Detailed Final Report

Report with major findings (Part- I)

Situation of human elephant conflict (HEC) and approaches for mitigating HEC in surrounding VDCs of Jalthal forest in Jhapa district, Nepal

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Detailed technical report submitted to:
The Rufford Foundation, UK

11th March 2018

Introduction

Elephants (Endangered-IUCN 2008, Annex I-CITES, Protected- Government of Nepal), the mega-fauna of all existent terrestrial animal, play an important role of umbrella species in the ecosystem they inhabit (Perera, 2009). The number of resident wild Asian elephants in Nepal were estimated to be between 147-171 animals, distributed in four isolated sub populations: Eastern, Central, Western and Far-western regions covering an area over 10, 982 sq. km of forest habitat in the lowland Terai (Pradhan et al., 2011; Yadav et al., 2015). The eastern population consisted 7–15 individuals, central population 20-25 individuals, western population 60-80 individuals and far-western population 15-20 individuals (Pradhan et al., 2011). The eastern population is dominated by migratory herds venturing into Nepal from India during the period between May and November along with approximately 15 resident elephant individuals (Yadav, 2007; DNPWC, 2008).

Human-Elephant conflict (HEC), the interaction between people and elephant that have a negative effect on people, elephants and the environment pose a challenge for biodiversity conservation (Parker et al., 2007). The Asian elephant *Elephas maximus* are highly threatened mainly as a result of habitat loss and fragmentation as well as conflict with people (Sukumar, 1993; Perera, 2009). It is a severe concern in Nepal where the elephants have been compressed into ever-smaller areas and their traditional migration routes have been cut off that resulted in HEC. Elephants elicit the greatest fear for the rural communities because they have the potential to damage large area of crops, destroy property and cause human injury and death (Parker et al., 2007). Elephants may not cause the greatest damage overall when taken at the district or national levels. However, the damage they often inflict is devastating for the individual farmer where average per capita income of people is less than 725$ (NPC, 2015).

Among 4 sub-populations of elephant in Nepal, the severity of economic loss from wild elephant in Jhapa (eastern population) is high (WWF Nepal, 2007). The eastern population is connected with the migratory animals from North Bengal (India), which have herd sizes ranging from a few individuals to over 100 animals. North Bengal is one of the more important elephant habitats, with nearly 400 resident elephants. The protected and reserve forests in Northern West Bengal house 90% of the elephants in the state, and link with the habitat of the northeast Indian elephant population (WWF India, 2012).

The population growth of our country and immigration of hill people have increased pressure on terai areas. Many people are illiterate and poor and are depended on forest resources for their subsistence daily life. Thus, they are putting heavy pressure to the habitat fragmentation and destruction. Similarly, development of infrastructures is also responsible for habitat destruction that ultimately results in HEC. The major source of income is agriculture in Jalthal, Jhapa and productivity is also not enough due to lack of proper farming technology and irrigation. The damages due to HEC have put on people in serious problem. The growing human population, coupled with the declining forest area, is bringing people and wildlife into closer contact, with detrimental impacts on both. Therefore, addressing the vulnerabilities to communities from large mega herbivores like

Elephants is one of the greatest conservation challenges faced by the country. Crop raiding and more recently human casualties have become major issues related to HEC. This conflict is increasing because the number of elephants visiting Jhapa has been increasing at recent years (Ram, 2014). Action programs for the reduction of human elephant conflict in Jhapa is inadequate although DFO of Jhapa district has been implementing some programs with the support of World Bank. To our knowledge, there is limited information pertaining to HEC in Jalthal, Jhapa. Thus, this study was aimed to provide baseline information regarding human-elephant conflict (HEC) including crop and property damages, human casualties and injuries and the mitigation measures on study area along with community awareness programs providing information for its effective management and mitigation against HEC in days to come.

