A Case Study on
Human-Wildlife Conflict in Nepal

(With particular reference to Human-Elephant Conflict in Eastern and Western Terai regions)

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SYNOPSIS

This report assesses the various aspects of human – wildlife conflict with particular reference to the negative interaction of humans with the wild elephants in the western and eastern Terai of Nepal. Three sectors *v.i.z.* Jhapa district in the eastern Terai, and Shuklaphanta Wildlife Reserve and the Bardia National Park in the western Terai were selected for this study. Landuse data were acquired through Landsat TM scenes for three periods (1990/91, 2001/01, and 2006/07). Using GIS techniques, 'edge habitats' across the home range of elephants within each study sectors were classified into two broad land use types; Forests (forests and/or degraded forest), and Settlement (agriculture, settlements/water body etc.). During late September and early October, we collected ethnographic data through a combination of social survey methods involving participatory techniques, structured questionnaire survey of households, on-site focal group discussions and key informant interviews. Field work was conducted in the 'front-line settlements' with the highest incidence of human-wildlife conflict (HWC) in each sector. An attempt was made to quantify the level of threat posed by different problem animals, the significance of Human – Elephant Conflict (HEC) in the household economy, and the conservation attitude among respondents. Also, we assessed the effect of land use dynamics on the economic loss incurred due to crop raiding by elephants.

Our results revealed that Shukla had significantly high forest cover in the 'edge habitats' compared to Jhapa and Bardia, but the difference between later two sectors were not significant. Temporally, there was a net decrease in forest cover in all sectors from 1991 to 2001 and this trend continued in Shukla and Jhapa later in 2001 to 2007 as well, but in Bardia there was marginal increase in the forest cover during this period. The overall pattern of temporal change in forest cover however was not statistically significant.

Socio-economic indicators such as land holding size, family size, structure of house and the literacy rates all indicated that Jhapa to be better off than the other two sectors. Paddy was the primary crop accounting for more than half of the economic value of total production in all sectors. Jhapa and Bardia had similar amount of crop production per household which was significantly higher compared to Shukla.

The people in all sectors perceived wild elephant as the biggest threat to their life and livelihood and the majority in Bardia and Shukla were also equally concerned about wild boar and spotted deer. Most respondents believed that the populations of these problem animals were increasing. Also, the people in Jhapa reckoned that retaliatory killing of elephants by humans was on the increase.

Crop raiding by elephants was the major issue in the three sectors with Bardia and Jhapa reporting higher frequency of incidences compared to Shukla. Among crops, the damage to paddy by elephants was most pervasive. A total economic value of crop loss per househould per year accounted for NRs, 12,253, NRs. 10108, and NRs. 3391 in Jhapa, Bardia, and Shukla, respectively. Statistically, the loss in Jhapa and Bardia did not differ significantly. Considering the income from crop production, a household in Bardia (27%) and Jhapa (25%) lost about a quarter of the total income which is double the amount that a household in Shukla (13%) had lost. Temporally, little over 50% increase in the loss of paddy was observed in Shukla during the period between 1999 and 2002. The same in Jhapa accounted for 30% over the span of five years from 2002 to 2007.

With regards to the probable causes of the conflict, nearly everyone in all sectors agreed that the increasing elephant population was the main problem. However, majority in Jhapa also believed that shrinking habitat could also be one of the causes. People in Shukla on the other hand supported the notion that elephants' natural preference for agricultural crops and inefficient protection measures were the driving force behind the human-elephant conflict.

Correlating the economic loss due to crop damage (NRs/Hh/Yr) with the settlement coverage (i.e. percentage of the transformed land) and with the degree of fragmentation revealed the significant positive associations between them. This result has important management implications considering the spatio-temporal differences in the forest cover as well as the degree of fragmentation in all three sectors.

Regarding the measures to mitigate HEC, most people in Jhapa preferred electric fencing while people in Bardia and Shukla were unsure about its effectiveness. The majority in Shukla were in favour of using techniques, such as chasing with fire, use of noise and explosives, and regularly guarding fields while the respondents from Jhapa and Bardia had doubts over the effectiveness of such measures.

A combined measure of conservation attitude as expressed by attitude index revealed that both Bardia and Shukla were more positive towards conservation than Jhapa. Furthermore, nearly all people from the former two sectors believed that the benefits obtained from tourism, community forestry, conservation awareness initiatives and infrastructure development activities would encourage the people to be more actively involved in conservation initiatives. Also, they shared the opinion that devolution of power to the local people, integration of local needs with conservation, and involvement of women in conservation activities were the appropriate strategies to make people to come forward to undertake the conservation activities.

Majority of respondents in all sectors believed that local people and concerned governmental and non-governmental organizations should work together in order to tackle the human-wildlife conflict. So far, most people in Bardia appeared to be satisfied with the support received by the concerned agencies, while opposite was true in the case of Shukla and Jhapa.

Owing to larger settlement coverage together with higher degree of fragmentation of the edge habitats in Jhapa and Bardia, there seemed to be greater economic loss due to crop raiding by elephants compared to Sukla. Temporal pattern of land use change however indicated that the forest cover in Bardia was increasing in recent years and the closer look at the land use maps revealed that these were taking place mainly around the periphery of existing forest patches. This is definitely an encouraging result for all the stakeholders involved in conservation and management in the region. Sukla on the other hand possess large intact forest patches and hence the crop raiding here is minimal at present. Nevertheless, the relative decline in forest cover over the years along with the increasing rate of paddy loss in Sukla point out that this situation may not last long. The habitat in Jhapa was much more fragmented and the worst still is that it had not received adequate attention from concerned conservation agencies. Consequently, people here had less positive attitude towards conservation and thus were less tolerant to HEC than Bardia and Sukla.

The landscape level conservation especially designed to harmonize local peoples' needs with the conservation efforts has been increasingly acknowledged as the most efficient measure for the long term and efficient management of wildlife and its habitats. This is particularly true in the case of managing wide–ranging meghaherbivores like elephants in the fragmented landscapes.

GENERAL BACKGROUND

Human-Wildlife Conflict (HWC) or negative interaction between people and wildlife has recently become one of the fundamental aspects of wildlife management as it represents the most widespread and complex challenge currently being faced by the conservationist around the world. HWC arises mainly because of the loss, degradation and fragmentation of habitats through human activities such as, logging, animal husbandry, agricultural expansion, and developmental projects (Fernando et al. 2005). As habitat gets fragmented, the length of 'edge' for the interface between humans and wildlife increases, while the animal populations become compressed in insular refuges. Consequently, it leads to greater contact and conflict with humans as wild animals seek to fulfill their nutritional, ecological and behavioral needs (Sukumar 1990). The damage to human interests engendered by contact with such animals can include loss of life or injury, threats to economic security, reduced food security and livelihood opportunities (Plate 1). The rural communities with limited livelihood opportunities are often hardest hit by conflicts with wildlife. Without mitigating HWC the results are further impoverishment of the poor, reduced local support for conservation, and increased retaliatory killings of wildlife causing increased vulnerability of wildlife populations. The conflict problem is hence a cause for concern that urges managers to shift their conventional policy from that of managing wildlife populations to enhancing their societal values. As such understanding the ecological and socio-economical context of the HWC is a prerequisite to bring about an efficient and long-term management of wildlife and its habitats.

Plate 1. A property damaged by elephant in Bardia (Source: Field survey 2007)

Of all the wild animals, the destruction brought about by elephants is the most pervasive for their wide ranging behavior, fidelity to their home range, large appetite, propensity and ability to destroy properties. Asian elephants are particularly attracted to food crops because they are more palatable, more nutritious and have lower secondary defences than wild browse plants (Sukumar 1990). This is perhaps why the crop damage by elephants is reported to be the one of the most widespread issues and thus has been a root cause of human-elephant conflict across the elephant range countries (Schultz 1986, Kiss 1990, West and Brechin 1991). For example, an elephant eats around 200 kg of food per day (Sukumar 2003) and a single elephant can destroy a hectare of crops in a very short time; a small herd can decimate a farmer's livelihood overnight. Often, the people who suffer these attacks are already economically and nutritionally vulnerable, and the loss of crops and livestock can have grave impacts on their income and food consumption. Such attacks can also lead to human injury and/or death. For example, the records show that in India alone, about 150 - 200 people on average were killed by elephants each year during 1980 – 2000 (Sukumar 2003). Hence, the field reports across the elephant range countries both in Asia and Africa describe local antipathy to elephants beyond that expressed for any other wildlife. This animosity is an ominous sign for future survival of the elephants, especially in the context of increasing trend toward a decentralized wildlife management throughout the elephant range countries. Owing to this, it becomes imperative to raise public tolerance of elephants, and to do so the management should first try to find answers to the questions such as, why does human-elephant conflict occur? How serious is the impact of conflict on the livelihoods and lives of people? How can we protect vulnerable individuals from the costs of conflict while maintaining elephants for regional and global benefits?

HUMAN-WILDLIFE CONFLICT IN THE TERAI REGION OF NEPAL

The southern lowland of Nepal which forms a part of the Gangetic plain is commonly known as the Terai region. The area covers about 23% of the total land area (CBS 2001) and is composed of alluvial and fertile land that extends from westernmost part of the country to the eastern limit along a 900 km stretch. Representing little over 55% of country’s cultivated lands, the Terai is considered to be the bread basket of the country and housing five most important protected areas, it also serves as the critical habitat for many endangered and charismatic species including, Tiger (*Panthera tigris*), Rhinoceros (*Rhinoceros unicornis*), Elephant (*Elephas maximus*), etc.

Over the last half century, this region experienced a massive population growth (3.0% during 1991- 2001) induced by inter-regional migration and immigration. The population density here has reached 330 persons/km^2, which is more than double the national average. Consequently, more and more wildlife habitats are being converted to settlements, agricultural lands and other forms of land-use in order to cater the needs of the growing population. For example, over 65% of forest areas were converted for agricultural extension in the valley of Chitwan between 1961 and 1977 (Gurung 1983). Other studies show that the forest area in the Terai decreased at an annual rate of 1.3 percent between 1978-1991. This has pushed wild animals into the isolated patches of habitats as provided by the existing protected areas. Such 'packing' of wild animals into habitat pockets (Ratnam 1984) together with increased cultivated area and human movement in wildlife habitats (Blair *et al.* 1979) have been attributed as the most proximate causes of the conflict between humans and wildlife. Judging by the poverty rate of over 30 % and the average wage of approximately 1 US $ a day (NLSS 2005), the loss due to human-wildlife conflict can have serious consequences in the local household economy in the Terai of Nepal.

The nature and intensity of conflict in Nepal, however is believed to vary between eastern and western Terai. In the western Terai, the slower economic development activities coupled by later migration from the mountains might have minimized the rate of habitat degradation relative to the eastern Terai. Apart from this, planned land use such as the establishment of protected areas, delineation of buffer zones, launching of the Terai Arc Landscape (TAL) program and Western Terai Landscape Program by WWF and other conservation initiatives, such as Bardia Conservation Program, Bardia Integrated Conservation Program, Parks and People, etc. might also have played an important role in maintaining wildlife habitats while providing significant economic benefits to local people for living with wildlife in the western Terai. On the contrary, with the improvement in habitats, the wildlife populations and/or their mobility are also expected to increase thereby possibly raising HWC incidences. The people receiving benefits from the conservation initiatives, on the other hand, are more likely to tolerate the wildlife damage and be positive towards conservation (Studsrod and Wegge 1995). However, no study has yet been undertaken to substantiate this, nor is any analysis done to ascertain the factors causing the differential intensities of HWC between these two regions.

WWF through its Asian Rhino and Elephant Action Strategy (AREAS), envisages conserving endangered large mammal species and their habitats by adopting landscape-based approach that goes beyond isolated protected areas and addresses issues of land-use practices in the surrounding areas. Improved decision making about rural lands requires careful consideration of how ecological information and analyses can inform specific planning and policy needs.
With proactive social, economic, and biological analysis, AREAS believes that a balance can be struck so that wild species get the secure core areas and forest corridors they need, while people can pursue agriculture, forestry, and other forms of land-use in a more clearly planned and sustainable manner. Hence, WWF Nepal program commissioned this study to compare the various dimensions of human-wildlife conflict, with particular reference to human-elephant conflict (HEC) in the eastern and western Terai of Nepal. The specific objectives of this study are as follows:

- To compare nature, extent and intensity of human-elephant conflict in the Western and Eastern Terai of Nepal
- Quick analysis of the occurrence and intensity of other HWC
- To determine the impacts of conflict on wildlife populations
- To document the nature and intensity of damages due to HWC in the local economy.
- To explore major causes giving rise to HWC
- To analyze effectiveness of current mitigation measures
- To document economic benefits received by local communities from living with wildlife
- To assist WWF in analyzing historical changes in landuse/landcover as a result of conservation initiatives undertaken in the region
- To discuss the effect of land use change on HEC and provide its economic implications

METHODOLOGY

Study site selection

We selected the three sectors, Bahundangi VDC of Jhapa District in the eastern Terai, Mahendra Nagar Municipality of Shuklaphanta Wildlife Reserve, and six buffer zone VDCs of the Bardia National Park (i.e. Shivpur, Neulapur, Baganaha, Magaragadi, Manau and Patabhar) in the western Terai of Nepal (Fig. 1), hereafter referred to as Jhapa, Shukla and Bardia, respectively. The major characteristics of these sites are outlined in the Table (Table 1). In doing so, our attempt here is primarily focused on assessing the impact of land use change on the nature and extent of HEC along the 'edge habitats' (boarder areas between settlement and the home ranges of elephant).

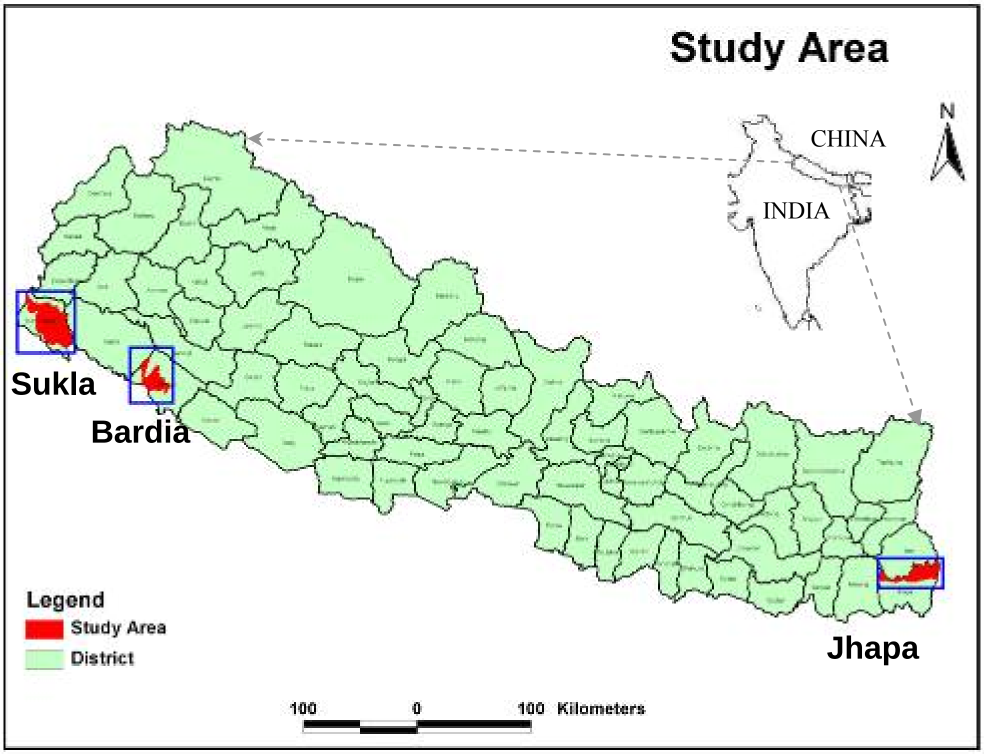
Table 1. Major characteristics of the study sectors

Sector	Region	Approx. population size	Human density[a] (persons/km^2)	Land management
Jhapa	Eastern	80 (Thousless 1993)	451.7 (CBS 2001)	Non protected area
Shukla	Western	20 (Velde 1997)	573.06 (Anon. 2004)	Protected area
Bardia	Western	80 (Pradhan 2007)	416.67 (CBS 2001)	Protected area

[a] Human densities are given for sampled VDCs/Municipalities within each study sector.

We acknowledge the complex interplay of other explanatory variables such as, population dynamics and behavioral ecology of elephants (Sukumar and Gadgil 1988, Sukumar 1990, 1991, Hoare 1999), habitat heterogeneity and other landscape attributes (for e.g. shape) (Nellemann et al. 2002) etc. in describing the nature and extent of HEC. We could not include these factors in our analysis as they were beyond the scope of this study. Thus, our report should be evaluated in this context. We however, believe that our results would be useful in understanding the issues as specified in the objectives and also serve as baseline information for further works particularly dealing with the HEC in Nepal.

Figure 1. Map of Nepal showing the locations of three study sectors, Jhapa, Bardia and Shukla.



