% (5)	
	Tourism-involved	100% (36)	0% (0)	0.142
	Not-involved	92.7% (229)	7.3% (18)	
	Tribal	92.2% (154)	7.8% (13)	0.342

	Non-Tribal	95.7% (111)	4.3% (5)	
	Near Park	96.7% (145)	3.3% (5)	0.03*
	Further away	90.2%(120)	9.8% (13)	
	Low conflict	93.0% (226)	7.0% (17)	0.485
	High conflict	97.5% (39)	2.5% (1)	
Does your community benefit from tourism?	Farmer	70.9% (105)	29.1% (43)	0.691
	Non-farmer	68.6% (83)	31.4% (38)	
	Tourism-involved	38.5% (10)	61.5% (16)	0.001***
	Not-involved	73.3% (178)	26.7% (65)	
	Tribal	59.1% (91)	40.9% (63)	0.000***
	Non-Tribal	84.3% (97)	15.7% (18)	
	Near Park	79.4%(112)	20.6%(29)	0.001**
	Further away	59.4% (76)	40.6% (52)	
	Low conflict	71.9% (166)	28.1% (65)	0.089
	High conflict	57.9% (22)	42.1% (16)	
Do you benefit from tourism?	Farmer	59.2% (90)	40.8% (62)	0.262
	Non-farmer	66.4% (83)	33.6% (42)	
	Tourism	45.2% (14)	54.8% (17)	0.048*
	Non-tourism	64.6% (159)	35.4% (87)	
	Tribal	48.4% (78)	51.6% (83)	0.000***
	Non- Tribal	81.9% (95)	18.1% (21)	
	Near Park	79.4% (112)	20.6% (29)	0.001***
	Further away	59.4% (76)	40.6% (52)	
	Low conflict	63.8% (150)	36.2% (85)	0.300
	High conflict	54.8% (23)	45.2% (19)	

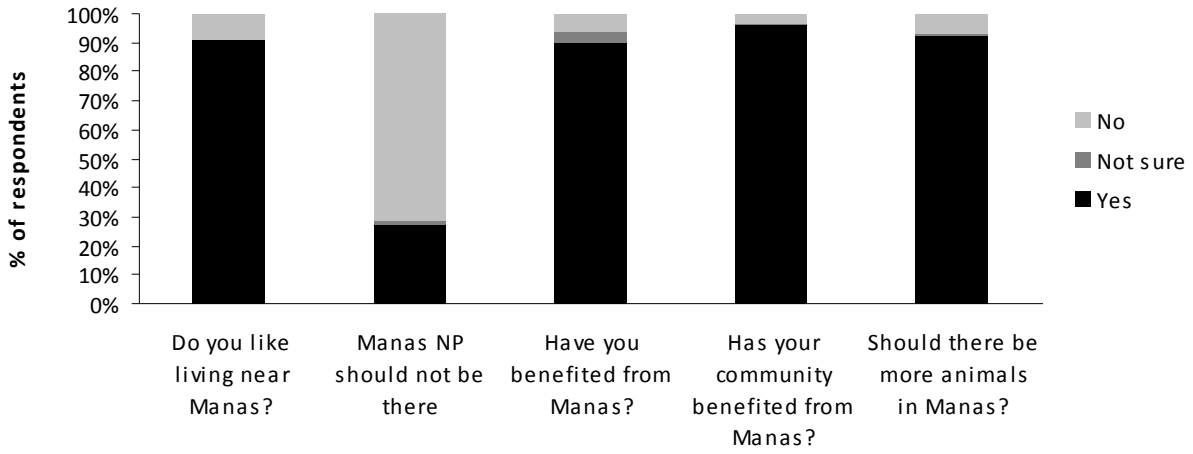
[1]*Fischer's Exact Test; two-tailed; *p≤0.5, **p≤0.01, ***p≤0.001*

There were significantly different viewpoint on community benefit among tourism 'involved' and 'not involved' respondents (*Fischer's Exact Test; two-tailed; p≤0.001).* Those who were involved in tourism, said that the community is not benefited from tourism, while those who are not involved in tourism activity, said community has benefited from tourism. This might be because, the people who are involved in

tourism has seen the benefits as their own while those people who are not involved in tourism, has seen these benefits coming to the community.

There were also significant differences among community benefits between tribal and non-tribal people (*Fischer's Exact Test; two-tailed; p≤0.000)*. The non tribal community has benefitted more than the tribal people; while at individual level, again non tribal has more benefit than the tribal people. This unequitability in community benefit from tourism may create antagonistic approach towards the Park.