Objectives

1. Collect detail information on the incident of human casualty and injury by the attack of wild elephant from all victims' household
2. Assess the crop and property damages information and identify the settlements with severe damages
3. Conduct community outreach (awareness) programs to aware the local communities about the ecology and behaviour of wild elephants, existing situation of HEC (based on this project's preliminary findings) and recommend appropriate safety and mitigation measures

Methodology

Study area

Jalthal is located in Jhapa district in between 26° 31' 0" North, 87° 59' 0" East with lowland Terai of Southern eastern part of Nepal at an altitude between 60 m to 180 m (Figure 1). It is the unique tropical mixed forest patch of Nepal. The total area of Jalthal is 80.34 sq. km that covers 8.55% of Jhapa district and the forest within Jalthal covers 63 sq. km. It consist of 9 wards out of which ward no. 7 occupies largest area and ward no 3 occupies least area. It is about 17 km south from Birtamod city and 12 km south-west from Bhadrapur. Dauniae, Bhutane, Bhusanda, Kajale are the main rivers of the study area. Dauniae is the eastern border where as Bhutane is located in western border. Soil in this region is mostly acidic to neutral. The land is dominated by agriculture and grassland followed by forest (Table 1). The land use pattern has been changed over the period of time. The average temperature varies from 16.4°C in winter to 30°C in summer which is closely to tropical type of climate. The precipitation lies between 2000 to 3000 mm.

Table 1: Land use pattern of Jhapa

Land use	Area (ha)
Forest	13,239
Shrubs	1,863
Agriculture and Grassland	141,795
Water bodies	778
Barren land	6,517

Others	0

Source: CBS (2012)

The Jalthal forest is composed of Sal (*Shorea robusta*) as a dominant tree species with other associates such as *Artocarpus chama, Lagerstroemia parviflora, Dillenia pentagyna, Terminalia bellerica, T. chebula, Sizygium cuminii*, etc. The forest is unique due to the presence of species like katus (*Castanopsis* indica), Chilaune (*Schima wallichii*), Mahuwa (*Madhuca longifolia),* etc. which are out of their normal distribution range. It is also a habitat for rare and endangered species like Thakal (Cycas *pectinata),* Satisal (*Dalbergia latifolia),* Champ (*Michelia champaca),* Chandmaruwa (*Rauvolfia serpentine*), Simal (*Bombax ceiba*), etc. A preliminary survey documented 57 species of trees, 17 species of shrubs, 67 species of herbs and 10 species of climbers representing 129 genera under 76 families (Bhattrai, 2013). The wild fauna consists of Elephant (*Elephas maximus),* Chital (*Axis axis*), python, rabbit, fox (*Vulpes bengalensis*), monkey, malsapro, khirkhira, gohoro, tortoise, snake, (*Manis*) pangolin, peacock and different types of birds.