Site description

Jhapa District

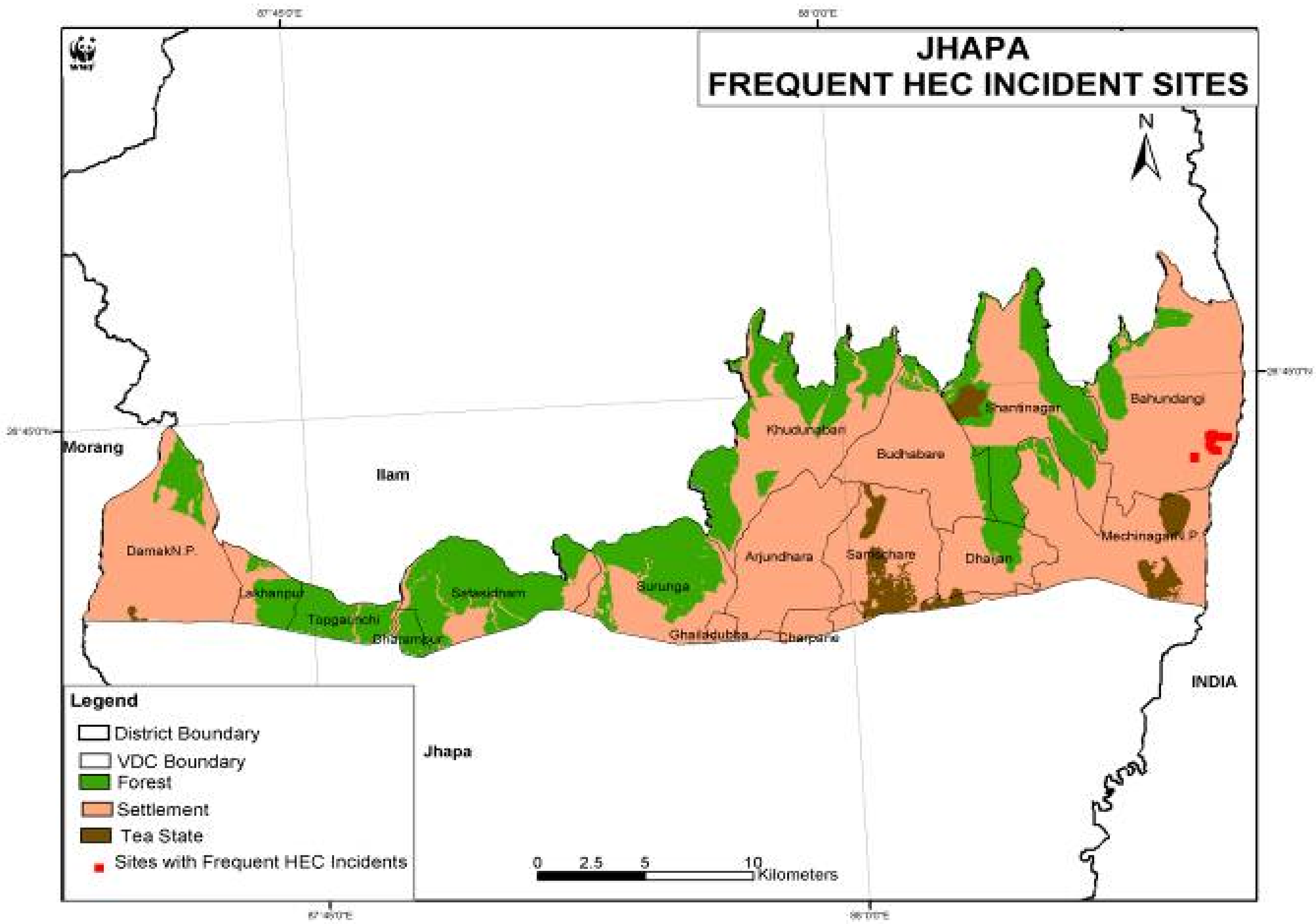
Within the district of Jhapa, Bahundangi Village Development Committee (VDC) is reported to be one of the sites with most frequent HEC incidents (Velde 1997). The 54 km^2 Bahundangi VDC (26^o 30' N, 88^o 0' E) is located about 10 km north of the East-West Highway and is bordered by the Indian district of Darjeeling in the east (Fig. 2). Spreading across an altitudinal range of 125 to 381 m., the climate here is subtropical with April and May as the warmest period (27.2^oC to 41.5^oC) and January as the coolest period (0.3 ^oC to 19.2^oC). Most of the rainfall (annual average 2336 mm) occurs during monsoon in the months of June to September. The district has about 30% of forest area and sal forest is the dominant forest type followed by mixed hardwood forest (*Adina cardifolia*, *Terminalia chebula*, *Terminalia blerica*, *Lagerstroemia parviflora*) and Chirpine (*Pinus roxburghii*) forest.

The people here are migrated from the hills and they comprise various ethnic groups mainly belonging to Bahun, Chhetri, Newar, Rai, Damai, Kami, etc. Agriculture constitutes the major occupation and the primary crops are rice, wheat, maize and lentils. Among cash crops, ginger, coconuts beetle nuts and tea are commonly grown. Apart from this, people also keep livestock such as cow (*Bos indicus*), buffalo (*Bubalus* sp.), goat (*Capra hircus*), and pig (*Sus* sp.) to supplement their livelihood.

Elephants of Eastern Terai region are considered to be a part of population of about 80 individuals, who spend most of their time in India (Thouless 1993). Bahundangi VDC is located in the gateway as the elephants enter Nepal from West Bengal by crossing the Mechi River (Plate 2, Velde 1997). Within Bahundangi VDC, the ward no 1, 2, 6, 8 and 9 are known to be most frequently visited by the problem elephants as they lie along side of the Mechi River (Yadav 2003, Bhandari 2004). Hence, we focused our household surveys and field observation in these 'frontline' settlements (Hoare 1999) (Fig. 2).

Plate 2. Elephant route in the boarder between India (on the right side) and Nepal (on the left side) across the Mechi River in Jhapa (Source: Field Survey 2007)

Figure 2. Map showing the sites with the most frequent Human-Elephant Conflict incidents (HEC) within the Bahundangi VDC of the Jhapa study sector.



As for the conservation initiatives, some activities are being undertaken by District Forest Office and the District Soil Conservation Office. The activities in connection with HEC are also being particularly dealt by the District Development Committee, Village Development Committee and the District Administration office. Apart from this, the local people have also formed an organization called 'Hatti Niyantran Committee' in order to look after the issues pertaining to the HEC. However, more effective integrated conservation activities seem lacking in the area. Absence of organizations such as WWF, IUCN and NTNC in the area also reflects it.

Bardia National Park (BNP) and Buffer Zone

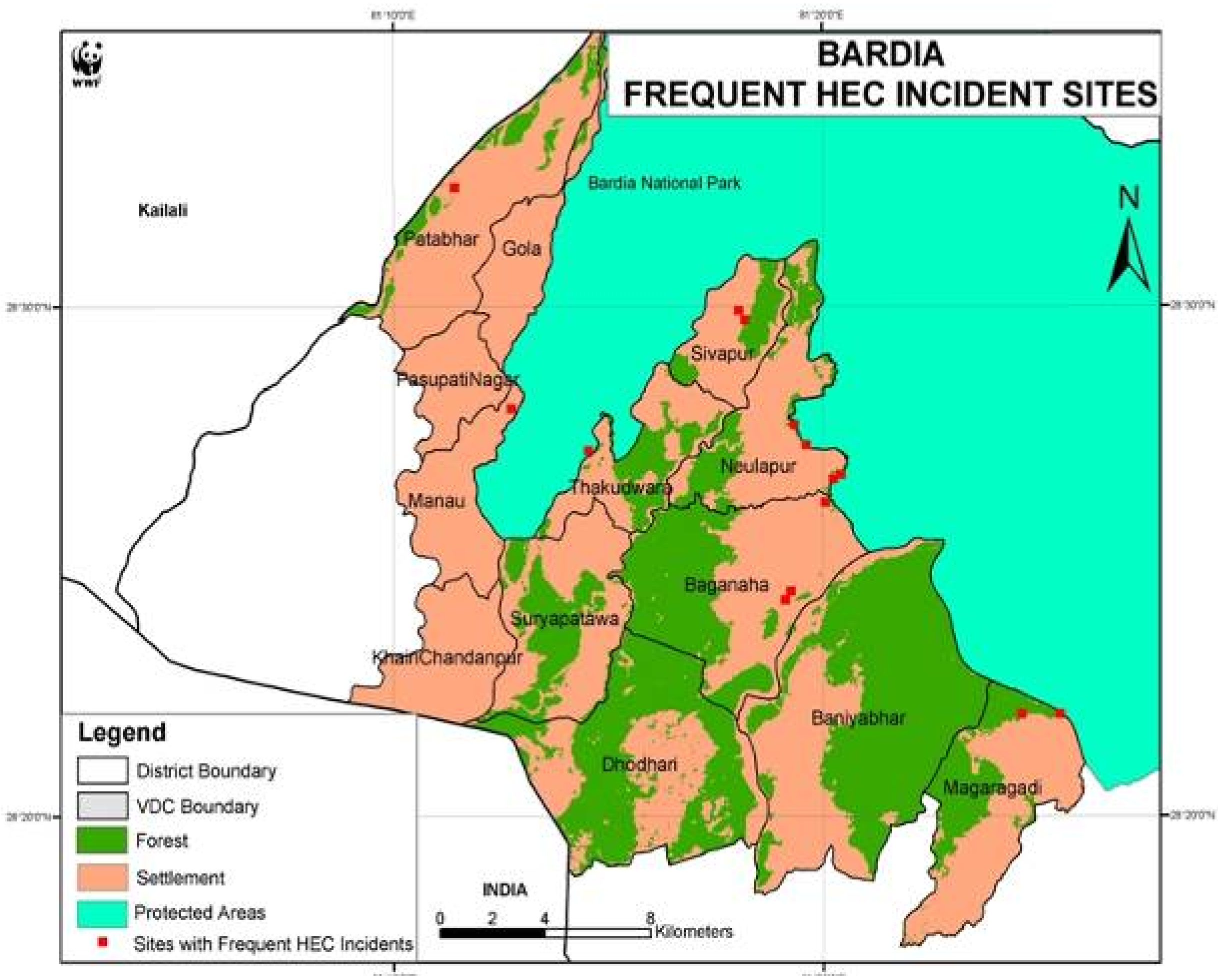
Located in the Bardia and Banke District of the western Terai and covering 968 km^2, Bardia National Park (81^o 15'E and 28^o 30'N) is the largest protected area in the Terai. In contrast to many other isolated habitat fragments in the western part of the Terai landscape of northern India and Nepal, narrow natural corridors still connect BNP with Shuklaphanta Wildlife Reserve in the west, Katarniaghat Wildlife Sanctuary and Dudhwa National Park in India to the south, and a large tract of government forest to the east. The Park spreads across Chure hills in the north and riverine flood plain in the south within the altitudinal range of 152 to 1441 m. The climate here is subtropical monsoonal type with three distinct seasons: cool-dry (November to February), hot dry (March to June) and monsoon (July to October). Average annual rainfall amounts to 1500 mm and it occurs mostly between June and September, somewhat later than the rest of the country (Bolton 1976). Average temperature in the cool season drops to 10 ^{o}C in January while in the hot dry season temperature may rise up to 41 ^{o}C in May (Dinerstein 1979). Seven major vegetation types (Jnawali and Wegge 1993) are distributed in the landscape complexes comprised by Karnali floodplain, the Babai river, Churia hills (Bhuju et al. 2007). Sal forest is the most widely distributed as it covers 70 percent of the total area. Khair-Sissoo Forest is the pioneer association occurring alongside the rivers. Moist riverine forest is patchily distributed in depressions along the watercourse. The well drained flat lands were mostly occupied by the mixed hard wood forests. In addition to this, three types of grasslands viz. floodplain grasslands, wooded grasslands and phantas have been located in the park in flood plain areas, forest edges and in the previously cultivated areas, respectively.

BNP has the Nepal's largest population of elephants that roam between the Park and adjacent forested areas in India. It also contains the largest biomass of ungulates per km^2 reported from anywhere in Asia, and these include endangered swamp deer (*Cervus duvauceli*), spotted deer (*Axis axis*), hog deer (*Axis porcinus*), sambar deer (*Cervus unicolor*), nilgai antelope (*Boselaphus tragocamelus),* and the four-horned antelope (*Tetracerus quadricornis)* (Andersen and Naess, 1993). The Karnali floodplain also harbors a population of rhinoceros (*Rhinoceros unicornis*) which had been relocated from Chitawan Natitonal Park. The park is also well known for leopard (*Panthera pardus*) and one of the highest recorded tiger (*Panthera tigris*) densities in the world (Wegge et al. 2004).

Following rapid habitat destruction that started after the eradication of malaria in the 1950's, the elephant population in the BNP reached the brink of functional extinction, consisting of less than

20 seasonal visitors (Bolton 1976). However, in 1994 the number of elephants increased abruptly due to immigration, probably from India (Velde 1997), and the current resident population is estimated at approximately 80 animals (Pradhan 2007). With increasing population size, animals are expected to move outside particularly in the eastern sector of the national park thereby raising a potential for conflict with the humans inhabiting there (Pradhan 2007). Among the most heavily affected Buffer Zone VDCs, we focused our household surveys in the selected wards within the VDCs of Shivpur, Neulapur, Baganaha, Magaragadi, Manau and Patabhar (Fig. 3).

Figure 3. Map showing the sites with most frequent Human-Elephant Conflict (HEC) incidents within the VDCs of Sivapur, Neulapur, Baganaha, Magaragadi, Manau and Patabhar in the Bardia study sector.



In order to address the park-people conflict, the 327 km^2 of area around BNP was declared as the Buffer Zone in 1996. Historically, the Buffer Zone area was settled by the Tharu people, but as a result of substantial immigration over the last 60 years the present population has become ethnically mixed. The majority of the villagers live in a subsistence economy in which land and livestock holdings are the principle economic assets. Paddy (*Oryza sativa*), Maize (*Zea mays*), Wheat (*Tricticum aestivum*), Lentil (*Lens culinaris*), and Mustard (*Brassica campestris*), are the principle crops and are mostly grown for domestic consumption. Livestock is economically important as a source of milk, manure, draft-power, and cash income.

The park is being managed by the Department of National Parks and Wildlife Conservation (DNPWC) and the Nepalese Army is guarding and enforcing the existing rules and regulations including controlling poachers, stopping illegal fishing, checking boundaries, preventing encroachment into the park, and preventing livestock grazing and extraction of resources by local inhabitants. Besides this, other partner agencies are also assisting DNPWC's conservation and development efforts. Among them the key institutions include, WWF, NTNC, CARE Nepal and UNDP. Bhuju et al. (2007) outlined some of the major achievements made in recent years as follows:

- Seven agroforestry plots have been established in nearly 1600 hectares thereby providing benefits to 2137 households over a period of three years from May 2000 to April 2003
- A well functional community health centre has been established at Thakurdwara
- About 893 km^2 of additional area has been proposed to extend the park in line with 'Gift to the Earth' initiatives
- The number of tourists visiting the park has been increased by 14% per year
- In order to compensate for losses incurred due to HWC, endowment funds such as the 'Rahat Kosh', Apatkalin Kosh' have been established

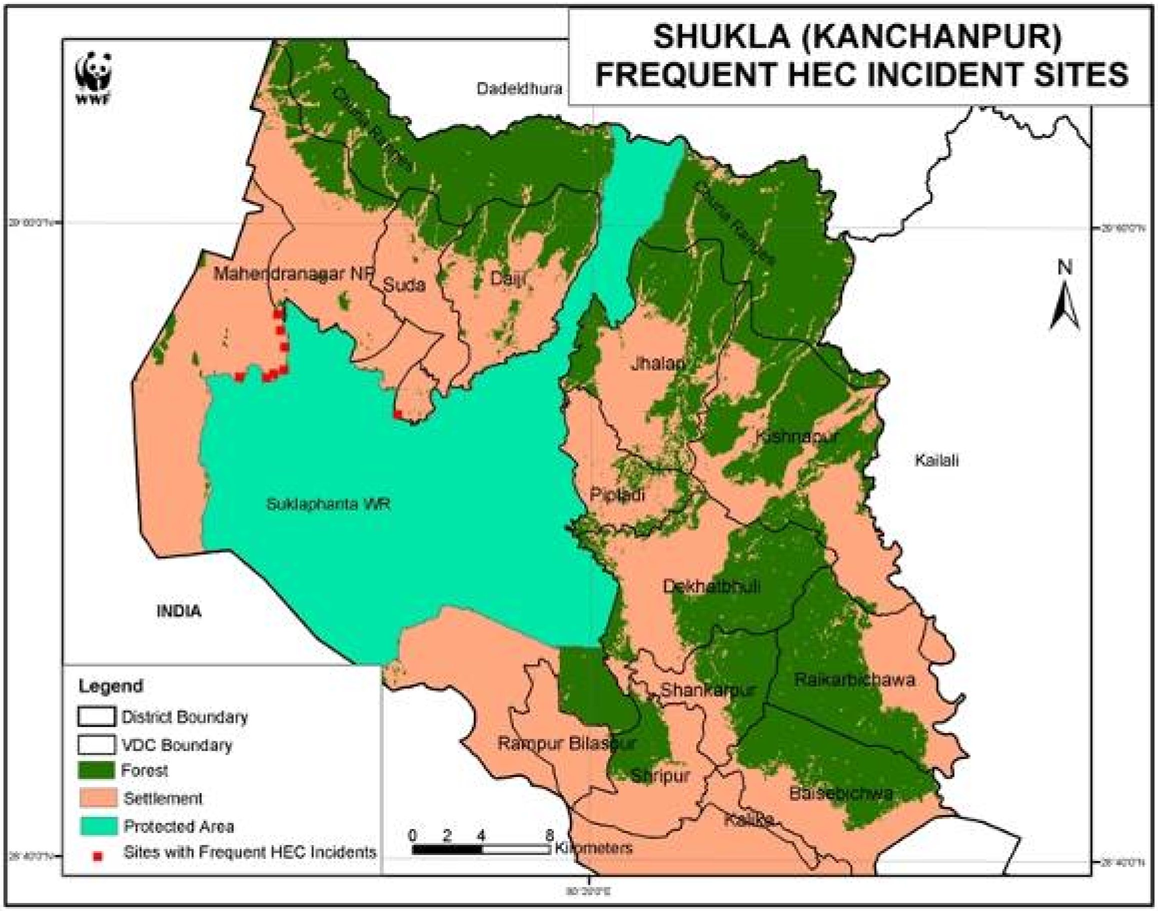
Apart from this, local communities are also greatly benefited by the extensive community forests of the buffer zone. The community forests here, not only provide the much needed forest products to local households but also are the constant source of income for the Buffer Zone User Committees.