Attitudes to Manas NP



Majority of the respondents said they like living near the Park (90.6%; n=269) while 8.8%; n=26 said they don't like to live near the Park. Surprisingly, 26.6%; n=79 of the respondents said that Manas should not be protected while 70.0%; n=208 said Manas should be protected. Majority of the people said they had some amount of benefits from Park 88.2%; n=262 and 6.1%; n=18 said they has no benefits from the Park. When they were asked about what sort of benefits, natural resources (84.18%; n=250), firewood (70.71%; n=210), Park/tourism-related employment (48.15%; n=143) were the major benefits.

Majority of the respondents also said that (91.6%; n=272) there should be more animals in Manas, but when asked which animal elephant lied in the third place (11.11%; n=3) after, tigers (16.84%; n=50), rhinos (16.50%; n=49).

The differences among different community groups are shown below:

	Group	Yes % (n)	No % (n)	Sig.[1]
Do you like living near Manas NP?	Farmer	94.4% (153)	5.6% (9)	0.038*
	Non-farmer	87.2% (116)	12.8% (17)	
	Tourism-	100% (36)	0% (0)	0.055

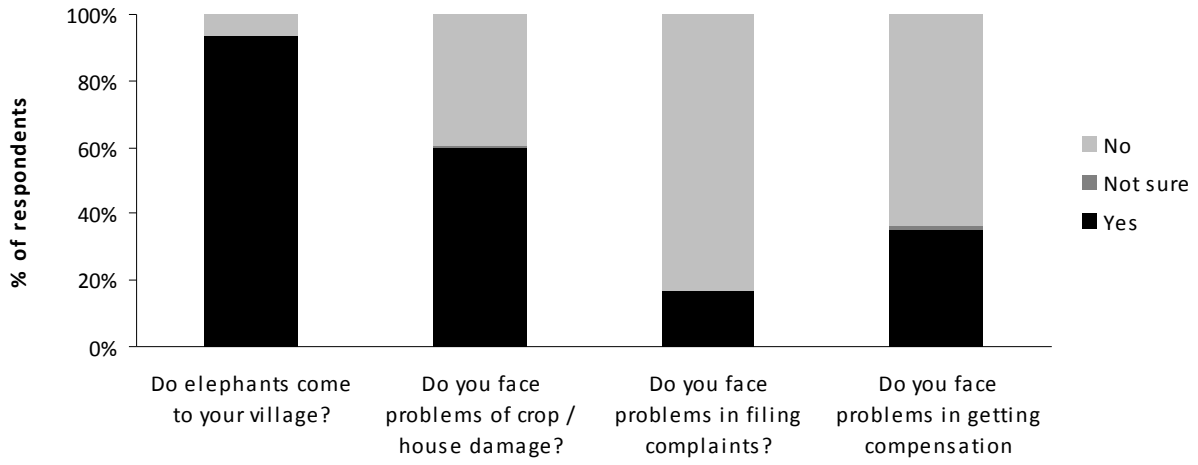
	involved			
	Not-involved	90.0% (233)	10.0% (26)	
	Tribal	96.6% (172)	3.4% (6)	0.000***
	Non- Tribal	82.9% (97)	17.1% (20)	
	Near Park	90.8% (138)	9.2% (14)	0.84
	Further away	91.6% (131)	8.4% (12)	
	Low conflict	90.5% (228)	9.5% (24)	0.394
	High conflict	95.3% (41)	4.7% (2)	
Manas NP should not be protected	Farmer	35.7% (56)	64.3% (101)	0.001***
	Non-farmer	17.7% (23)	82.3% (107)	
	Tourism-involved	2.8% (1)	97.2% (35)	0.000***
	Not-involved	31.1% (78)	68.9% (173)	
	Tribal	14.5% (25)	85.5% (148)	0.000***
	Non- Tribal	47.4% (54)	52.6% (60)	
	Near Park	27.9% (41)	72.1% (106)	0.896
	Further away	27.1% (38)	72.9% (102)	
	Low conflict	28.7% (70)	71.3% (174)	0.357
	High conflict	20.9% (9)	79.1% (34)	
Have you benefited from Manas NP?	Farmer	90.9% (140)	9.1% (14)	0.052
	Non-farmer	96.8% (122)	3.2% (4)	
	Tourism	100% (35)	0% (0)	0.142
	Non-tourism	92.7% (227)	7.3% (18)	
	Tribal	92.8% (154)	7.2% (12)	0.624
	Non- Tribal	94.7% (108)	5.3% (6)	
	Near Park	94.6% (139)	5.4% (8)	0.627
	Further away	92.5% (123)	7.5% (10)	
	Low conflict	92.5% (221)	7.5% (18)	0.085
	High conflict	100% (41)	0% (0)	
Should there be more animals in Manas NP?	Farmer	91.9% (147)	8.1% (13)	0.364
	Non-farmer	94.7% (125)	5.3% (7)	
	Tourism	91.4% (32)	8.6% (3)	0.718
	Non-tourism	93.4%	6.6% (17)	