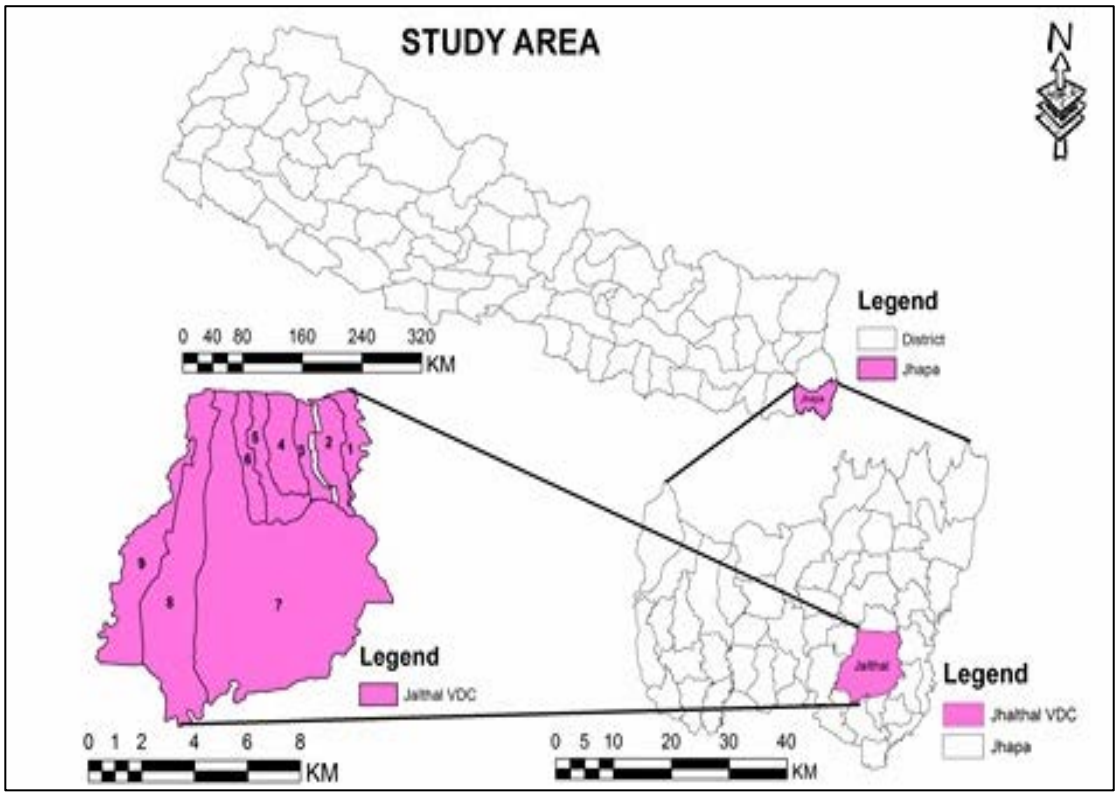

Figure 1: Map of study area

Data Collection

This study was based on direct field observation, household surveys, key informant interviews and focus group discussions. Extensive field visits was performed from January to March 2017. The study area included all the 9 wards of Jalthal VDC (Figure 1). The study area was selected after discussions and consultations with District Forest Office, Community Forest User Groups, local stakeholders and people. The study site

was selected because there were emerging issues of HEC and such information was not raised substantially up to date. Based on the reported cases documented in District Forest Office (DFO) Jhapa, Nepal, we collected the addresses and went to each household who were the victims of human casualty and injury from the wild elephant's attack since last 6 years. Through the informal interviews and discussions with victim's family members, we collected detailed information regarding where, when and how the incident took place followed by recording the GPS coordinates and capturing the photographs from all victim's houses. Similarly, after examining the file records (request letter for claiming the damage compensation of last 5 years) of the victims for crop and property losses by wild elephants from DFO, Jhapa, the most affected settlements (sites) around the Jalthal Forest were purposively selected and representative's households (samples) were randomly chosen from each sites for the household survey. In case of absence of member during household survey, next household was selected for questionnaire survey. The semi-structured questionnaires were prepared in Nepali language that focused on the socio-economic information of the respondents, their dependency on the forest, major crops grown, season and stage of crop damages, types of property damage, monetary value of annual crop and property losses, mitigation measures practiced as well as their perception about the existing government's compensation schemes. We chose 190 out of 760 households having repeated cases of crop and property damages over several years (25 % sampling intensity) for data collection and analysis. Similarly, 20 key informants' interviews were conducted representing the elite people of all affected sites for collecting site-specific detail information about causes, effects, yearly and seasonal damage trend and local mitigation measures adopted against HEC. In addition, 10 group discussions were conducted to triangulate the information collected from household survey and key informant interviews. In order to share this project's preliminary findings and raise the existing issues of HEC, we conducted one day workshop with 60 participants including district forest officer, Jhapa, staffs of DFO and sector offices Jhapa, chairperson and representatives of different community forests of the affected sites, local elites, youths, bachelor level forestry students and other concerned local stakeholders. During the workshop, different issues of HEC were explored and discussed in one common platform and discussions were made concerning planning and implementing effective mitigation measures, policy amendment for existing government's relief/ compensation schemes. Besides, speech context was conducted in 2 government schools within the affected sites to aware the students (youths) about the existing HEC and the effective mitigation measures. We also prepared the awareness and conservation education materials in Nepali language and distributed during the awareness programs (group discussions, workshop and speech contexts) in all the affected sites. Secondary information were collected from district forest office, Illaka forest office, VDC offices, police office, different literatures, journals articles, books, thesis and relevant websites.

Data Analysis

The data was analyzed using MS Excel, SPSS and Arc GIS. By using SPSS, Pearson's Chi-Square test of independence was performed to test the association between different categories of castes or ethnic groups and dependency on forest resources. Similarly, the association between other variables that includes settlements vs. crop and property damages, land holding size vs. monetary value of crop losses and community forest vs.

types of crop damages were tested. The significance of test was set at $P \leq 0.05$ (i.e. 5% level of significance).