Shuklaphanta Wildlife Reserve (SWR) and Buffer Zone

The 305 km^2 Shuklaphanta Wildlife Reserve (80^o $14^'$ E and 28^o $55^'$ N) is located in the district of Kanchanpur in the western most Terai of Nepal. It is bordered by Mahendranagar Municipality in the north and Indian state of Uttar Pradesh in the south and east across the Mahakali River. SWR has subtropical monsoonal climate with three distinct seasons viz., cool-dry (late September to mid February), hot-dry (February to mid June), and monsoon (mid June to late September). The mean monthly rainfall is about 1500 mm and about 90 percent of it occurs during monsoon. Average temperature goes as high as 37^oC in the hot dry season and drops to 7 ^oC in the cool dry season (Baral 1999). Due to its topography which ranges from the slopes of the Churia hill to the vast flood plains within an altitudinal span of 174m to 1386m, the area consist diverse ecosystems. Sal forest predominates the higher elevations along the Churia foot hills, whereas the lower flat flood plains consist mosaic of habitats made up of grasslands, wet lands and riverine deciduous forests. Covering nearly 20 per cent of total area, the grassland is the biggest continuous land use of the reserve. Khair-Sissoo forest is found along the Mahakali river in the sounthern boundary of SWR. The reserve is also a home to the largest existing herds of swamp deer (*Cervus duvaucelli*). Other mammalian fauna of interest especially with reference to HWC include tiger, elephant, hog deer, barking deer (*Muntiacus muntjak*), wild boar (*Sus scrofa*), monkey (*Macaca mulata*), and porcupine (*Hystrix indica*).

Although no specific census have yet been undertaken to ascertain the elephants numbers in the park, Velde (1997) estimated about 15-20 elephants entering Nepal from India. Most of the incidences of HEC is known to occur in the villages bordering the parks southern and northern boundaries (Velde 1997). In the present study, we selected the five wards viz. 13, 14, 15, 18, and 19 of the Mahendranagar municipality which are situated adjacent to north-western boundary of the park with reportedly highest intensity of HWC (Baral 1999) (Fig. 4).

Figure 4. Map showing the sites with most frequent Human-Elephant Conflict (HEC) incidents in the Mahendra Nagar Muinipality of Shukla study sector.



Of late, 243 km^2 area surrounding the park was declared as Buffer Zone which is currently inhabited by 111,783 people (Anon. 2004). Tharus comprise indigenous inhabitants of this area. As with the other parts of Terai, the immigration of people from hills outnumbered Tharu people in recent years and subsequently formed a community with mixed ethnic groups. Agriculture is the major economic enterprise and people here cultivate paddy, maize, wheat, mustard, peas and other lentils. In addition to this, they also raise multiple species of livestock such as cow, buffalo, ox, goat and sheep.

Regarding the conservation and the management of the park, the SWR was initially designated as Royal Hunting Reserve in 1969. Later, in 1976 it was gazetted as Royal Shuklaphanta Wildlife Reserve (Anon. 2006) and in late 1980s about 150 km^2 area towards eastern side of the park was extended to link the flood plains of the Terai to Churia hills so as to facilitate the seasonal migration of wildlife. The government's effort through DNPWC is assisted by various conservation agencies such as WWF Nepal, NTNC and UNDP. More importantly perhaps is the WWF Nepal's involvement in launching the Western Terai Landscape Complex Project (WTLCP) to bring about landscape level conservation in and around SWR. Bhuju et al. (2007) documented following significant achievements made in recent years in SWR.

- Maintenance of six water holes, 22 km trench, and 10 km of barbed wire fence
- Construction of three 'machans', and 22 km of fire lines
- Two poaching units established in order to control the poaching and illegal slaughter of wild animals.
- Nominated by CITES as A site for Monitoring of Illegally killed elephants (MIKE)
- Formation of a Tiger Conservation Action Plan to increase the number of breeding tigers
- Establishment of 422 user groups (DNPWC/PCP 2002)
- Development of databases and annual and five-year plans of 40 user groups with the technical and financial support of the SWR/PCP (DNPWC/PCP 2002).

Data collection

Ethnographic data

Prior to data collection, extensive literature surveys and discussions with the key persons were undertaken to locate the sites with the highest incidences of HEC in and around Bardia National Park, Shuklaphanta Wildlife Reserve, and Jhapa District (Fig. 2, 3 & 4). We then collected ethnographic data in these sites by employing combination of social survey methods involving participatory techniques (focal group discussions and key informant interview), structured questionnaire survey of households (plate 4) and on-site observations. Our queries were designed to solicit information such as the general socio-economic status of the community, issues of HWC currently being faced in each site such as the number of incidences, extent of damage to wildlife and humans, economic implications of that damage, attitude and behavior of humans in relation to HWC, and mitigation measures and initiatives designed to allow communities to benefit from wildlife.

Plate 3. A focal group discussion in Bahundangi, Jhapa (Source: Field survey 2007)

Plate 4. A household survey in Bardia (Source: Field survey 2007)

Between September and October 2007, we interviewed every 10th household along a randomly placed transect line in a village/ward. We maintained approximately 10% sampling intensity in each village/ward by interviewing a total of 150, 150 and 152 households in Shukla, Bardia, and Jhapa, respectively. The interview was conducted simultaneously in all sectors by three research assistants, all were university graduates and well-versed in local languages. Each of them was also supported by a locally hired guide. Before initiating the fieldwork, the research assistants were trained to administer the survey and the questionnaire went through several rounds of pre-testing. We usually interviewed the household heads and as they were generally male, our sample was biased towards males to some extent. We began our interview by explaining the purpose of the study and if the respondent was willing to participate, the interview proceeded. Each interview lasted 30–75 minutes and took the form of a conversation, structured around a written questionnaire consisting of both fixed-response and open-ended questions. In some cases, the respondents were invited to score the extent to which they agreed or disagreed with the statement offered. A five-point Likert scale was used in this context. Prompt and probs were used to improve the precision of answers and the clarification was sought immediately if there was any ambiguity.

In addition to the household surveys, we also carried out on-site focal group discussions and key informant interviews in order to obtain general information such as cropping pattern, benefits from living with wildlife, role of other governmental and non-governmental institutions, local market price of major crops, and the location of most heavily affected fields. Later we visited the affected sites to assess the extent of crop damage and also to take the GPS measurements of these sites. The damage data were also collected opportunistically as and when possible. Apart from obtaining the supplementary information, one of the major objectives of these undertakings was to cross-validate the information that we obtained through household interviews.

Landuse data

Land use data based on GIS analysis was provided by the WWF/Nepal programme. The data covers the 'edge habitats' in and around elephant ranges within the districts of Jhapa (Fig. 2), Bardia (Fig. 3) and Kanchanpur (Fig. 4) (Velde 1997, Yadav 2003, Pradhan 2007) (see appendix for the detailed description of edge habitats in each site). We selected the edge habitats assuming that land use dynamics along the edge habitats of elephants will have significant impact on HEC as these are the areas where the interface between human and wildlife mostly take place (Hoare 1999). A brief description of methods followed is outlined below.

Three sets of Landsat TM data were obtained in order to examine the rate of change of forest cover along the 'edge habitats' of the three districts between the years 1990/91, 2000/01 and

2006/07. Topographic maps of 1: 25,000 covering the study area were also obtained and the vector data were used during the analysis.

Each study area was classified into two broad types: 1) forest (forested land covered with forest and/or degraded forest), 2) settlement (agriculture, huts, water body etc.). Of the three sets of Landsat TM scenes, the classified data for the years 1990/91 and the 2000/01 were already existed. Thus, they were clipped by the study area and subsequently used in this study. For the 2006/07, the classification was accomplished by using the NDVI methodology and generated the same classes as was done for the other two classes. Corrections for shadow and cloud were applied following the standard procedures (appendix). Ground verification was done in October 2007 by generating sample points with the help of ERDAS software. District Forest Office of the respective study areas were also consulted during the process of field verification. Five types of maps were prepared for each study area comprising three different forest/non forest maps for each of the three aforementioned periods and the two change analysis maps for the period between 2000/01 to 2006/07 and 1990/91 to 2000/01. While doing so, minimum mapping unit was maintained at 1 hectare (12 pixels).

Data analysis

Ethnographic data

We first organized our data into different topics by following the objectives of the study. We then coded the data from interviews according to the topics already described. We used descriptive statistics to summarize data and the categorical responses were analyzed using χ^2 tests to explore the association among variables. One-way ANOVA along with Tukey's HSD for multiple comparisons was applied for all continuous data so as to obtain the quantitative information on similarities and differences of issues across the study sectors.

We determined the threat level of different problem animals by computing the geometric mean of the frequency of sighting of the species and its rank based on perceived extent of damage.

$$T_i = \sqrt[2]{f_i \times d_i}$$

where,

Ti = Threat level of the species *i*

Fi = Frequency of sighting of the species *i*

di = rank given by respondents on the basis of species *i*'s potential to cause damage

This measure was used because the distribution of both *fi* and *di* can neither be completely independent (whereby variable are multiplied) nor be totally dependent (whereby the arithmetic mean is taken) of each other (May 1975, Hanski and Koskela 1978). The threat levels thus obtained were ordered into three different categories: High (≥ 4), Moderate (2.1 – 3.9), Low (≤ 2).

Estimating total economic loss of assets other than crop (i.e. livestock and property) may lead to biased conclusion, especially in the comparative studies as the economic value of such assets depend on many site and species - specific factors (Studsord and Wegge 1995). Thus, in order to make our results comparable between the three sectors by maintaining the consistency, we focused our data analysis only on crop damage by elephants. As there is a general tendency of villagers to inflate the loss (Upreti 1985, Sharma 1991), we used an indirect approach to calculate it:

$$\mathrm{Li} = \mathrm{Ai} \times \mathrm{Yi}$$

where,

Li = Loss of a given crop (kg/year) incurred by household *i*

Ai = Area damaged by elephant as reported by household *i*

Yi = Average yield in (kg/year/unit area) for a given crop as reported by household *i*

Monetary values of the lost crop (NRs /kg /household) were obtained by multiplying *Li* with the farm-gate price of the crop (Table 2).

Table 2: Farm-gate price of the common crops as of November, 2007 in Jhapa, Bardia and Shukla (Source: Field Survey, 2007).

Crop	Price/kg (in NRs)		
	Jhapa	**Bardia**	**Shukla**
Paddy	11.00	10.50	8.00
Wheat	6.25	15.00	12.00
Maize	8.75	11.00	11.00
Mustard	40.00	37.50	50.00
Millet	12.50		
Lentils	65.00	42.50	40.00

We acknowledge that aforementioned calculation entirely relied on a questionnaire survey and used farmers' own perceptions of damage, thus it is likely that our estimates may not be as accurate as that obtained through the Net Area Damage (NAD) method suggested by Sharma (1991). However, we believe our data would still provide comparable results because of the indirect approach that we followed.

In order to obtain information on the temporal pattern of crop loss, we compared our estimates of paddy loss per household with the data from previous works undertaken in 1999 in Shukla (Baral 1999), and in 2002 in Jhapa (Bhandari 2004). We restricted our comparison to paddy as this was the only crop for which the comparable data were available. Owing to the heavy loss incurred in paddy in all sites, we assume that the results from this comparison will provide useful insights on the temporal pattern of loss. Moreover, we used wards as a sampling unit and attempted to build a matching pair of wards by selecting only those wards from our study for which the data existed from previous study. We preformed paired t-tests to assess the mean differences.

We quantified the conservation attitude of respondents by computing the attitude index of local people. It was done by organizing the responses associated with the conservation attitude on Likert scale and subsequently evaluating the logical coherence of attitudes for internal consistency of responses by calculating the Cronbach' alpha (Cronbach 1951). We then computed the attitude index for a given respondent by summing up his/her responses for all statements taken into consideration divided by the number of statements (Sah and Heinen 2001).

Land use change at the sectoral level

We computed the forest coverage as the percentage forest in the total area. The forest coverage data were arcsin square root transformed and the Two-way ANOVA was performed using district and year as the two factors. In the case of significant differences, the multiple comparisons were carried out by applying Tukey HSD test to isolate the group that differed from the others.

Impact of land transformation and the habitat fragmentation on the extent of crop damage by elephants in VDCs

We first combined the VDC level economic loss data from this study and from earlier studies carried out in Jhapa (Yadav 2003, Bhandari 2004), Bardia (Studsord and Wegge 1995), and Shukla (Baral 1999). This was followed by conversion of the economic value of crop losses reported in earlier studies to the present value by multiplying the quantity loss (kg/Hh) with the current farm-gate prices of the corresponding sites (Table 2). The impact of land transformation was then assessed by calculating the 'settlement coverage' in each VDC. The settlement coverage essentially signifies the percentage of transformed area in each VDCs and was obtained by dividing settlement area with the total area of the corresponding VDC (Hoare 1999). The settlement coverage values thus calculated were arcsin squart root transformed for the further analyis. Since the dates of some of our economic loss data and land use data do not correspond with each other, we merged such economic data with the nearest date that the land use data were acquired. While doing so, we did not expect that it would cause significant bias as the land use (both agriculture and settlement) across the years did not vary significantly (Fig. 8, P = 0.55). The effect of land transformation was subsequently examined by employing two statistical techniques: Spearman rank correlation (r_s) was used to obtain the significance level owing that our data may not match the conditions required by parametric tests. Once the significance level has been ascertained, we determined the magnitude of effect by computing the coefficient of determination (r^2).

In order to assess the impact of habitat fragmentation, we calculated the ratio between ‘habitat frontage’ and the corresponding forest cover in each VDC. Habitat frontage is defined as the length of the boundary between forest cover and settlement and the increased fragmentation due to the anthropogenic causes is expected to produce greater habitat frontage (Sukumar 1990, Hoare 1999). The relationship between habitat fragmentation and economic loss was later determined by correlating the arcsin square root transformed values of the habitat frontage ratio with the economic loss due to crop damage. We used Spearman rank correlation (r_s) and the coefficient of determination (r^2) for this purpose as described above.

With limited number of VDCs included in Shukla and Jhapa, the concerns about equal sampling effort would be valid. However, judging by the fact that we have focused our studies only in those sites with the highest incidences of HEC in all three sectors and maintained about equal number of sample households, we expect that our data are comparable across sites and thus it is likely that the bias if any would not significantly alter the conclusion.

RESULTS

Demographics

Jhapa

A total of 4434 households comprising 22,837 people inhabit in Bahundangi VDC (CBS 2001). The average family size accounted for 5.05 persons. All people in our sample were literate. Nearly all people owned private houses and the 80% of their houses were made up of brick and concrete with roofing predominantly by corrugated sheets (Table 3, 4). About 10% inhabitants were landless. The average landholding size was 0.97 ha (SE = 0.08 ha) per household. Paddy and maize were the major crops (Fig. 6) supplemented by cash crops such as beetle nuts, banana and ginger. People here also raised multiple species of livestock: mainly comprised by goats, cows, buffaloes (Fig. 5). Poultry farming is also commonly practiced.

Bardia

A total of 70,721 people live in 10, 276 households in the 6 VDCs (CBS 2001) considered for this study. Average family size is 6.88 persons. Little over 35% of people in our sample were literate. Majority lived in private residence (98% of households) and their dwellings were primarily made up of earth and mud (Table 3) with roofing by thatch and straw (Table 4). Nearly all households owned land (98% of households), each with 0.53 ha (SE = 0.05 ha). Paddy, wheat, maize, lentils and mustard formed principal crops (Fig. 6). Livestock constituted mainly of goats, ox and buffaloes (Fig. 5).

Shukla

The Mahendra Nagar Municipality is a home to 80,839 people who live in 13738 houses. The average family size is 5.88 persons. Over 70% of people in our sample were literate. All most all people owned houses (99%) and about 58 % of houses were built of concrete and brick and another 42 % by earth and mud. They had predominantly concrete and slate roofing in their houses (88%). Nearly all households owned (99%) land, each with 0.56 ha (SE = 0.07 ha). Paddy and wheat are the primary crops (Fig. 6). All people here had multiple species of livestock comprised by cows, buffaloes, ox and goats (Fig. 5).

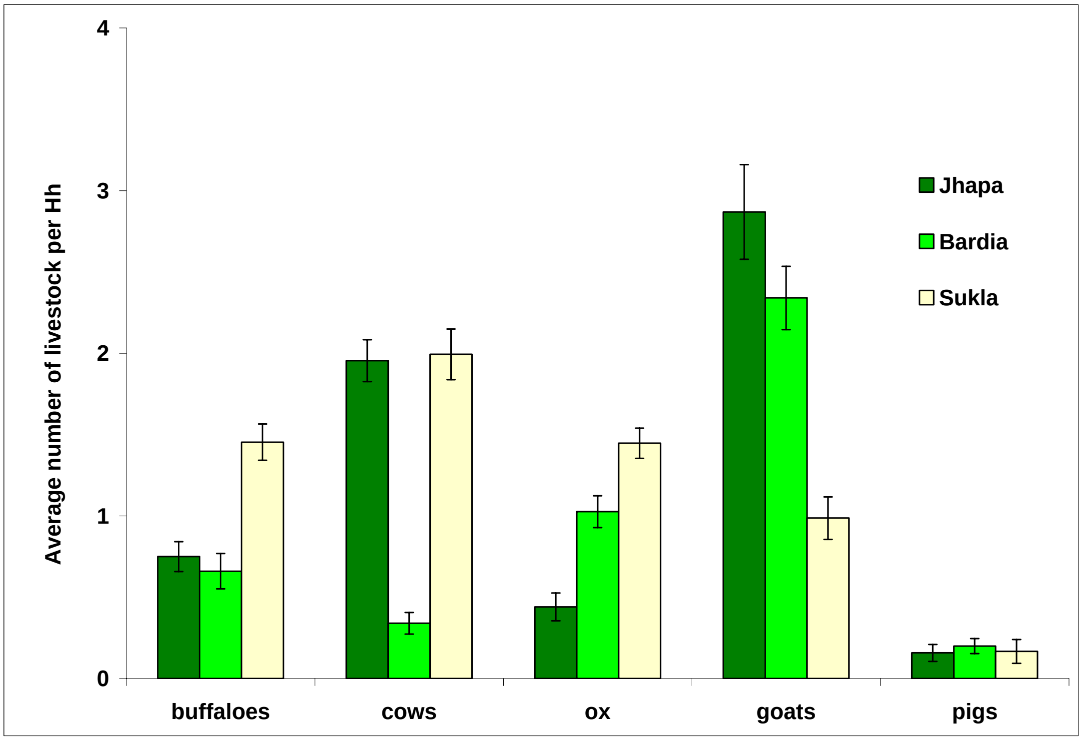
Table 3. Type of house in Jhapa, Bardia and Sukla

	Jhapa (%)	Bardia (%)	Sukla (%)
Concrete	23.03	2.00	0.67
Stone	0.00	0.00	0.00
Brick	13.82	12.00	57.33
Earth/Mud	20.39	86.00	42.00
Others	42.76	0.00	0.00

Table 4. Type of roof in Jhapa, Bardia and Shukla

	Jhapa (%)	Bardia (%)	Shukla (%)
Straw/Thatch	7.24	71.33	16.00
Wood/Planks	0.66	4.00	0.00
Corrugated Sheet	88.16	3.33	6.00
Concrete	3.95	21.33	50.67
Tiles/Slate	0.00	0.00	27.33

Figure 5. Average number of livestock per household in Jhapa, Bardia and Shukla.