	(240)		
Tribal	94.3% (155)	5.7% (10)	0.351
Non- Tribal	91.4% (106)	8.6% (10)	
Near Park	93.3 %(140)	6.7% (10)	1.000
Further away	93.0% (132)	7.0% (10)	
Low conflict	93.6% (235)	6.4% (16)	0.500
High conflict	90.2% (37)	9.8% (4)	

[1]*Fischer's Exact Test; two-tailed; *p≤0.5, **p≤0.01, ***p≤0.001*

There were significant difference between tribal and non-tribals when asked about whether they like living near Manas (*Fischer's Exact Test; two-tailed; p≤0.000).* While More tribal people liked living near Manas than non tribal. Furthermore, there were differences whether Manas should be protected or not among those involved in tourism and those not involved in tourism.

Exposure to Wild Elephants / HEC / Perceived Levels of Conflict



Majority of the respondents felt that elephants visit their village (92.6%; n=275) while few have no experience of elephant visit (6.1%; n=18) to their village. Atleast, 58.6%; n=174 respondents said that they face problems of crop/house damage from wild elephants; while 38.7%; n=115 people said no to crop/house damage problem. However very few respondents felt that they receive any compensation 24.6%; n=73 while rest received no compensation (74.4%; n=221). Again, 16.2%; n=48 felt that they have problems in filling complaints and 81.5%; n=242 felt they didn't have any problems in filling complaints. 34.0%; n=101 said that didn't face problems in getting reimbursements while 62.0%; n=184 felt had problems in getting reimbursements.

The differences among different communities are shown below:

	Group	Yes % (n)	No % (n)	Sig.[1]
Do elephants come to your village?	Farmer	95.7% (154)	4.3% (7)	0.221
	Non-farmer	91.7% (121)	8.3% (11)	
	Tourism-involved	94.3% (33)	6.2% (16)	1.00
	Not-involved	93.8% (33)	5.7% (2)	
	Tribal	93.2% (164)	6.8 % (12)	0.627
	Non- Tribal	94.9% (111)	5.1% (6)	
	Near Park	94.0% (142)	6.0% (9)	1.000
	Further away	93.7% (133)	6.3% (9)	
	Low conflict	94.8% (239)	5.2% (13)	0.150
	High conflict	87.8% (36)	12.2% (5)	
Do you face problems of crop / house damage?	Farmer	62.9% (100)	37.1% (59)	0.335
	Non-farmer	56.9% (74)	43.1% (56)	
	Tourism-involved	71.4% (25)	28.6 (10)	0.197
	Not-involved	58.7% (149)	41.3% (105)	
	Tribal	58.4% (101)	41.6 (72)	0.464
	Non- Tribal	62.9 (73)	37.1 (43)	
	Near Park	62.0% (93)	38.0% (57)	0.549
	Further away	58.3% (81)	41.7% (58)	
	Low conflict	59.3% (147)	40.7% (101)	0.493
	High conflict	65.9% (27)	34.1% (14)	
Have you received any compensation?	Farmer	21.0% (34)	79.0% (128)	0.104
	Non-farmer	29.5% (39)	70.5% (93)	
	Tourism-involved	52.8% (19)	47.2% (17)	0.000***
	Not-involved	20.9% (54)	79.1% (204)	
	Tribal	35.0% (62)	65.5% (115)	0.000***
	Non- Tribal	9.4% (11)	90.6% (106)	
	Near Park	17.2% (26)	82.8% (125)	0.003**
	Further away	32.9% (47)	67.1% (96)	
	Low conflict			
	High conflict			
Do you face problems in filing complaints?	Farmer	13.1% (21)	86.9% (139)	0.111
	Non-farmer	20.8% (27)	79.2% (103)	

	Tourism	47.1% (16)	52.9% (18)	0.000***
	Non-tourism	12.5% (32)	87.5% (224)	
	Tribal	25.3% (44)	74.7% (130)	0.000***
	Non- Tribal	3.4% (4)	96.6% (112)	
	Near Park	13.2% (20)	86.8% (132)	0.115
	Further away	20.3% (28)	79.7% (110)	
	Low conflict			
	High conflict			
Do you face problems in getting compensation?	Farmer	33.8% (53)	66.2% (104)	0.535
	Non-farmer	37.5% (48)	62.5% (80)	
	Tourism	52.9% (18)	47.1% (16)	0.034*
	Non-tourism	33.1% (83)	66.9% (168)	
	Tribal	39.9% (69)	60.1% (104)	0.058
	Non- Tribal	28.6% (32)	71.4% (80)	
	Near Park	27.7% (41)	72.3% (107)	0.006**
	Further away	43.8% (60)	56.2% (77)	
	Low conflict			
	High conflict			

[1]*Fischer's Exact Test; two-tailed; *p≤0.5, **p≤0.01, ***p≤0.001*

Result suggested that there is significant differences among those involved in tourism or park management and those not involved in receiving compensation (*Fischer's Exact Test; two-tailed; p≤0.000).* This shows the unequitability in getting compensation scheme.