Results

We found that there were altogether 10 human casualties from the attack of wild elephants in different time periods till the time of our fieldwork. Names, addresses, dates and cases of human casualties in our study area since 5 years are listed below:

1. Sharmila Limbu (Bhadrapur-4, Jhapa; 27th December 2017; in search of firewood nearby forest; afternoon 2 p.m.)
2. Sushila Limbu (Bhadrapur-4, Jhapa; 27th December 2017; in search of firewood together with Sharmila Limbu; altogether 4 people went to the forest but 2 other escaped from the elephant attack)
3. Devi Kumari Rai (Prithvinagar-2, Jhapa; 24th February 2016; while walking on the road nearby house; morning 7 a.m.)
4. Bhawani Prasad Ghimire (Banyani-7, Jhapa; 19th December 2015; while cutting grasses in the farm nearby; morning 7:15 a.m.)
5. Bajari Rajbanshi (Balubadi-6, Jhapa; 11th October 2014; while going to toilet nearby house to urinate; 4 a.m.)
6. Mangalbir Tamang (Prithvinagar-1, Jhapa; 30th March 2013; while collecting firewood nearby forest; around 8 a.m.)
7. Gyan Bahadur Chamling Rai (Prithvinagar-5, Jhapa; 19th March 2013; while cutting grasses in nearby forest; 3 p.m.)
8. Gunamaya Basnet (Prithvinagar-5, Jhapa; 5th January 2012; while sitting in front of the house; 8:30 a.m.)
9. Durga Prasad Pandey (Prithvinagar-8, Jhapa; 5th January 2012; while resting outside the house; 6:30 a.m.)
10. Aasha Maya Rai (Prithvinagar-5, Jhapa; 5th January 2012; while working in the home garden on the side of the house; at around 7 a.m).

We found that the most damaged crop in our study area was paddy (Figure 2) and the most damaged property type (Figure 3) was House/hut.