Comparison among sites

Socio-economic status

Jhapa had significantly lower family size compared to both Bardia and Shukla (both; $p < 0.05$). The literacy rate differed across the sites ($\chi^2 = 153.51$, df = 2, $P < 0.01$) with more literate people in Jhapa than in Shukla and Bardia ($\chi^2 = 98.41$, df = 1, $P < 0.01$). Also, the majority of houses in Jhapa were well-built compared to other two sectors (both; $\chi^2 > 15.45$, df = 1, $P < 0.01$). Jhapa had larger mean landholdings than Bardia and Shukla (Tukey HSD, $P < 0.05$) and the later two sectors did not differ (Tukey HSD, $P = 0.81$). Paddy was the most widely-grown crop in all sectors and Jhapa had the highest production per household among the two other sectors (Fig. 6). Bardia, on the other hand had moderate amount of production which did not significantly differ from Jhapa and Shukla (Fig. 6). In summary, our results generally indicated that Jhapa is relatively economically prosperous compare to Bardia and Shukla.

Figure 6. Average production of paddy, maize and wheat and loss (kg/Hh/year) due to the crop raiding by wild elephants in Jhapa, Bardia and Shukla.

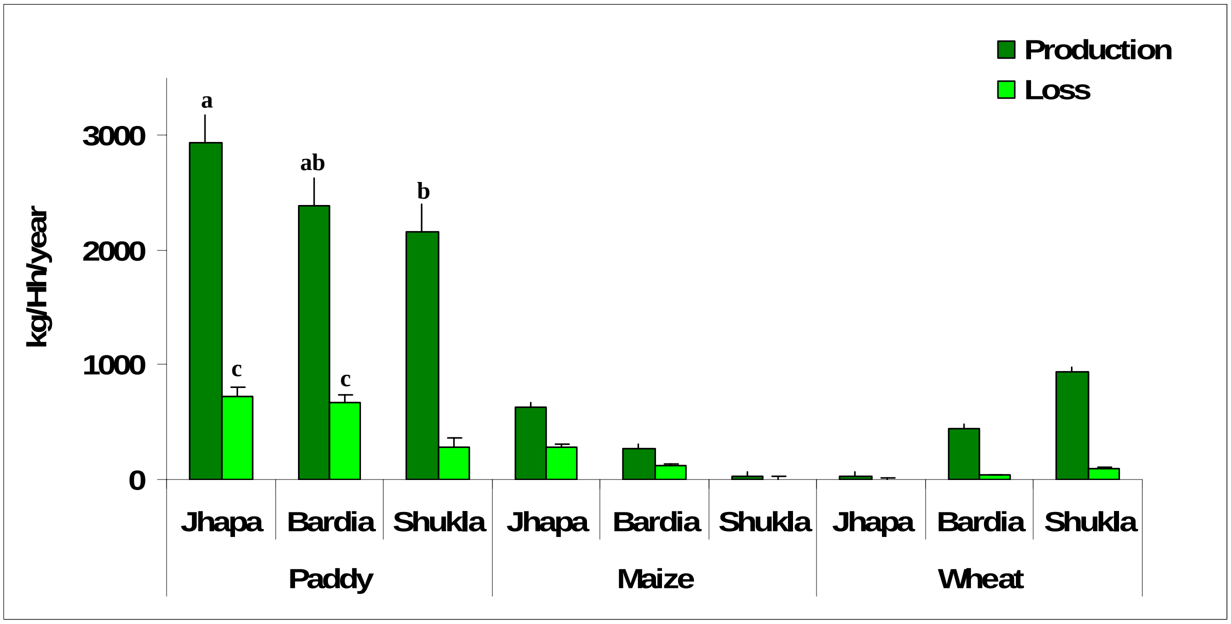
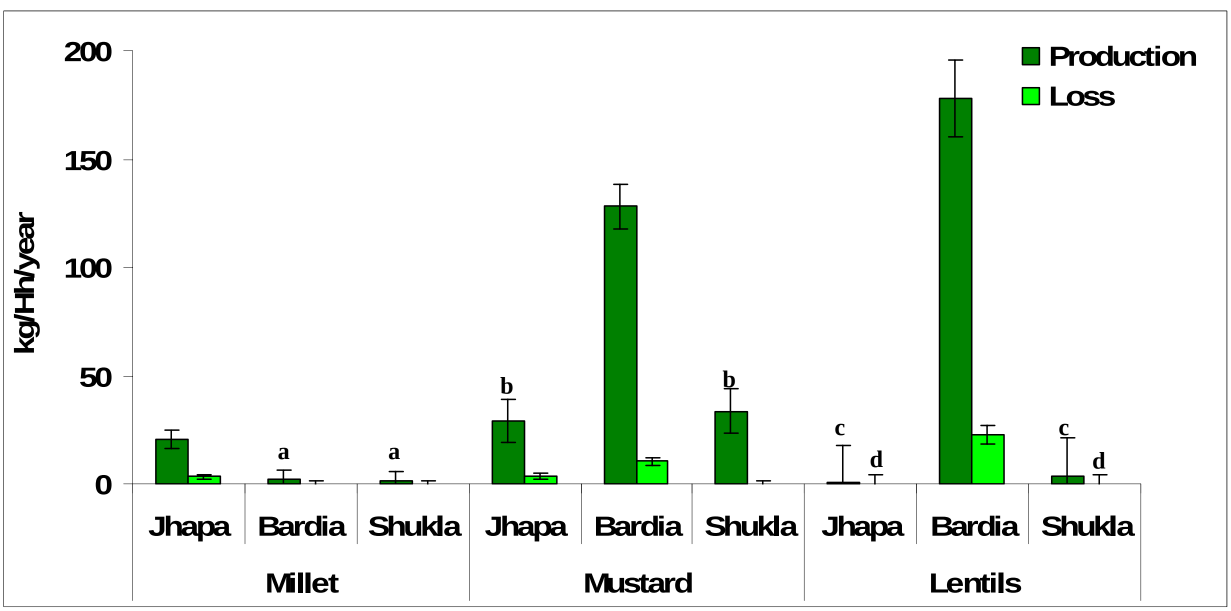


Figure 7. Average production of millet, mustard and lentils and loss (kg/Hh/year) due to the crop raiding by wild elephants in Jhapa, Bardia and Shukla.



Note: Bars with the same letters in the same figure are not significantly different ($p > 0.05$) based on Tukey HSD test.

In monetary terms, paddy accounted for about 62% of total economic yield in Jhapa and over 53% and 57% in Bardia and Shukla, respectively (Table 5). The paddy yield in Bardia did not significantly differ either with Jhapa or with Shukla. Among other crops, cash crops, lentils, and wheat in Jhapa, Bardia, and Shukla, respectively formed a bulk of a total yield. Regarding overall averaged economic value of crops grown per household, Jhapa topped the list but the difference was not significant with Bardia, probably because of the large variation associated with the paddy yield, especially in Bardia.

Table 5.: Economic value of crop production (in NRs) by a household in Jhapa, Bardia and Shukla (Source: Field Survey 2007).

Crops	**Jhapa**			**Bardia**			**Shukla**		
	NRs/Hh	**SE***	**%**	**NRs/Hh**	**SE***	**%**	**NRs/Hh**	**SE***	**%**
Paddy	32357.37[a]	2152.03	61.66	25089.05[ab]	3441.84	53.34	17285.33[b]	1139.01	56.67
Maize	5546.46	558.16	10.57	2991.93	291.83	6.36	0.00	0.00	0.00
Wheat	129.52	47.17	0.25	6555.60	734.20	13.94	11252.00	717.97	36.89
Millet	256.58	87.72	0.49	0.00	0.00	0.00	0.00	0.00	0.00
Mustard	1169.47[a]	228.00	2.23	4806.75	599.21	10.22	1681.67[a]	214.77	5.51
Lentils	29.93[a]	22.98	0.06	7563.30	1302.35	16.08	150.40[a]	62.70	0.49
Cash crops	12989.43	1890.34	24.75	27.67[a]	8.93	0.06	133.33[a]	125.22	0.44
Total production	**52478.77[a]**	**3681.76**		**47034.29 [a]**	**5494.80**		**30502.73**	**1875.53**	
Land holding size (ha)/Hh	**1.17**	**.09**		**0.62[a]**	**.07**		**0.68[a]**	**.05**	

Means with the same letter in the same row are not statistically different ($p > 0.05$) based on Tukey HSD test.

* Standard error of the mean

Land use

The proportion of forest area in the edge habitats of three sectors varied ($P < 0.05$) as Shukla had significantly more forests compared to both Jhapa and Bardia (Fig. 8. $P < 0.05$). The later two sectors however did not differ ($P > 0.05$). Temporally, there was net decrease in the forest coverage from 1991 to 2001 in all sectors, and from 2001 to 2007 in Jhapa and Shukla (Fig. 8 and Table 6), but none of these were significant ($P = 0.55$). Bardia had gained the forest area during the period between 2001 and 2007.

Figure 8. Proportion of forest area in the edge habitats in Jhapa, Bardia and Sukla in years 1991, 2001 and 2007

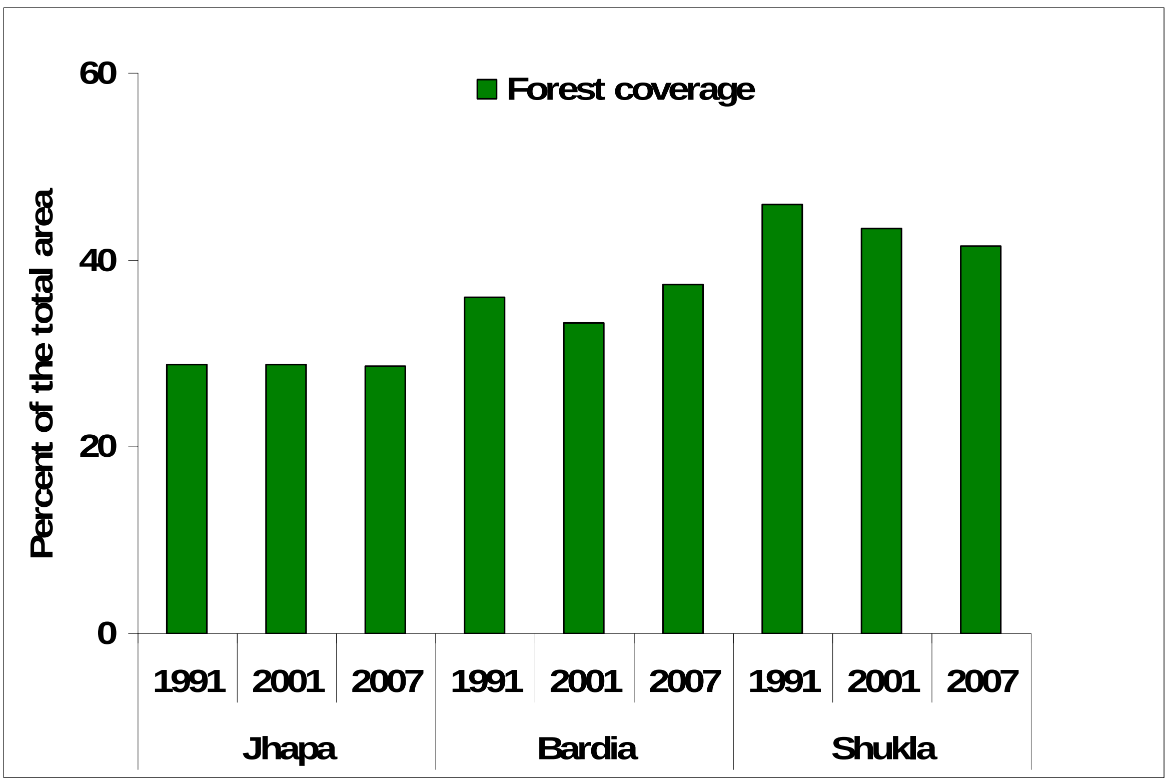


Table 6. Rate of change of forest cover over time

District	Forest cover 1990/91 (ha)	Forest cover 2000/01 (ha)	Change in forest cover (ha)	Rate of change (%)	Forest Cover 2006/07	Change in forest cover	Rate of change
Jhapa	12,880	12,892	-12	-0.009	12,844	-48	-0.05
Bardia	14,096	12,979	-1117	-0.80	14,677	+1698	+1.87
Shukla	35,559	33,554	-2005	-0.56	32,167	-1387	-0.60

Human-Wildlife Conflict (HWC)

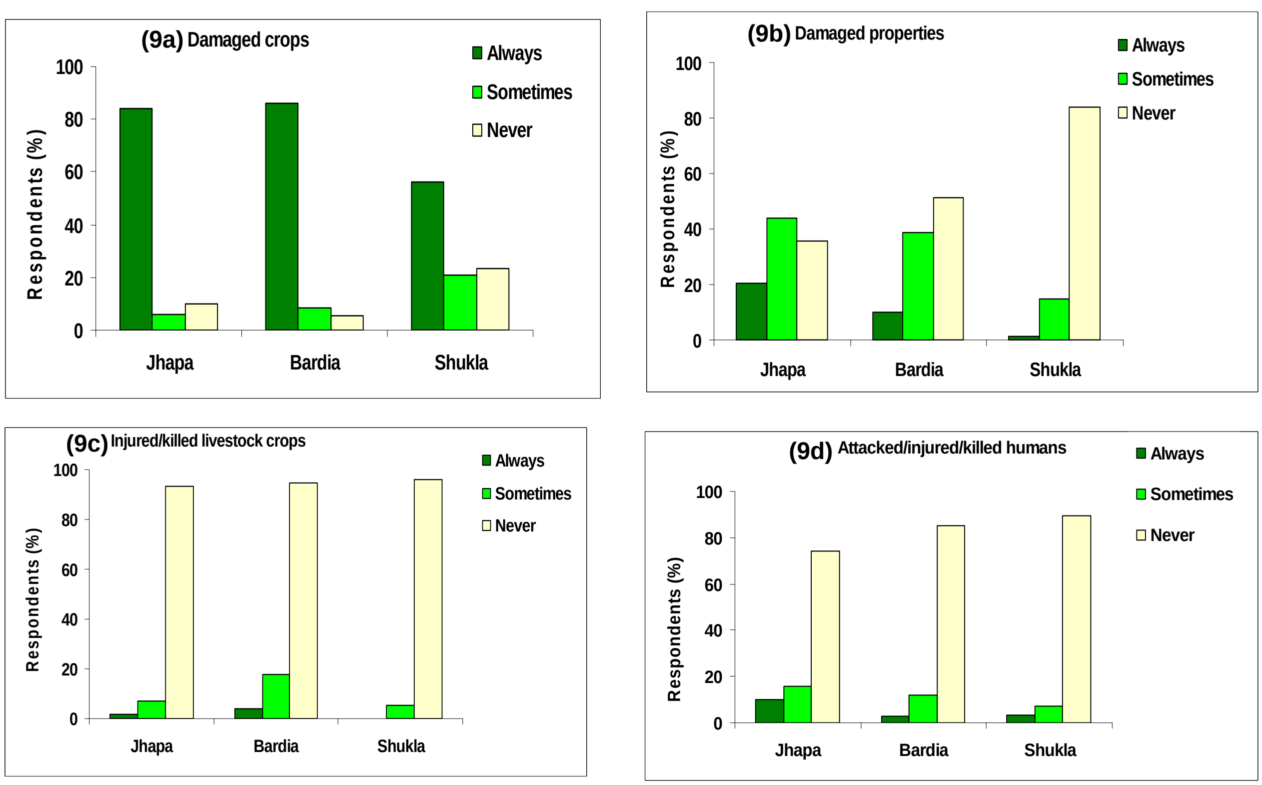
Over 90 percent of respondents in each sector reported that they faced problems from wildlife. Crop damage was the most common problem in all sectors, with Bardia and Jhapa reporting the highest (both sectors > 80%) and about equal frequency of incidents (Plate 5, Fig. 9a, $\chi^2 = 2.85$, df = 2, P = 0.24). Shukla had significantly lower frequency of crop damage incidences compared to other two sites ($\chi^2 = 45.85$, df = 2, P < 0.01). Nonetheless, damage to properties occurred more often in Shukla than that in Bardia and in Jhapa (Fig. 9b, $\chi^2 = 69.32$, df = 2, P < 0.01). Other types of problems such as loss of and injury to livestock (Fig. 9c) and human lives (Fig. 9d) were reported to occur in all sectors but not as significant as that of the aforementioned problems.