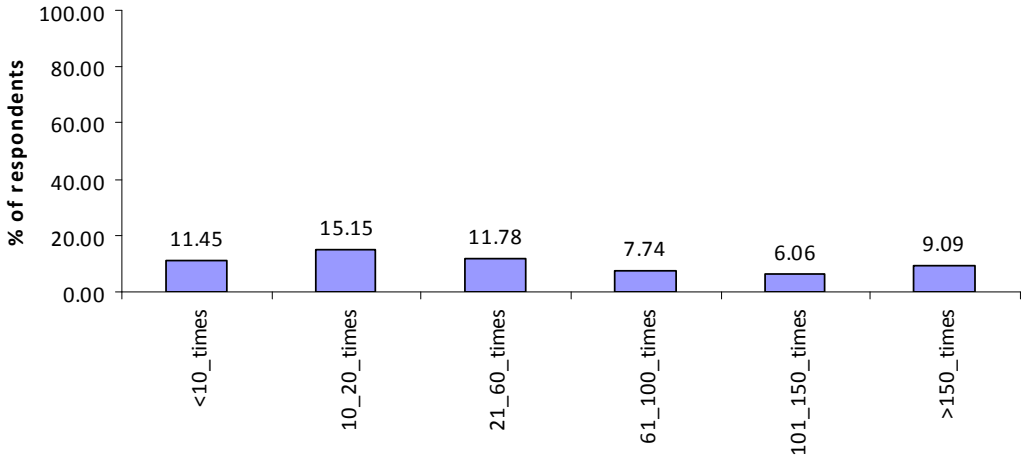


Fig. The perceived level of elephant visit to villages is shown here.

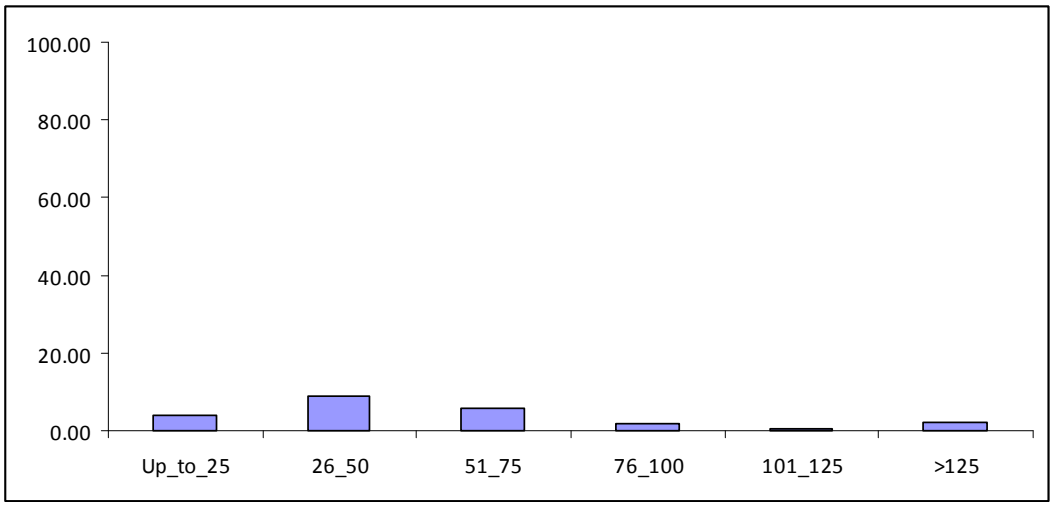


Fig. The perceived number of conflict incident in a year in a village

Differences between the actual and perceived number of incidents was significant (Wilcoxon Signed Ranks Test; Z= -11.390, p=0.000) with respondents quoting far higher numbers of conflict than what actually occurred in the villages.

Maunds	**%**	**n**
Up_to_25	4.04	12
26_50	8.75	26
51_75	5.72	17
76_100	1.68	5
101_125	0.34	1
>125	2.02	6

The amount of crops damaged in a year in a village

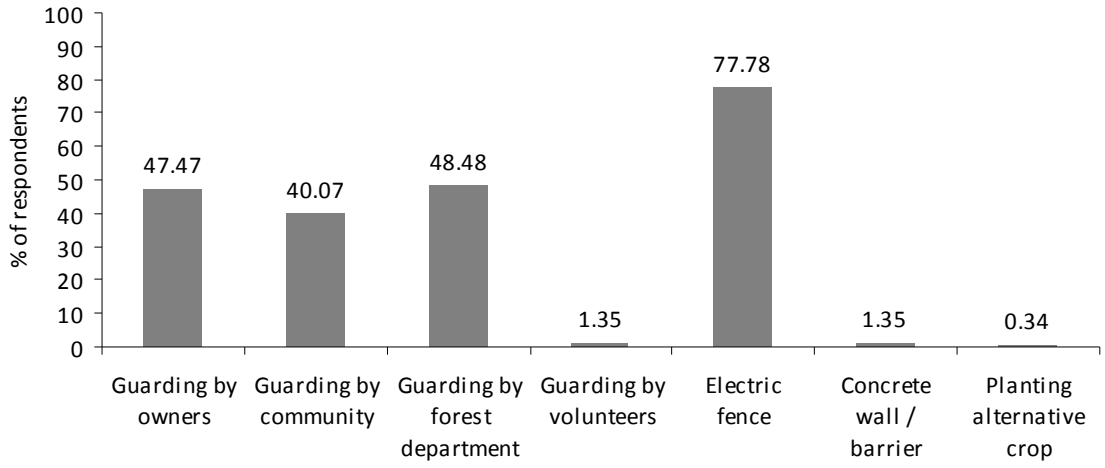
Herd	**%**	**n**
Lone_Bulls	65.32	194
Bull_herds	37.04	110
Groups	18.52	55

65.32 % of respondents replied that lone bulls raid more than the female led group

Mitigation strategies

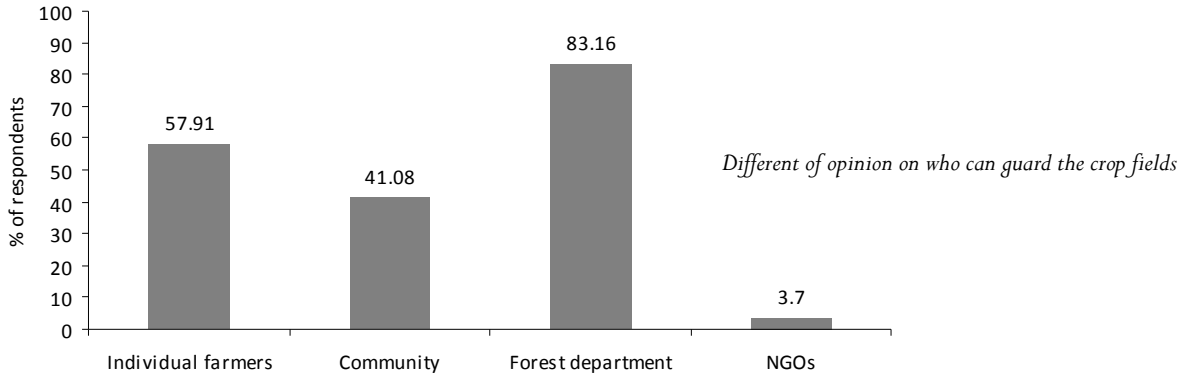
When asked about who is responsible for crop/property damage, most replied that forest department is more responsible (53.87%; n=160) followed by community (30.30%; n=90), Individual farmers (3.37%; n=10) NGOs (0.67%; n=2), nature (0.34%; n=1), no one (0.34%; n=1). Differences in choice were significant (Cochran's Q=5.632; df=5; p=0.000); more people thought that the forest department was responsible for crop loss.

More people believed that constructing electric fence (77.78%; n=231) and followed by guarding by forest department (48.48%; n=144), guarding by owners (47.47%; n=141) guarding by community (40.07%; n=119), guarding by volunteers (1.35%; n=4); concrete wall or barrier (1.35%; n=4), alternative crop (0.34%; n=1) can be the measures taken to protect crops/villages.