Plate 5. Crop damage by wild elephants in Bardia (Source: Field survey)

Wild elephant was categorized as the animal with the highest level of threat in all three sectors (Threat level > 4.0) and was the sole problem animal in Jhapa (Fig. 10). The people of Bardia and Shukla were also equally concerned about wild boar and spotted deer. A megaherbivore rhino, carnivores leopard and tiger, and an omnivore monkey posed a moderate level of threat to the people in Bardia (Threat level 2.0 to 4.0) whereas people in Shukla listed all of them except monkey in the lowest threat category (Threat level < 2.0). Likewise other herbivores such as nilgai, swamp deer and porcupine were considered as a moderate level of threat in Shukla but it was listed in the lowest threat category in Bardia.

Regarding the population status of problem animals, nearly all the respondents from Jhapa and Bardia suggested that the elephant population was increasing (Fig. 11a), while little over 60 percent respondents in Shukla were not sure about trend of elephant population in their area and the another 30% believed that their population was stable (Fig.11, $\chi^2 = 383.49$, df = 6, $P < 0.01$).

Figure 9. Types of problems faced by local communities



Likewise, majority of people from Shukla and Bardia reported that the populations of spotted deer (Fig. 11b) and wild boar (Fig. 11c) were also on the increase (both species, $\chi^2 > 390.34$, df = 6, P < 0.01). The numbers of other species included in the moderate threat category in Bardia such as tiger (Fig. 11d), rhino (Fig. 11f), langur (Fig. 11g), and leopard (Fig. 11h) were also reported to be increasing by the majority of respondents (all, $\chi^2 > 324.78$, df = 6, P < 0.01). Furthermore, most respondents from Shukla were not sure of the population status of their moderate threat category animals such as nilgai (Fig. 11i), swamp deer (Fig. 11e) and porcupine (Fig. 11j) (all, $\chi^2 > 117.91$, df = 6, P < 0.01) except for langur which they believed to be increasing ($\chi^2 = 338.59$, df = 6, P < 0.01). Also, most respondents were generally not sure of the population status of lower threat category animals in all the three sectors.

Figure 10. Threat level of problem animals as perceived by the people in Jhapa, Bardia and Sukla

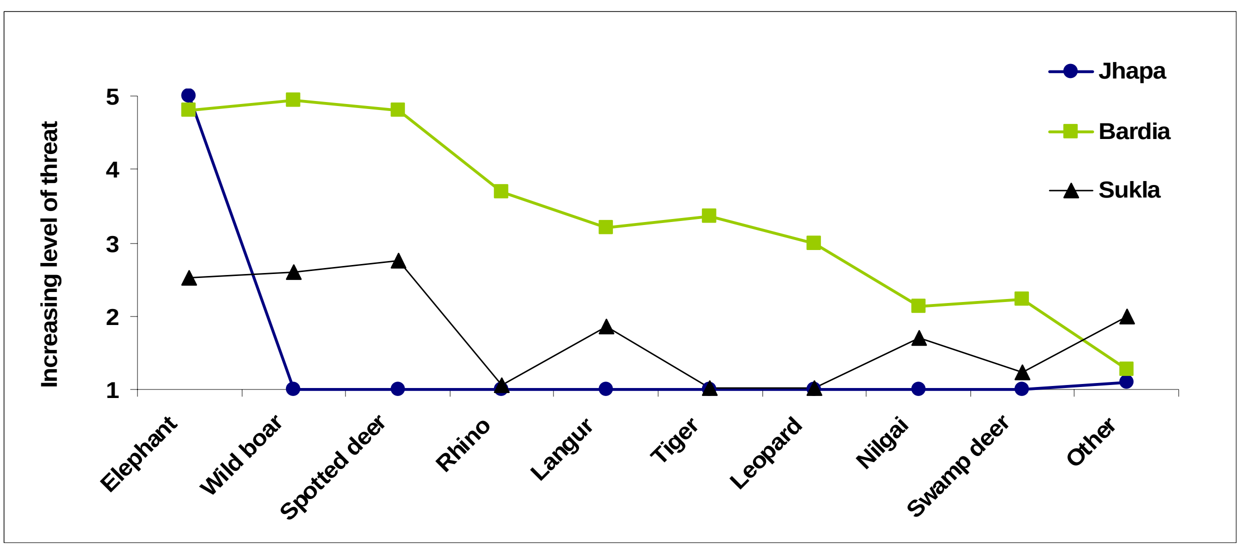
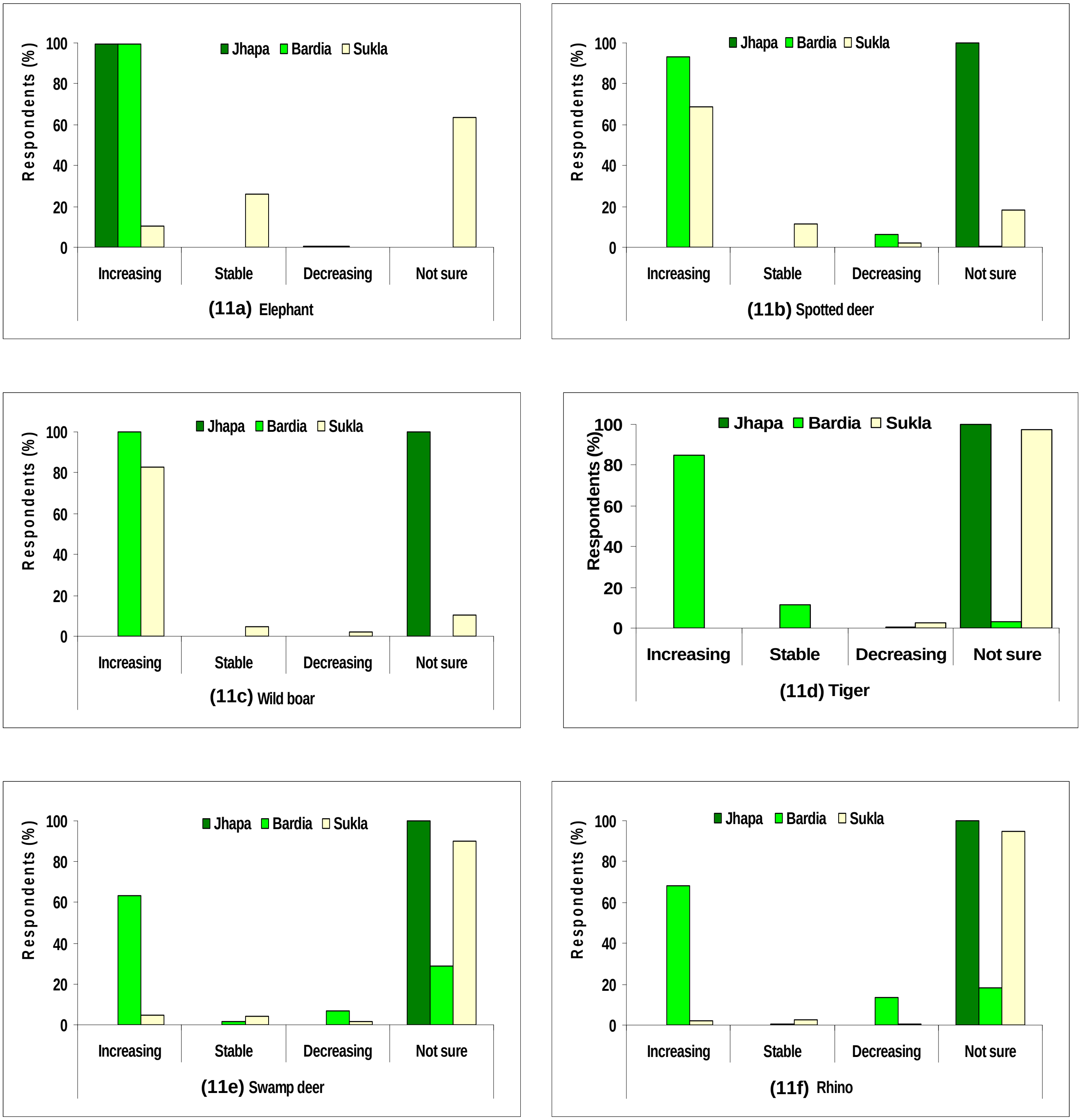
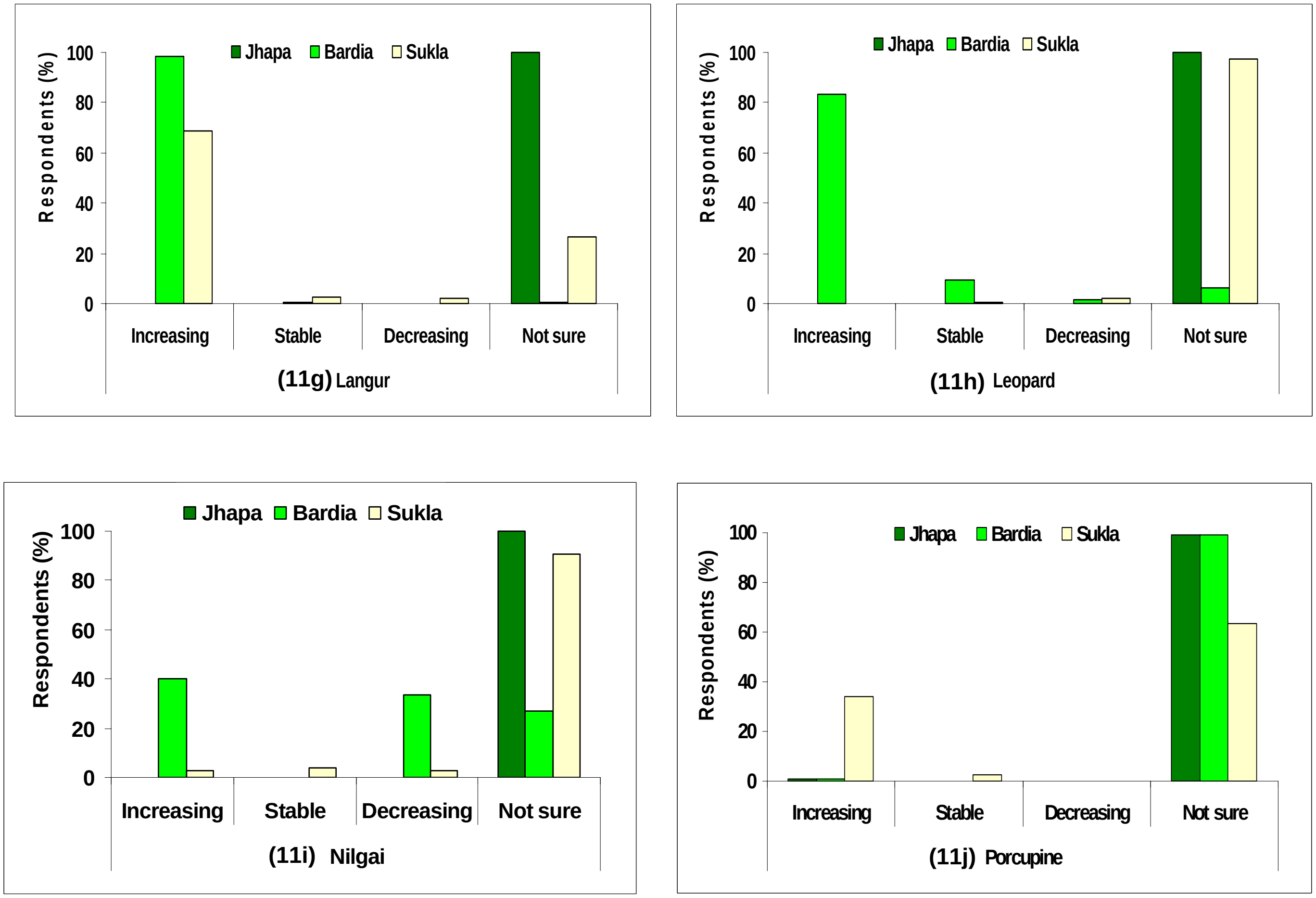


Figure 11. Peoples' perception on population status of problem animals





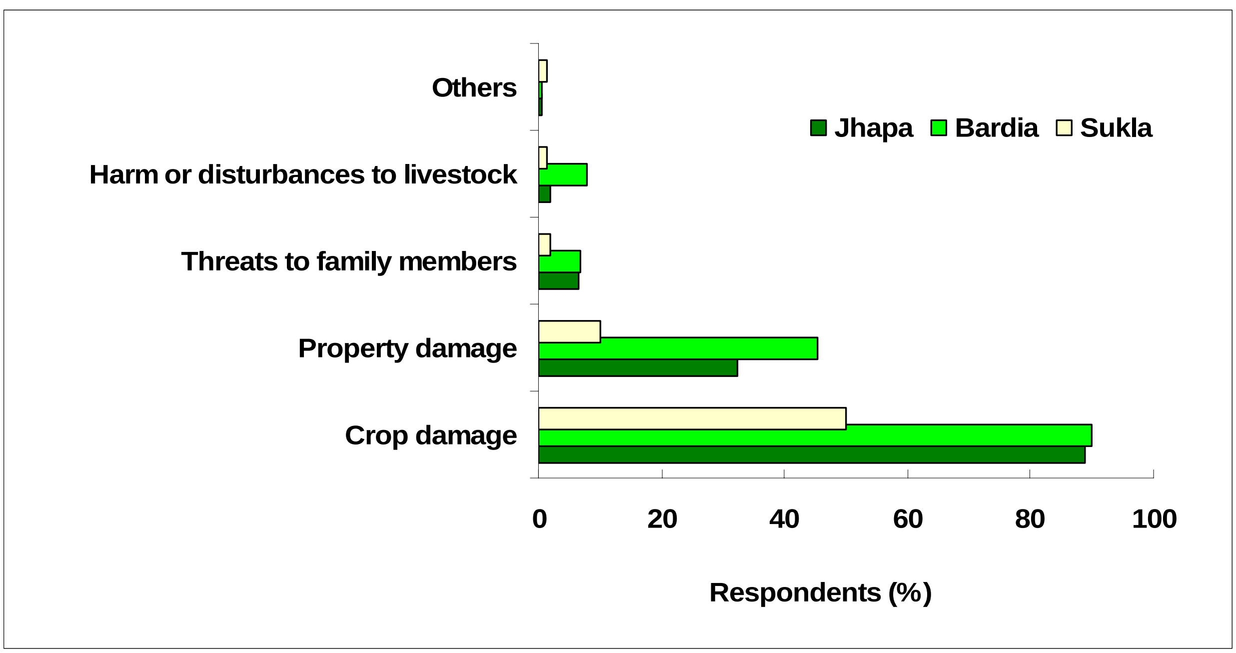
Human – Elephant conflict (HEC)

Because of these life threatening burglars, our boys here are facing problem in finding a mate for no girls are willing to live in a village where they have to spend every night with fear. – Shankar Luintel, Bahundangi VDC

The respondents of the three sectors differed in their experiences of negative interactions with problem elephants ($\chi^2 = 88.70$, df = 2, $P < 0.01$) mainly because Shukla had a fewer respondents reporting the problems than Bardia and Jhapa ($\chi^2 = 86.33$, df = 1, $P < 0.01$). The proportion of respondents with negative experiences with elephant, however did not differ in the later two sectors ($\chi^2 = 0.001$, df = 1, $P = 0.97$), and over 90% people here reported that they had faced one or more problems with elephant. Low elephant density coupled by the existing large tracts of 'edge' forests in Shukla could be the reason for relatively low HEC intensity. It was also reported during a focal group discussion that the HEC takes place in Shukla mainly around the villages where the reserve has established elephant stable 'hattisar' with a few female elephants. The bull elephants damages crops and properties around these villages mostly during the period when they come for the estrous females in the hattisar.

Regarding the nature of HEC, crop raiding was the most common problem in all three sectors followed by property damage and the threats to people (Fig. 12). Comparing between sites, Jhapa and Bardia had highest and about equal number of respondents responding to these problems than that of Shukla (Fig. 12). Elephants although the generalist feeders need food plants with certain level of protein content. When the protein content of wild food plants of elephants fall below the minimum level needed by elephant for their maintenance, they generally raid crops particularly paddy, maize and millet which contain higher protein level (Sukumar 2003).

Figure 12. Community experiences of negative interactions with problem elephants



The trend of conflict

Nearly all people in Jhapa and Bardia expressed that the frequency of encounter with the elephants together with the incidences of crop and property damage was on the increase. However, relatively fewer people in Bardia and Shukla than in Jhapa agreed that human causalities were increasing. Likewise, it is interesting to note that close to 80 percent respondents in Jhapa thought that there was an increase in retaliatory killing of elephants (Plate 6) while most respondents (> 90%) denied this statement in Shukla and Bardia.

Plate 6. An injured elephant in Bahundangi, Jhapa (Photo courtesy of Mr. Shankar Luitel)

During our field surveys, we observed the widespread application of electric fencing in Jhapa (Plate 7) that was directly obtained through the national grid using high voltage electricity. Through focal group discussions later, we found out that four elephants have been killed through electrocution in recent years.

Plate 7. 'Electric fence' in Jhapa - Gabion wire connected to main electricity line

Season, time of damage

The season and time of damage were similar in all three sectors. Two peak seasons for crop raiding were identified, one during maize or wheat maturing time (June – July) and other paddy maturing time (September – November). Most of the crop raiding and property damage by elephants were reported to occur in night. The elephants spend the day time inside the park or close to the edge forest areas.

A study carried out in Africa (Osborn 2004) and in India (Sukumar 1989) indicated that the onset of crop raiding and the quality of wild food toward the end of the wet season are linked. Sukumar (1989) further commented that protein content of wild food plants dropped far below the minimum level needed by elephant for maintenance during the late wet season. At this time, which was also the peak raiding season, the maturing finger millet and paddy crops had much higher protein levels. Maize cobs, which are selectively plucked by elephants, had protein levels even higher than in fresh growth of tall grasses.

Crop raiding by elephants

Quantity loss

Elephants raided substantial amount of paddy in all three sectors (Fig. 6). The quantity lost per household in Jhapa and Bardia was not significantly different. Among other crops, maize was lost in greatest quantities in Jhapa while wheat was in Shukla and lentils in Bardia (Fig. 6). Jhapa also lost significant amount of cash crops such as beetle nuts and banana. In general, paddy is reported to be a most preferred crop of elephants followed by cereals such as, maize, wheat and millets in the moist tropics of Asia (Sukumar 2003). An adult bull weighting 6,000 kg would consume 240 kg, and a lactating female weighing 2,700 kg would eat 162 kg of fresh plants material each day (Sukumar 2003).