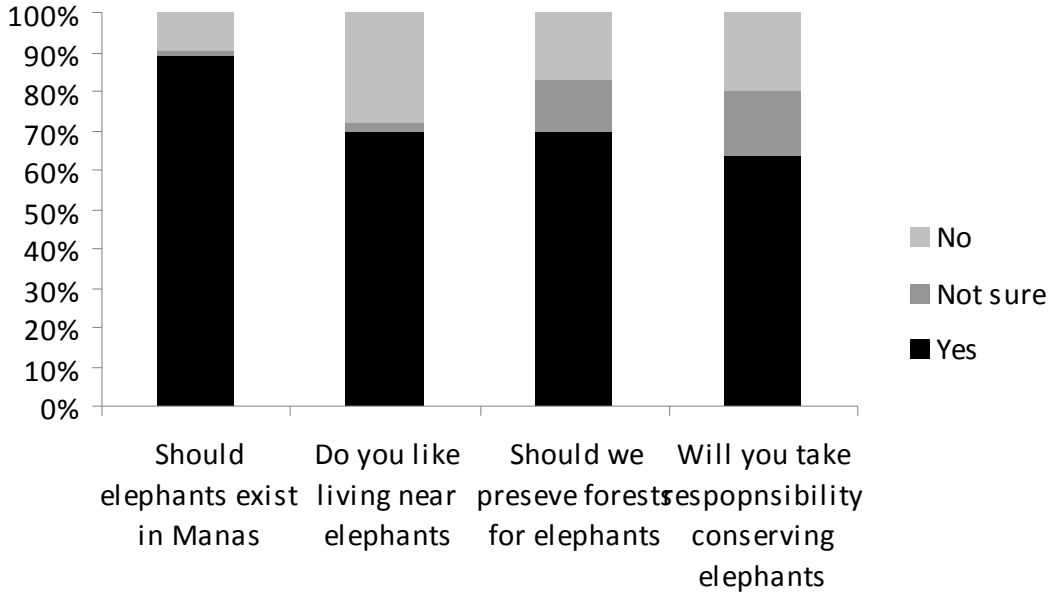


The different mitigation strategies suggested by the people.

Most people felt that forest department (83.16%; n=247), Individual farmers (57.91%; n=172), community (41.08%; n=122), NGOs (3.70%; n=11) are responsible for guarding fields from elephants. However there were significant differences in choice (Cochran's Q=3.574; df=3; p=0.000); most people believed the forest department is responsible for guarding fields from elephants.



Attitudes to Elephants / Intentions to conserve



Most people (89.2%; n=265) believed that elephants should exist in Manas while 9.8%; n=29 believed there should not be elephants in Manas, rest are not sure (3%; n=3). Again, 69.4%; n=206 said they like living near elephants and 27.6%; n=82 said they don't like living near elephants and rest are unsure (2.4%; n=7). Almost 68%; n=202 believed that we should preserve forest for elephants while 16.5%; n=49 said no and the rest are not sure (12.8%; n=38). Most people (62.3%; n=185) are ready to take responsibility to conserve elephants while 19.5%; n=58 said no and the rest are not sure (15.8%; n=47).

Most people felt that elephant is a property of everyone's (46.46%; n=138), Government (46.13%; n=137), Public (5.72%; n=17) and Nature (8.08%; n=24). There were significant differences in choice (Cochran's Q=1.824; df=3; *p=0.000*); people believed that the elephant was everyone's property (not one specific group). Again, when asked who should take the responsibility to conserve elephants, they felt

Everyone's (0.34%; n=1), Community (40.07%; n=119), Govt (64.65%; n=192) and NGOs (7.74%; n=23) should take the responsibility. Again differences in choice were significant (Cochran's Q=4.046; df=3; *p=0.000*); most people believed the government was responsible for conserving elephants, and NGOs were least responsible

The differences among different groups are shown here:

	Group	Yes % (n)	No % (n)	Sig.[1]
Should elephants exist in Manas?	Farmer	91.9% (147)	8.1% (13)	0.328
	Non-farmer	88.1% (118)	11.9% (16)	
	Tourism-involved	97.2%(35)	2.8% (1)	0.227
	Not-involved	89.1% (230)	10.9 (28)	
	Tribal	90.4% (160)	9.6% (17)	0.845
	Non-tribal	89.7 % (105)	10.3% (12)	
	Near Park	88.2% (134)	11.8% (18)	0.328
	Further away	92.3% (131)	7.7% (11)	
	Low conflict	?		
	High conflict	?		
Do you like living near elephants?	Farmer	74.7% (118)	25.3% (40)	0.238
	Non-farmer	67.7% (88)	32.3% (42)	
	Tourism-involved	65.7% (23)	34.3% (12)	0.428
	Not-involved	72.3 %(183)	27.7% (70)	
	Tribal	66.5 % (117)	33.5% (59)	0.012
	Non-tribal	79.5% (89)	20.5% (23)	
	Near Park	71.3% (107)	28.7% (43)	1.000
	Further away	71.7% (99)	28.3% (39)	
	Low conflict	?		
	High conflict	?		
Should we preserve forests for elephants?	Farmer	85.8% (115)	14.2% (19)	0.026
	Non-farmer	74.4% (87)	25.6% (30)	
	Tourism-involved	69.7% (23)	30.3% (10)	0.102
	Not-involved	82.1% (179)	17.9% (39)	
	Tribal	74.3% (113)	25.7% (39)	0.003**
	Non-tribal	89.9% (89)	10.1% (10)	
	Near Park	80.6%	19.4% (26)	1.000

		(108)		
	Further away	80.3% (94)	19.7% (23)	
	Low conflict	?	?	
	High conflict	?	?	
Will you take responsibility for conserving elephants?	Farmer	79.5% (105)	20.5% (27)	0.178
	Non-farmer	72.1% (80)	27.9% (31	
	Tourism	86.7% (26)	13.3% (4)	0.175
	Non-tourism	74.6 %(159)	25.4% (54)	
	Tribal	72.4% (105)	27.6% (40)	0.125
	Non-tribal	81.6% (80)	18.4% (18)	
	Near Park	75.6% (99)	24.4% (32)	0.881
	Further away	76.8% (86)	23.2% (26)	
	Low conflict			
	High conflict			

[1]*Fischer's Exact Test; two-tailed; *p≤0.5, **p≤0.01, ***p≤0.001*

There is a significant differences among tribals and non tribals regarding should we preserve forest for elephants (*Fischer's Exact Test; two-tailed; p≤0.003).*

However, the test between low conflict area and high conflict area are not conducted.

DISCUSSION

Spatial analysis

Predictors of human-elephant conflict are scale dependent: in our study, distance from park boundary was the only independent variable that predicted crop-raiding incidents across different spatial scales; all other variables varied with the spatial scale of analysis. Sitati *et al* (2003) found the distance from towns and area of cultivation were the two major drivers influencing HEC. Although these variables are scale dependent, we found the area of grassland was a predictor of conflict at 1km2 and 10km2 for groups, but did not show any effects at a 15km2 spatial scale. Similarly, total area of waterbody predicted crop-raiding by single (male) elephants at a 10km2 scale, but not at others. We are aware of non-independence of variables at a 1km2 resolution due to spatial autocorrelation (a trend also identified by Sitati *et al*., 2003); however other studies that conduct spatial analysis of HEC (Kumar and Singh, 2011; Bal *et al*, 2011) do not account for autocorrelation. Hence their findings may have errors in determining drivers.

Further, there is a need to conduct analysis of HEC at different spatial scales, as scale does introduce an effect on spatial predictors of HEC. (1) Independent variables show different effects at different spatial scales; (2) Moreover, the predictive capacity of the regression models also change with spatial scale. In our case, distance from Park boundary was the only predictor that caused any effect for single and group elephants in all 1 km2, 10 km2 and 15 km2. The area of waterbody showed effect for the single male elephants in the 10 km2, while total area of grassland showed effect for group elephant at 1 km2 and 10 km2. These findings strongly highlight the importance of scale and their dependency.

We therefore conclude in preferring multiple spatial scales in studying drivers of human elephant conflict. Spatial drivers may also vary across different regions and therefore are more localised in influencing patterns. In places like Manas, areas nearby to the Park has suffered more conflict as only distance from park boundary predicted conflict, i.e. villages or paddyfields closest to the park were most vulnerable to crop-raiding. This has direct implications for HEC mitigation: PA managers might be better placed if they concentrate mitigation efforts in villages closer to the park. It might also suggest that elephants do not use the non-reserve agroforestry matrix as often in other parts of India (Kumar and Singh, 2011; Bal *et al*, 2011; Assam Hathi Project, Ecosystem India) or Asia (Nyhus and Tilson, 2004). Hence landscape specific efforts are needed for mitigation of human elephant conflict. This indicates the influential factors in one region might not be applicable in others. The simple method of data collection and analysis utilized in this study could be used as a heuristic framework for identifying drivers of conflict in other landscapes.

What do our spatial models tell us? Only distance from PA effective across scales; not related to size of crop field; moreover this will vary with scale and cannot be generalized across contexts. In places like Manas, Forest department not geared of doing conservation work outside PAs; This may be because of influence of civil authority.

How can spatial models be used in HEC mitigation?

No one size fits all method: drivers are context-dependent and vary with scale; conservationists need to address this issue before using spatial models to try and mitigate HEC; the Table above shows that few studies till data account for effects of scale on HEC; hence drawing conclusions from such models is problematic; further drivers of conflict vary with areas.

Models need to be used in conjunction with social data for effective community-based HEC mitigation; our findings reveal that there are major differences within communities and benefits from PAs are not equitably distributed among them; solutions must take ethnicity, etc into account; they should try and identify the most vulnerable groups within the community (e.g. ethnicity; gender; low-income group; caste etc) who are likely to be disproportionately affected than those who are well off.

Social Data

Overall attitudes toward elephants and Manas National Park were positive. This might be because of the direct or indirect benefits (e.g. natural resources, park related benefits) coming from the Park. Difference between actual and perceived prevalent in our study area; respondents quoted far higher numbers of conflict than what actually occurred in the villages during our study period. Most people felt that the government forest department was responsible for crop loss and property damage by elephants, and shunned individual responsibility in this matter. This may be because a large number of respondents said that the elephant was government property (46.13%, n=137). Similarly, there was a belief that the government should take responsibility for guarding fields from elephants and this was significantly higher than individual and community responsibility.