Economic value of crop loss

The economic value of crop loss (NRs/Hh) in three sectors is given in Table 7. As expected, paddy accounted for the highest loss in all sectors, i.e. nearly 70 percent of the total economic loss per household in Bardia and approximately 65 percent each in Shukla and Jhapa. In Jhapa, average household faced a loss of NRs. 12,253 per year which was marginally higher than Bardia (NRs. 10,108 per year), but statistically not significant (Table 7). The total economic loss from crop damage was more than three times lower in Shukla than the other two sectors.

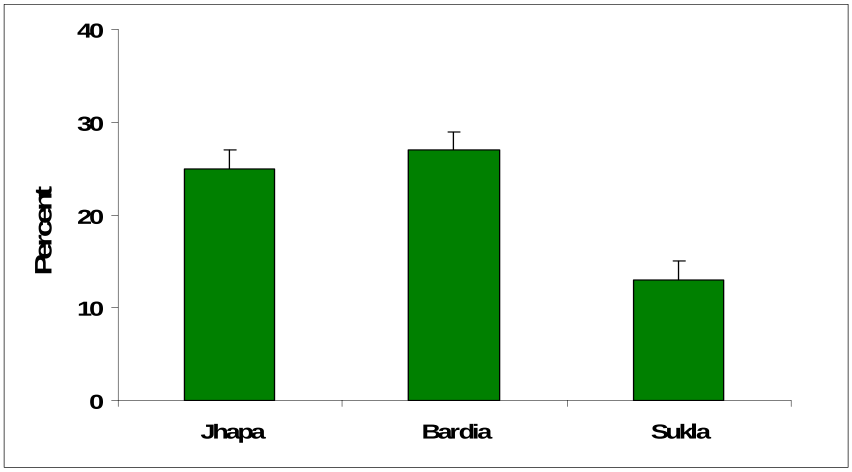
Table 7: Economic value of crop loss (in NRs/Hh/year) incurred by each household in Jhapa, Bardia and Shukla.

	Jhapa			Bardia			Shukla		
	NRs/Hh	SE*	%	NRs/Hh	SE*	%	NRs/Hh	SE*	%
Paddy	7942.65[a]	695.97	64.82	6987.75[a]	1143.99	69.13	2262.93	329.66	66.72
Maize	2473.95	282.62	20.19	1283.04	224.04	12.69	0.00	0.00	0.00
Wheat	0.00	0.00	0.00	516.00	146.62	5.10	1126.16	189.32	33.20
Millet	43.17	23.22	0.35	0.00	0.00	0.00	0.00	0.00	0.00
Mustard	146.84	63.77	1.20	377.50	79.64	3.73	0.00	0.00	0.00
Lentils	8.55[a]	8.55	0.07	943.78	304.57	9.34	2.67[a]	2.67	0.08
Cash crop	1637.86	386.37	13.37	0.70	0.70	0.01	0.00	0.00	0.00
Total loss	**12253.03[a]**	**1062.21**		**10108.77[a]**	**1314.36**		**3391.76**	**493.52**	

Means with the same letter in the same row are not statistically different (p>0.05) based on Tukey HSD test.
* Standard error of the mean

Taking into an account of the total income from crop production, the proportion of loss per household was highest in Bardia (27%) followed by Jhapa (25%) and Shukla (13%) (Fig. 13). However, the two percent increase in Bardia compared to Jhapa was not statistically significant.

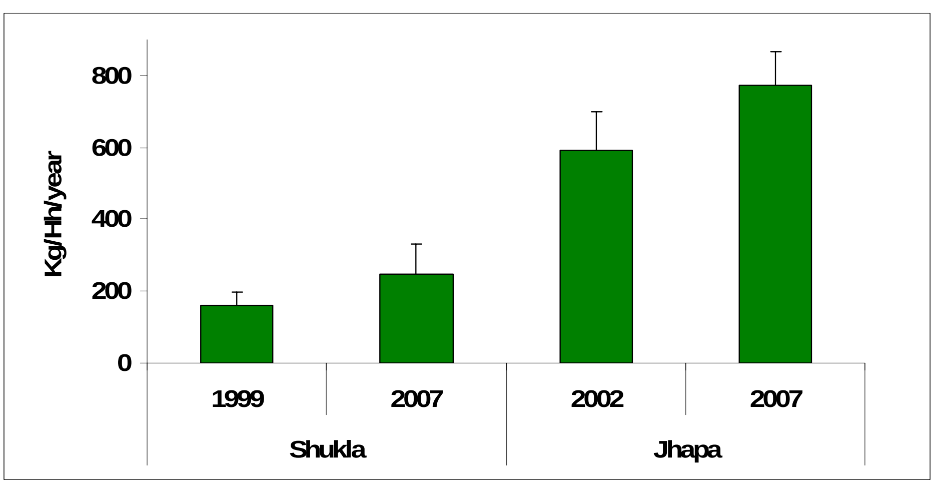
Figure 13. Percentage lost out of the total income from crop production.



Temporal pattern of crop loss

There is little over 50% increase in the loss of paddy per household in Shukla between the years 1999 and 2007 (Fig. 14). The same in Jhapa accounted for 30% during the period between 2002 and 2007. However the average loss in each sectors over these periods were not statistically significant (paired t- test, Jhapa: P = 0.12, Shukla: P = 0.27). We could not assess the temporal pattern of crop loss in Bardia due to the lack of comparable data.

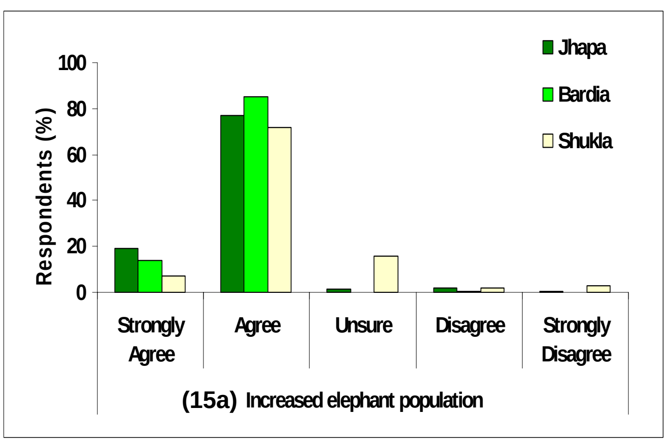
Figure 14. Temporal pattern of paddy loss to elephants in Shukla and Jhapa during the periods between (1999 -2007), and (2002-2007), respectively

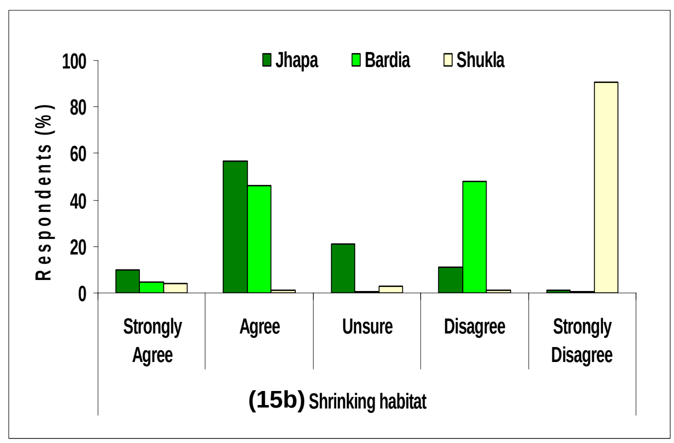


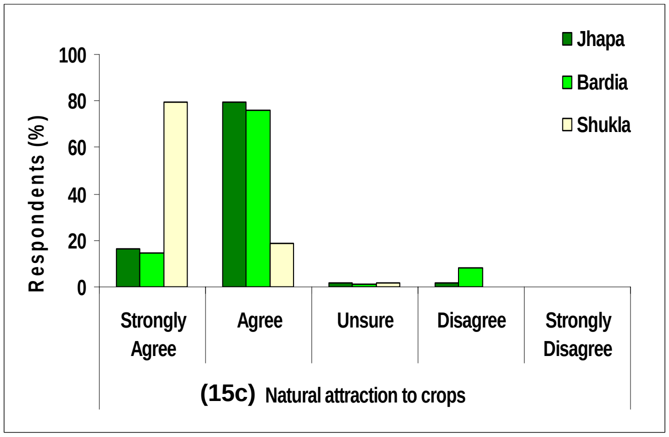
Key causative factors

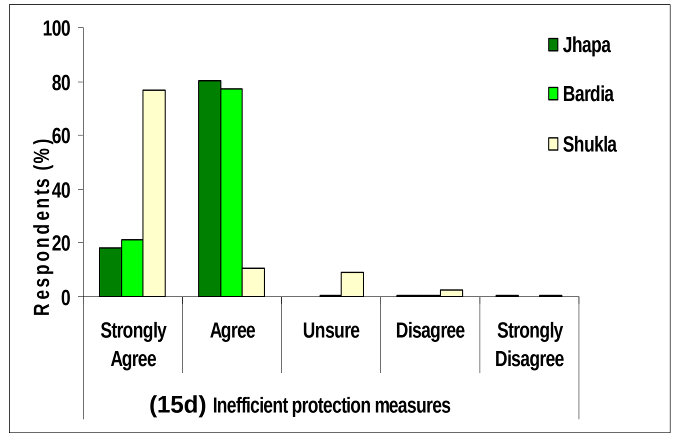
The respondents in the study area reported a few key causative factors regarding HEC. Nearly everyone in the three sectors agreed that increasing population of elephants was causing problem (Fig. 15a). Most people in Jhapa supported the opinion that elephants were causing problem because of the shrinking habitat (Fig. 15b). The respondents from Bardia, however were divided as nearly half of the respondents agreed with the statement and the other half denied. Contrary to this, the people from Shukla strongly rejected this statement. This is not surprising considering the large intact patches of existing forests in Shukla compared to Jhapa. Moreover, the respondents from Shukla strongly agreed that elephants were attracted to crops because of their natural preference (Fig. 15c). Bardia and Jhapa also supported this statement but not as strongly as did by Shukla. A majority of respondents especially in Shukla, subscribed to the view that one of the key causes of HEC was the inefficiency of the current protection measures (Fig. 15d). Behavioural flexibility of elephants thereby enabling them to quickly modify their foraging strategies in response to the protective measures are also believed to be one of the major reasons for this .

Figure 15. Some of the key causative factors perceived by communities regarding conflict





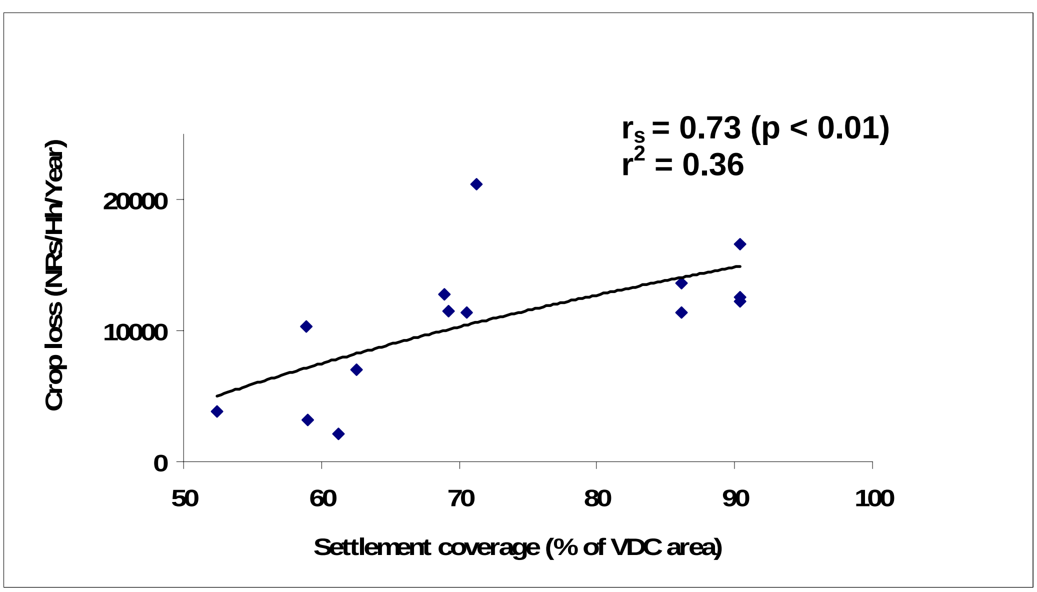




Impact of land transformations and habitat fragmentation on the extent of crop damage by elephants

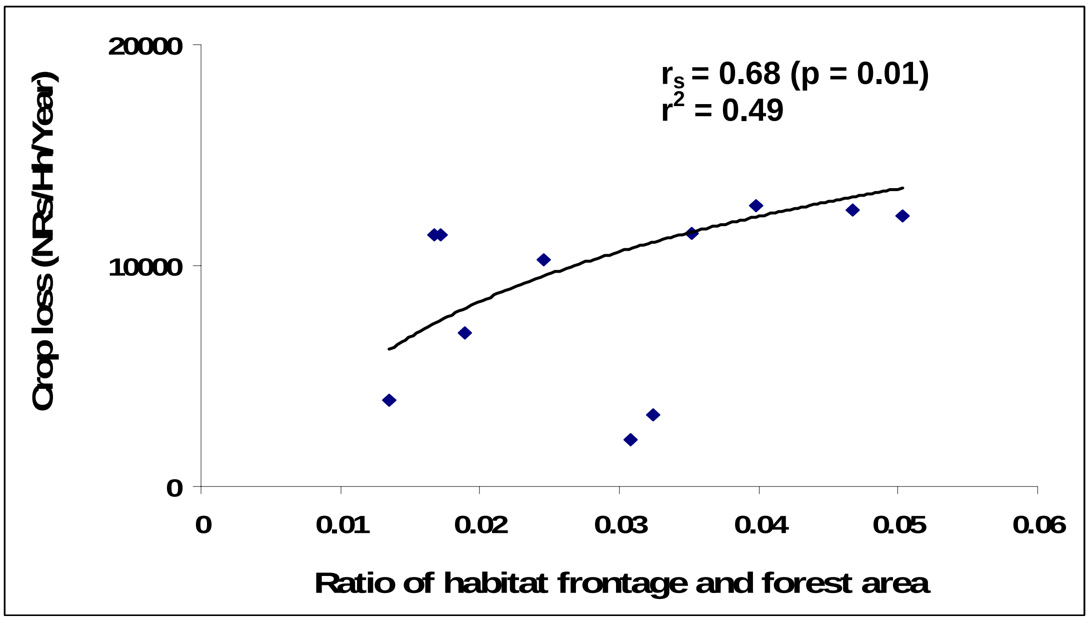
The percentage settlement area (settlement coverage) and the extent of economic loss due to crop damage by elephants was positively and significantly correlated (Fig. 16) indicating that transformation of elephant habitats to other uses (settlement, agriculture etc.) is highly likely to result in the increased economic losses from crop damage. The coefficient of determination r^2 here implies that about 36 percentages of the total variation in the economic loss can be attributed to the land transformation.

Figure 16. Impact of land transformation on the economic loss due to crop damage by elephants



Like the effect of settlement coverage, the habitat fragmentation, as reflected by the ratio between habitat frontage and the forest cover also had positive association with the crop damage (Figure 17). Moreover, it is interesting to note that the fragmentation of habitats can be attributed to about 50 percent of total variation in the economic loss which is nearly 15 percent more than that explained by the settlement coverage alone. This possibly indicates the importance of taking into account of the shape and distribution of the habitat patches over the landscape while examining the intensity of human – elephant conflict.

Figure 17. Impact of habitat fragmentation on the economic loss due to crop damage by elephants

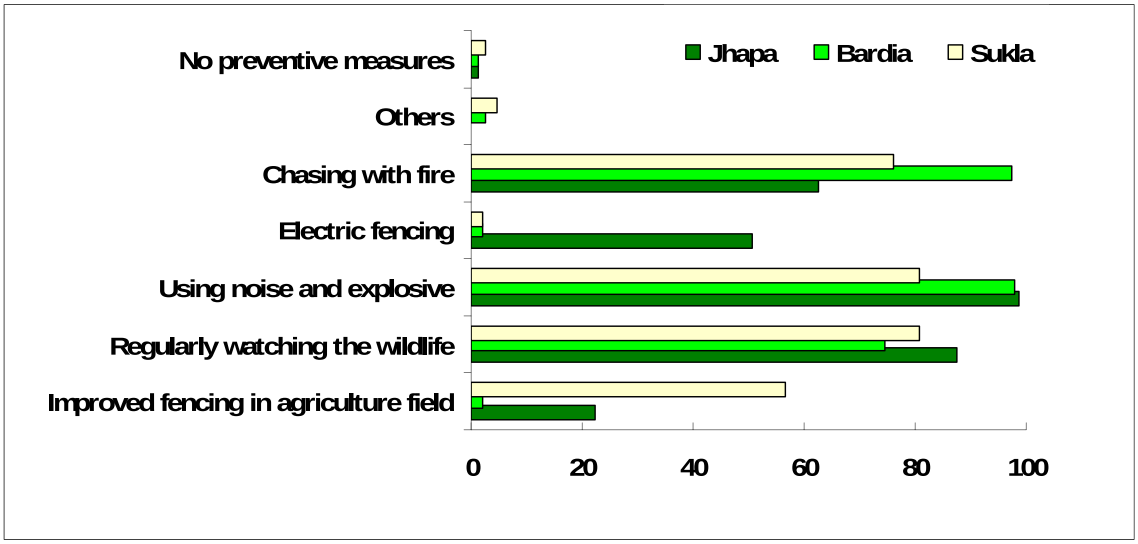


These results have the important management implication when we consider increasing fragmentation and the declining forest cover, especially in Shukla (Fig. 8). Despite the current low magnitude of elephant damage in Shukla (Fig. 13), it is likely that the intensity of HEC will increase in coming days if the above relationships hold true. Moreover, our results on the temporal pattern of crop loss to elephants showed that there was an increasing trend of loss of paddy to the elephants in Shukla in the recent years, which further attests to the aforementioned statement (Fig. 14).