Compensation schemes: Those related to PA management ("Tourism-involved") received more compensation; more members of the ethnic tribal community received compensation; this suggests that compensation might not be equitably distributed within the community; Again tribals faced greater problems in filing complaints.

PA related benefits: Responses to the question "do you benefit from tourism?" showed that fewer tribals benefited from tourism; as a consequence fewer tribals said they liked living near elephants and felt that forests should not be preserved for elephants; and individuals who were not involved in PA-related activities (i.e. "Tourism involved" in our table) said that Manas should not be protected. These trends show that (A) benefits from tourism are not equally distributed in society; (B) those who do not get benefits harbour more negative attitudes to the Park.

People suggested electric fencing is the most effective way of reducing conflict in the villages. However in places like Manas this may not be the best option, electric fencing cost more higher than any other options and also maintaining the cost of putting up electric fencing has zero chances of continuing in Manas. The alternative way may be a chilli fence, and how effective are they has already been discussed by Hedges & Gunaryadi, 2009.

Planting alternative crops may be another option, however very few people were willing to do so. Guarding by individual owners has greater vulnerability to elephants; not safe to guard on one's own. Hence we propose Elephants Response Unit (ERU) who can be more effective in guarding crop fields (Riddle, 2007).

Capacity building and internship

Miss Alolika Sinha, a project team member had 18 days of internship and training on field data collection and analysis at Nature Conservation Foundation, Mysore. During her internship, she was assigned with data generation in a field study at Valparai, Southern India. She has been under the guidance of Dr. M D Madushudan, Dr. Divya Mudappa, Dr. Shankar Raman and Dr. Anand Kumar at the Nature Conservation Foundation

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- *"I am thankful to Conservation Leadership Program for supporting my training cum internship at Nature Conservation Foundation (NCF), Mysore. I had enough opportunity to learn mew techniques and methods in preparing human-wildlife conflict studies. I thank Madushudan sir, Shankar Raman sir for their constant support and help at the NCF, undoubtedly I had learnt a lot after the training. This exposure had improved my networking and communication skills immensely. I also thank Dr. Bibhuti Lahkar at Aaranyak for facilitating the training at NCF".*

- Alolika Sinha

Three training programme on "Capacity building on conservation issues in Manas National Park" was conducted during 2010 as part of the project to build capacity for the local youths working on conservation in different organizations in the area at Bansbari range, Bhuyapara range and Panbari range in Manas National Park. A total of 115 participants activity participated in the three programs. The training was conducted for 19 days, six days in each training where all the participants showed a deep involvement and interest towards the subject both during classroom and field sessions.

The objectives of the training program were to introduce them to biodiversity conservation, Manas and about elephant conservation.

The programs had the following components:

1. Two days of classroom sessions
2. Two days of field sessions
3. Two days of interactive session

The classroom sessions focused on topics such as Manas at a glance, bird watching techniques, tourism guidelines, elephant conservation and general ideas on conflict, herpeto-fauna of Manas, how to identify plants etc. Mr. Bibhuti P Lahkar from Aaranyak was the main resource person along with Mr. Joydeep Mondol from Gauhati University. During the field session, practical demonstrations were made and the participants were introduced to the different approaches followed.

Scenes from the training programs held at Bansbari, Bhuyapara and Panbari ranges in Manas National Park.

Conservation coffee mug

A conservation coffee mug with five different designs were produced part of the project to distribute among different stakeholders, policymakers and politicians that may disseminate conservation message. It was for the first time such coffee mugs were developed at Elephant Research and Conservation Initiative, Aaranyak, which generated a huge interest among all the masses.

Coffee mugs with conservation message generated huge interest among stakeholders

Internship to graduate student

Part of the project, Ms. Jessika Ava, a graduate student from University of Oregon, US has completed her internship with us. She spent three months in field with the field team and assisted in data collection. She was also a part of data analysis as well. This exposure has helped her gaining more knowledge on the species and its interaction with people.

- *Working on an elephant conservation project for me, is literally, a dream come true. In a country where elephants are so common one can even see them on a busy city street, working in this type of wildlife conservation may not seem so far-fetched. However, for someone from North America, working on a project pertaining to "exotic" animals is – not figuratively - a world away from realistically speaking. Through this internship with Aaranyak, I was able to assist with various aspects of conservation, from research biology to capacity building community awareness programs. In only three short months, what I have learned from the experiences of working with Aaranyak has helped to create a better understanding of the dynamics of wildlife conservation and much that is involved in running a successful NGO. I have personally gained from this work and this work has helped to shape my future decisions and career path.*

- Jessika Ava
Oregon, USA
April 1, 2010

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