Measures undertaken to mitigate HEC

The severity of the problem is reflected by various measures undertaken at the community level to mitigate HEC in all the sectors. Most people applied one or more measures to cope with HEC (Fig. 18). Among them, chasing with fire, use of noise and explosives, and regularly guarding the fields were the most widely used measures in all the sectors. Apart from this, high voltage electric fence in Jhapa and improved fencing (mainly, digging trenches and planting hedgerows) in Shukla were also commonly practiced.

Figure 18. Some of the measures undertaken to mitigate conflict

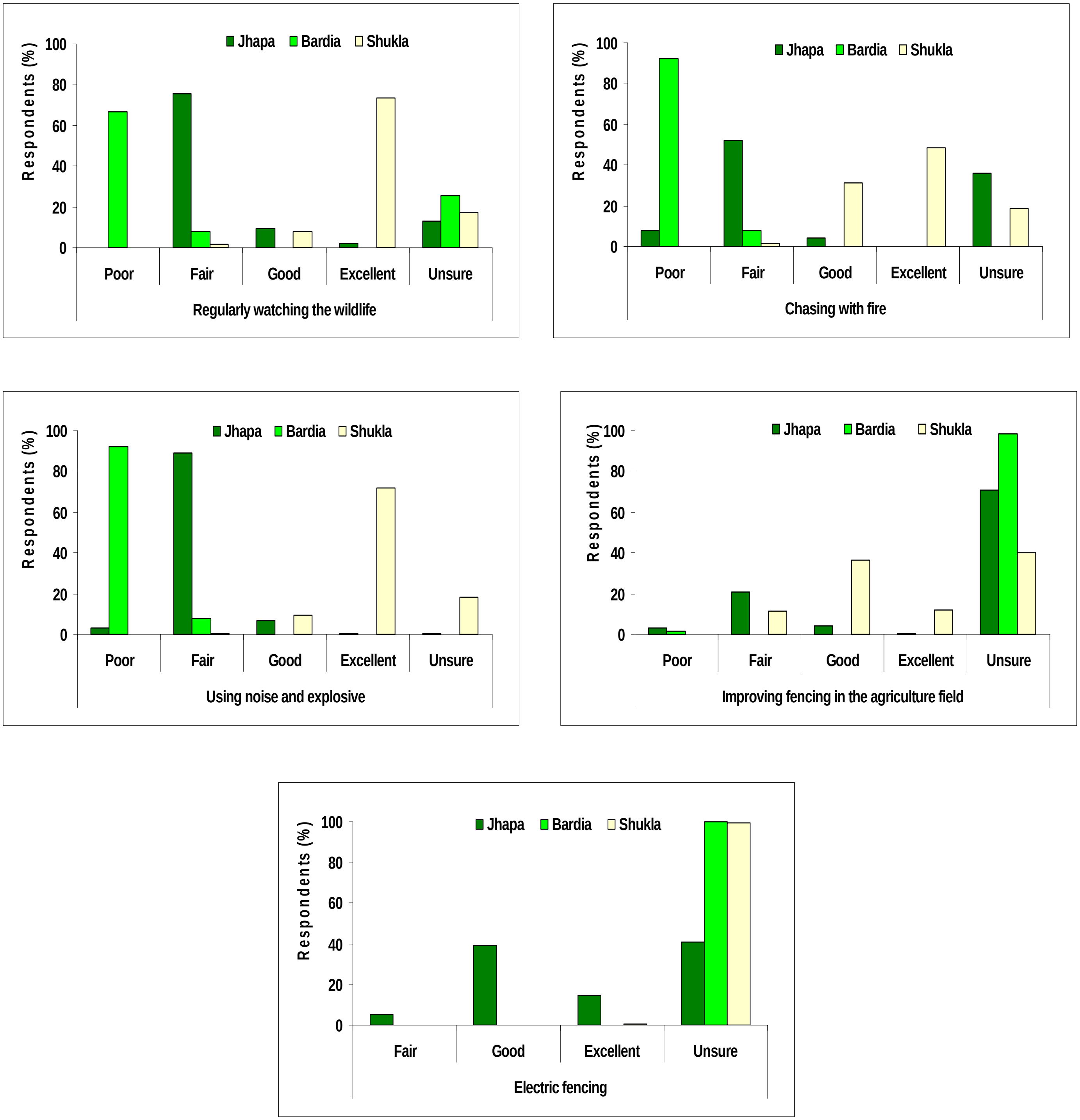


Effectiveness of existing measures in mitigating HEC

Elephants are always one step ahead of us human beings in this 'arms race' of offenses and defenses. They develop counter measures in no time in response to the techniques that we apply to drive them away. – Manoj Thapa, Bahundangi VDC

Despite the wide spread application of measures *v.i.z.* chasing with fire, use of noise and explosives, and regularly guarding fields, these were not considered to be effective in mitigating HEC by the people of Bardia and Jhapa (Plate 8 and 9, Fig 19). This agrees well with Sukumar (2003) whereby he observes that these techniques are merely effective to drive away inexperienced crops raiders, whereas veteran raiders, usually adult bulls or even some family groups are difficult to be fooled. The respondents from Shukla, however showed clear preference for these measures. Likewise, electric fencing was rated positively by Jhapa while the respondents in Bardia and Shukla were unsure about its effectiveness (Fig. 19).

Figure 19. Effectiveness of existing measures in mitigating HEC



Nevertheless, the electric fencing applied in Jhapa through local initiatives can be considered as an electrocuting mechanism which is neither scientific nor safe to human beings. There are reported cases of human and livestock casualties because of the accidents that took place in the recent past. Also, with regards to the use of improved fencing (digging trench, planting hedgerows), majority of people in Jhapa and Bardia were unsure about its applicability while in Shukla, people had their opinion divided as little over half of the respondents were positive and the rest were not sure (Fig. 19). The studies have shown that the effectiveness of protection measures including electric fence depends not only on fence design and maintenance, but also on learning capacity and behavioral response of crop-raiding elephants. However, in compare to other traditional measures, a proper electric fencing is much more effective as the 80% success rate has been reported from a study in Malaysia (Sukumar 2003)

Plate 8: A fog light being used in Jhapa (Source: Field survey)

Plate 9: A watch tower constructed to guard crop field

Economic benefits for living with wildlife

Secondary information from three sectors clearly showed that Bardia and Shukla are directly getting economic benefits for living with wildlife. Villagers living adjacent to these parks were allowed to collect grass within their boundaries for thatching. It is collected during a yearly two-week' period towards compensation for the denial to use traditional resources of the national parks and otherwise protected areas, and for damage caused by wildlife. Park authorities and conservation partner organizations also assisted local development efforts by providing timber for construction of local schools and bridges, support in establishment of health post, diverting park rivers for irrigation purposes, training on ecotourism and other income generation activities, and also various other activities. In some parks, endowment funds including the 'Rahat Kosh'and Apatkalin Kosh' to compensate for injuries and loss of life, livestock depredation, and damage to property by wild animals have also been established (DNPWC 2001). Various national level initiatives such as TAL and WTLCP have been launched to conserve biodiversity at the landscape level and improve the living standard of local communities living with wildlife. While this may be true in cases where there is already established park system, it does not apply to eastern Nepal particularly for the Jhapa area where no such initiatives has been planned. Thus, it is reasonable to argue that eastern Nepal should have conservation projects such as TAL and WTLCP as in the western Nepal.

Attitude towards conservation

Respondents of Jhapa differed with Bardia and Shukla in their opinion with regards to the need for undertaking the conservation initiatives (Table 8. $\chi^2 = 121.04$, df = 4, $P < 0.01$). Without much surprise, there was a striking difference between Jhapa and other two sectors in the proportion of respondents involved in conservation activities (Table 9, $\chi^2 = 322.79$, df = 1, $P < 0.01$). The former had relatively lower number people with any sort of conservation experience than in Bardia ($\chi^2 = 192.95$, df = 1, $P < 0.01$), and Shukla ($\chi^2 = 218.77$, df = 1, $P < 0.01$). Similarly, the difference between Bardia and Shukla, although marginal was significant ($\chi^2 = 5.26$, df = 1, $P = 0.02$).

Table 8. Respondents' opinion (% respondents) with regards to the need for undertaking the conservation initiatives.

		% Respondents		
		Jhapa	**Bardia**	**Sukla**
Do we need to initiate conservation activities?	Yes	64.47	100	100
	No	17.76		
	Unsure	17.76		

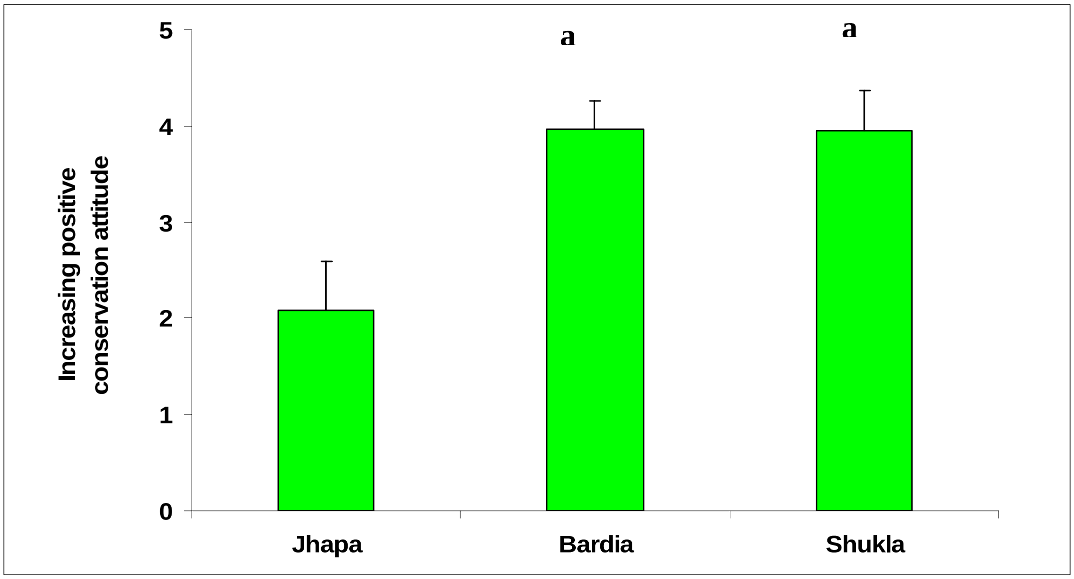
Table 9. Percentage of respondents involved in conservation activities.

		% Respondents		
		Jhapa	Bardia	Sukla
Are you involved in any of the conservation activities?	Yes	15.13	94.33	98.00
	No	84.87	5.67	2.00

A combined measure of conservation attitude as expressed by the attitude index revealed that both Bardia and Shukla were more positive towards conservation than Jhapa (Fig. 20). This is mainly because of the fact that most respondents here generally accepted the conservation friendly ideas such as reducing disturbance to wildlife habitats (Fig. 21), protecting elephants for religious sentiments (Fig. 21), and the need for trans-boundary cooperation to conserve the elephant populations (Fig. 21). Moreover, they firmly rejected the notion of reducing elephant populations (Fig. 21). This strongly implies that continuous support from park authorities and other conservation organizations such as WWF, NTNC and UNDP for participatory conservation and development activities had led to the enhanced tolerance level against HEC both in Bardia and Shukla.

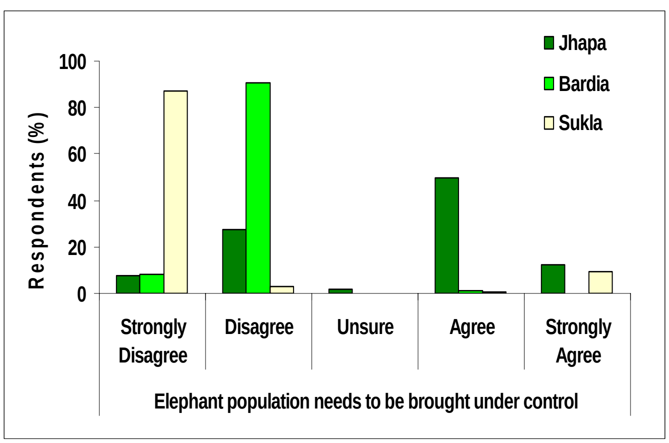
It is important to emphasize our findings that majority of respondents in Jhapa are in favor of controlling the elephant population and therefore it is not surprising that 13 elephants have been reported to be killed between the years 1980 – 2001 (Yadav 2002). Likewise interview of key informants in this survey revealed that four more elephants were killed in recent years in the district of Jhapa.

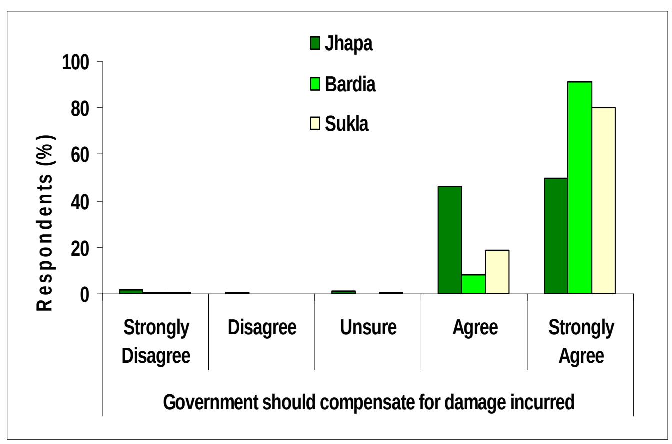
Figure 20. Combined measure of conservation attitude (attitude index) among respondents of the Jhapa, Bardia and Shukla.

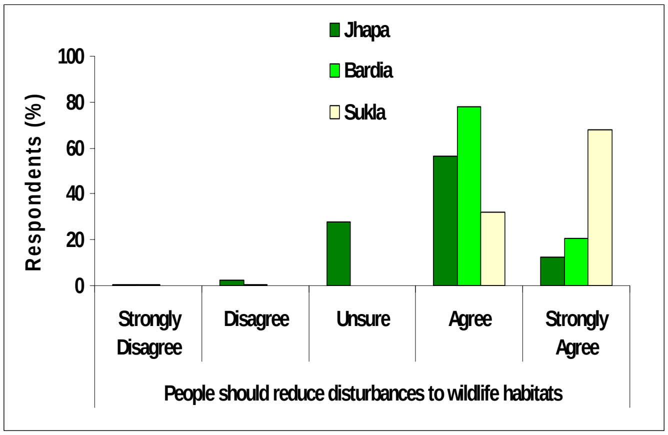


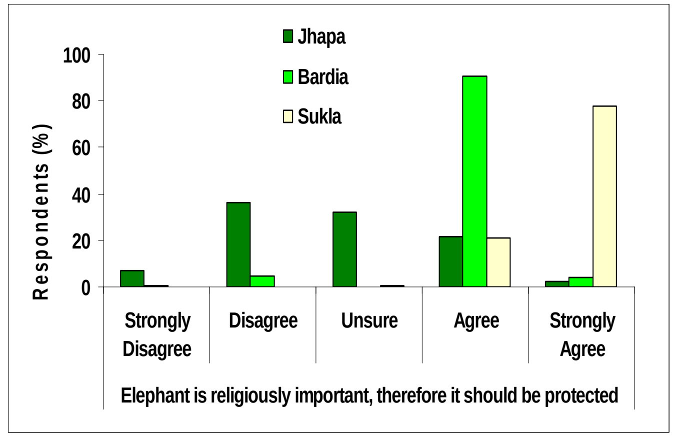
Note: Bars with same letters are not significantly different ($p > 0.05$) based on Tukey HSD test.

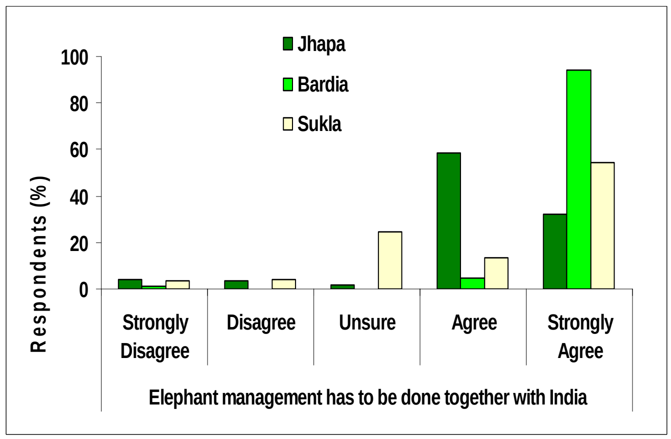
Figure 21. People's attitude towards conservation of elephants







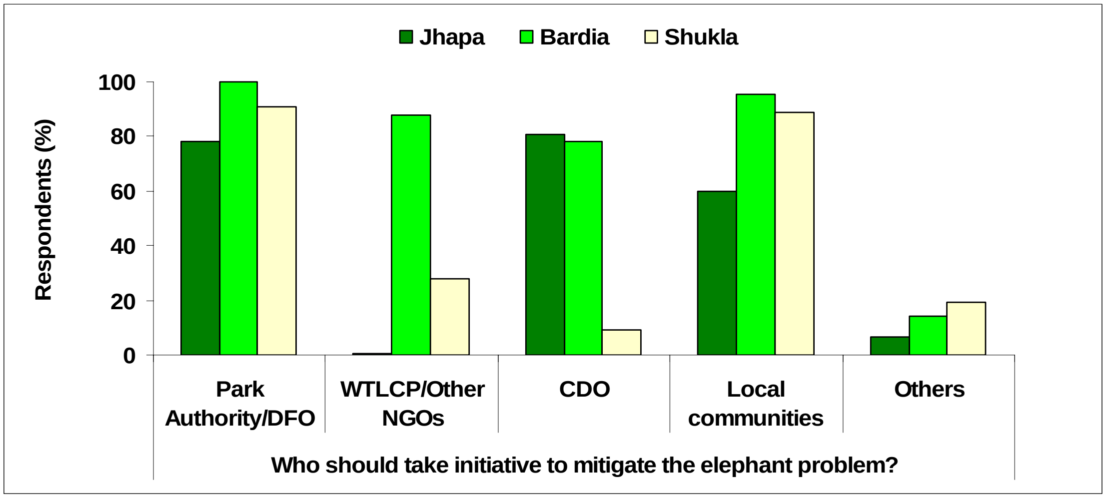




Role of GOs/NGOs in mitigating HEC

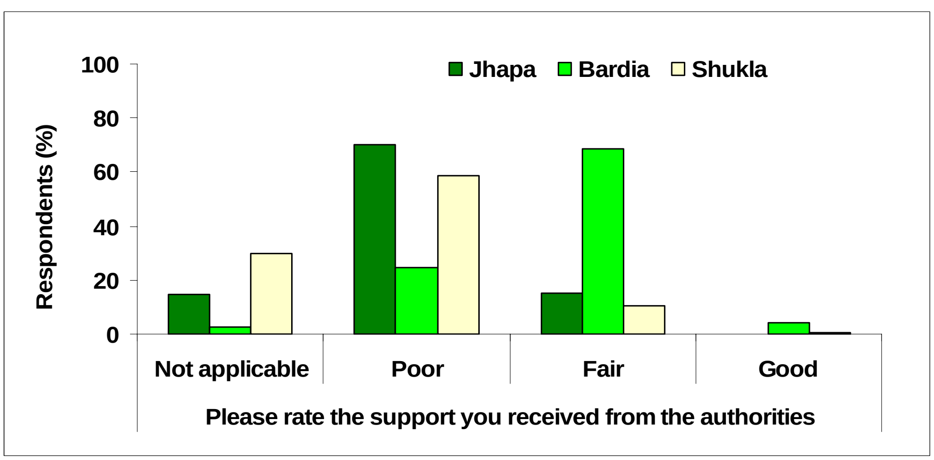
Over 90% respondents in Bardia and Shukla expressed that park authorities and local communities should take initiatives to mitigate HEC (Fig. 22). The majority of people in Bardia also expected the major undertakings from the Western Terai Landscape Complex Project (WTCLP) and other NGOs towards this cause. Respondents from Jhapa, on the other hand believed that local administration *v.i.z.* District Forest Office and the Chief District Officer should work together with local communities in order to reduce HEC. Also, key persons from all the sectors expressed the urgent need for establishing an effective cross-sectoral coordination among various government and non governmental agencies while dealing with the HEC.

Figure 22. Respondents' perception regarding the distribution of responsibility among governmental and non-governmental institutions in dealing with human-elephant conflict



Nearly every respondent in Bardia (96.7%) and the majority in Jhapa (81. 58%) approached the concerned authority in order to obtain support to control elephant problems. A considerable number of people from Shukla (59.33%) had also requested the authorities for the same. The higher proportion of respondents in Bardia appear to be satisfied (rated as fair and good) with the support so far received compared to other two sectors (Fig. 23, χ^2 =31.75, df = 1, P < 0.01), while the opposite holds true in the case of Shukla and Jhapa (χ^2 =125.68, df = 2, P < 0.01).

Figure 23. Satisfaction over the support received from the authorities



Conservation initiatives influencing the living with wildlife

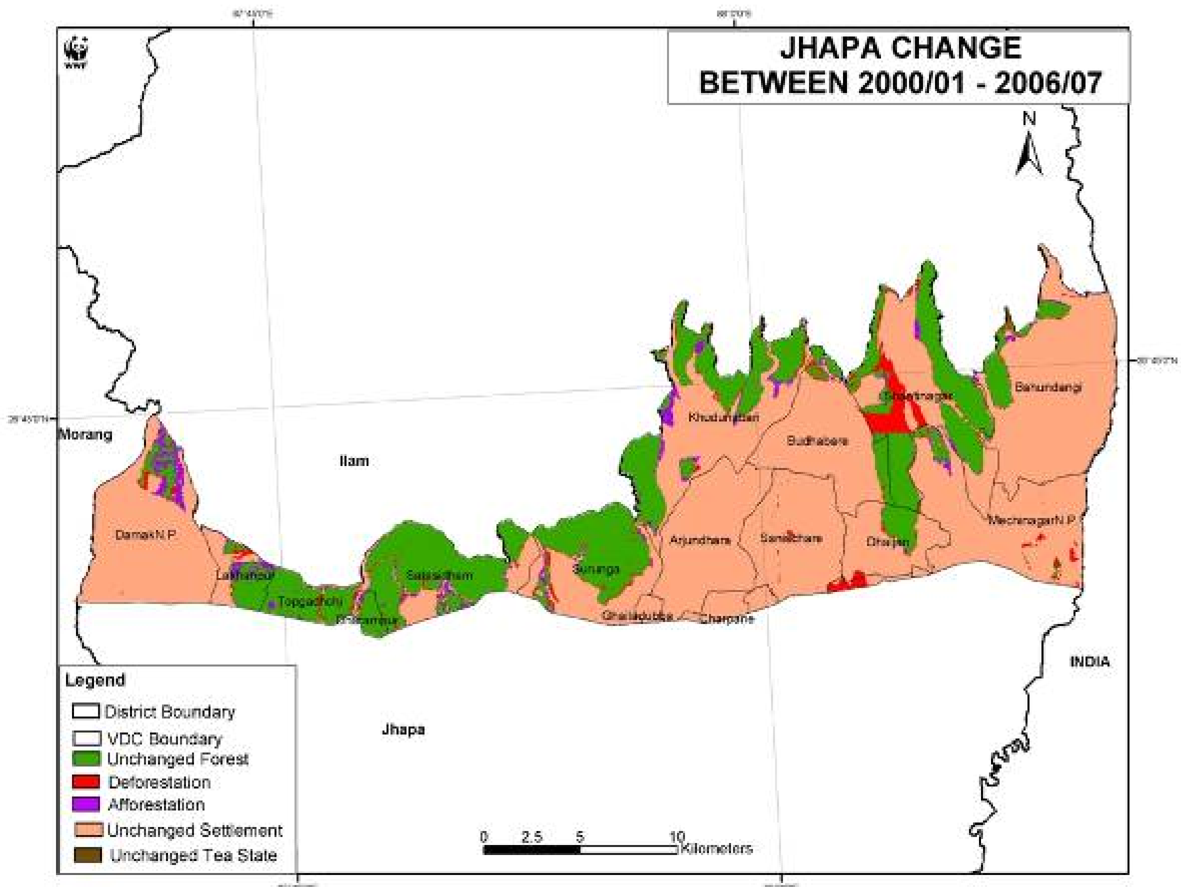
Regarding the initiatives that will encourage communities to be involved in conservation, both Bardia and Shukla had strikingly similar opinion. Over 95% people here believed that the benefits obtained from tourism, community forestry, conservation education and awareness initiatives and infrastructure development activities could positively influence the conservation activities. They also felt the need of integrating local needs with conservation, devolution of power to the local people and involvement of women in conservation activities. Jhapa, however responded passively to all the aforementioned initiatives except for the necessity of integrating the local need with conservation.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Jhapa and Bardia were most severely and about equally affected by human-elephant conflict in terms of crop damage as households here had lost nearly quarter of their total annual income from crop production. Shukla on the other hand lost about 13 percent of the annual income which was significantly less than both Bardia and Jhapa. Among other factors, land use changes leading to depletion of forested areas in the 'edge habitats' appear to have significant bearing on the magnitude of economic loss due to crop raiding by wild elephants. Evidently, Jhapa and Bardia had about equal amount of forests in the 'edge habitats' that is less than what Shukla had in such habitats. This closely agrees with the propositions of Barnes, Asika and Asamoah (1995) in Africa and Sukumar (1991) and (Fernando et al. 2005) in Asia that loss of elephant range increases the probability of contact between elephants and human settlement and thus leads to an increase in crop raiding. This suggests an association between the amount of land transformed by agriculture and the level of problem elephant activity (Hoare 1999).

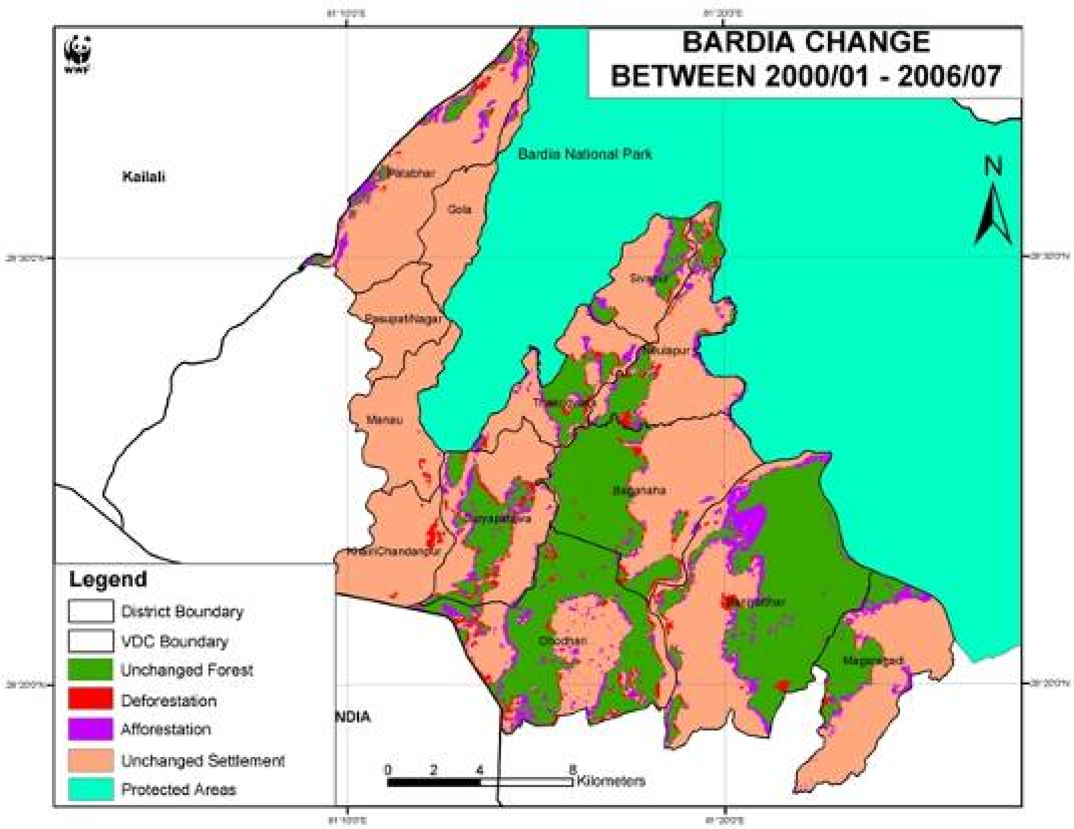
While interpreting the landscape features with respect to human-wildlife conflict, the knowledge about degree of fragmentation across the landscape also becomes crucial. In the highly fragmented landscape, the greater ratio of the perimeter of the forest-cultivation boundary to forest area will lead to increased frequency of raiding (Sukumar 2003). The significant positive relationship between habitat fragmentation and the economic loss due to crop raiding obtained in the present study closely agreed with this. A similar findings by Sukumar (2003) in the Kodagu District in India further attests to this notion. Thus, it is highly likely that the more fragmented landscape in Jhapa could be one of the primary causes for the observed level of HEC there (Fig. 24). .

Figure 24. Change in forest cover in Jhapa during the period between 2000/01 to 2006/07



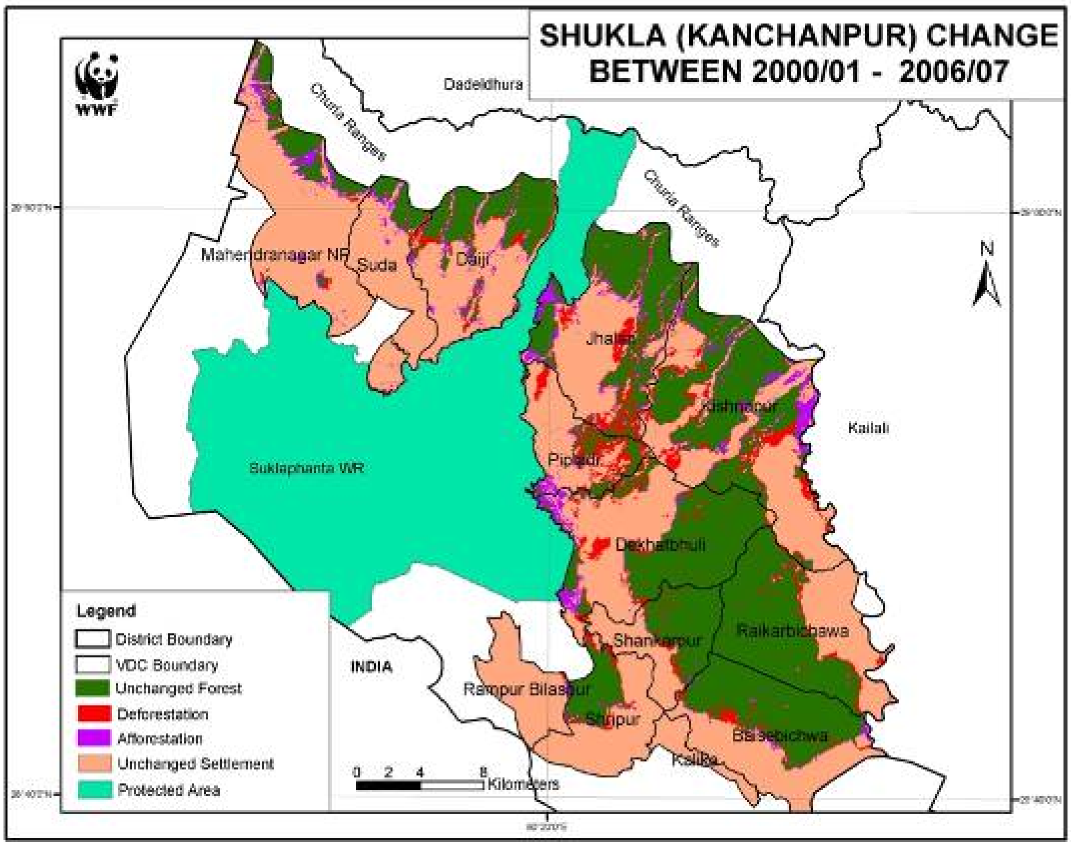
Although the existing forest cover in the edge habitats in Bardia appeared to be fragmented but the closure look at the temporal pattern shows the increasing amounts of forest cover (Fig. 25). This is most likely due to the recent expansion of the community forests in and around the buffer zones. As such, it brings some promise in dealing with HEC in the days ahead. This could be particularly true because the new vegetation is mainly confined around the periphery of existing forests (Fig. 25, refer to WWF Nepal program office for higher resolution map), thus if present trend of forest extension continues, the HEC in future is expected to decline because of the enlarged patch size and the improvements in the connectivity (i.e. reduction in the fragmentation)

Figure 25. Change in forest cover in Bardia during the period between 2000/01 to 2006/07



Likewise, the temporal pattern of land use changes in Sukla showed the relative decline in the forest cover over the years. This possibly implies that HEC might increase in future if immediate conservation measures are not put into place. Moreover, a closure look at the map indicates the on set of forest fragmentation in some VDCs, particularly the VDC of Pipladi, Kishanpur and Jhalan (Fig. 26, refer to WWF Nepal program office for higher resolution map). These isolated fragments may actually serve as the attractive dwellings for elephants as well as other problem animals as an important source of food and a refuge. Secondary vegetation available in such degraded areas is considered to be more preferred by elephants than the corresponding prime habitats (Sukumar 1990). Also, these patches may provide safe haven for indulgent crop raiders during day time to venture out into the surrounding human settlements at night (Sukumar 1990). Our observation of the 50 percent increase in paddy damage during the period between 1999 to 2007 further supports this statement.

Figure 26. Change in forest cover in Sukla during the period between 2000/01 to 2006/07



Another important finding of this study is the differential level of HEC tolerance across the study sites. Comparison of conservation attitude among people of Bardia and Jhapa clearly showed that people from former sector were more tolerant to HEC than the later despite the similar level of damage occurred in the both places. This indicates the important role being played by concerned GOs and NGOs in Bardia and suggests need for the similar course of action in Jhapa where people have been known to resort to the killing of elephants in the recent years. Judging by the global decline in the elephant population, such conservation measures should be urgently initiated in the district. Moreover, we also noticed the strong motivation of local people to mitigate HEC as shown by the local efforts such as the formation of NGO, called 'Hatti Niyantran Committee'. This together with the prevailing higher literacy rate in Jhapa probably offers an ample ground for conservation endeavors.

The landscape level approaches that address the conservation issues beyond the boundaries of the protected areas, has been increasingly acknowledged as an effective strategy to conserve the wide ranging large mammals (Harris 1984, Wikramanayake et al. 1998). More data on the population and behavioral ecology of elephants together with both temporal and spatial pattern of land use dynamics across the Nepalese boarder would provide invaluable insights to devise effective management plans. The local people from the all sectors, especially Bardia and Jhapa in our study also share this view (Fig. 21).

Delineating the ecological boundary for elephants and installing barriers on such boundaries rather than on administrative boundaries is a prerequisite to bring about effective conservation of elephants (Fernando et al. 2005). Hence, it is essential to identify priority elephant conservation areas and work with policy-makers to agree on land use within these landscapes (Fernando et al. 2005). While doing so, trans-boudary cooperation with India coupled by the cross-sectoral coordination between concerned ministries such as forestry, environment, agriculture, local development etc. would be instrumental to effectively mitigate the root causes of the HWC.

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APPENDIX