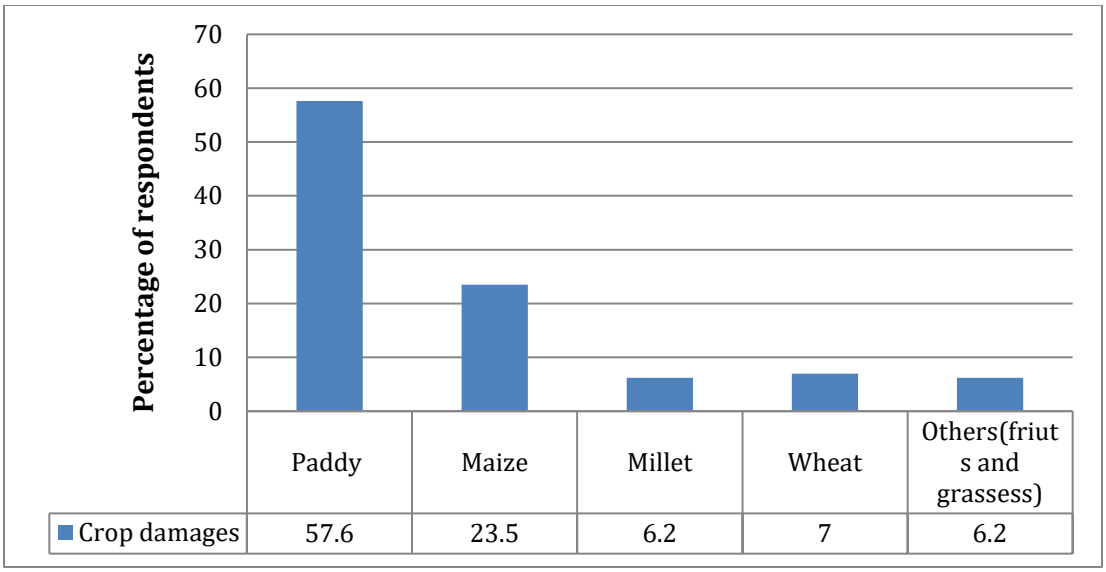

Figure 2: Major crops damaged in the study area

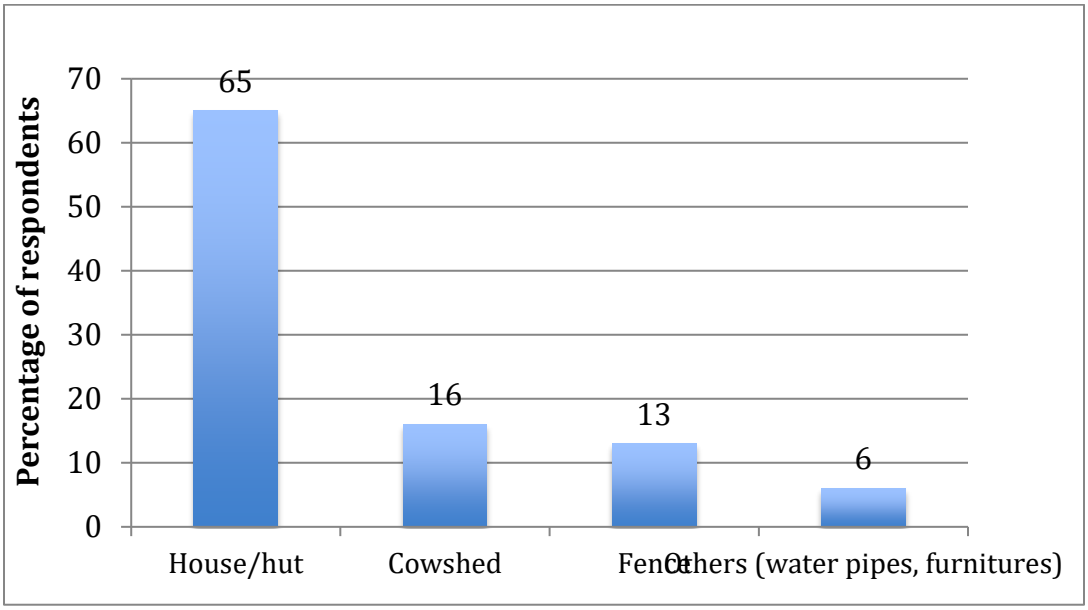

Figure 3: Major properties damaged in the study area

We also found that more than 70 % of the respondents had average annual crop damages up to 20,000 Nepali rupees or 191 US dollars. Some of the major findings (based on chi-square test of independence) were:

- Among 3 categorized castes or ethnic groups (Brahmins/chhetri, Indigenous castes and disadvantaged groups), there was high dependency on forest resources by the indigenous group of people **($\chi^2 = 19.004$; $p < 0.05$).**
- Among 4 different affected areas around Jalthal forest area in Jhapa district (Baradashi, Bhadrapur, Haldabari and Kachankabal), the most affected area in

terms of monetary value of crop loss was Bhadrapur **(χ^2 = 75.087; p < 0.05)** and in terms of monetary value of property loss was **(χ^2 = 24.863; p < 0.05).**

However, there was no any association between land holding size of households and monetary value of crop loss **(χ^2 = 113.270; p > 0.05)**. Similarly, there were no differences in type of crop damages among different community forests users residing around the Jalthal forest areas **(χ^2 = 27.462; p > 0.05)**.

Conclusion

Our study concluded that the increased HEC has put on people of Jalthal in real trouble. Crop damages and property damage were the major problem faced by the people. Among different crops, paddy was severely damaged by wild elephants and among different properties, house/hus was most damaged. Further, research investigation can be done on the wild elephant's habitat within Jalthal forest and investigation can focus on how land use affects elephants' ability to persist and thrive. This would provide an opportunity to determine if there are seasonal pattern of movement, if movement is influenced by availability of water, and if movement is related to the distribution of vegetation. This information would also enable researchers to evaluate how elephant population affects the vegetation and the general health of the ecosystem.

Statement of interest

None

Permits

Fieldwork was performed with the required permits from the District Forest Jhapa, Nepal.

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Report with major findings (Part-II)

Evaluating the effectiveness of solar-powered fence in reducing human - wild elephant conflict (HEC) in northeast Jhapa district, Nepal

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Detailed technical report submitted to:
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11th March 2018

Introduction

Elephants are the largest terrestrial animals that play the role of umbrella species in the ecosystem. They are categorized as endangered species by IUCN, Annex-I by CITES and protected species by government of Nepal (Perera, 2009). The resident wild elephants are distributed in 4 isolated sub-populations in Nepal viz. eastern, central, western and far western (Yadav et al., 2015). The area inhabited by elephants is spread over 135 village development committee (VDCs) in 19 districts (17 in lowland Terai and 2 in the hills) of Nepal, covering about 10,982 sq.km of forest area (DNPWC, 2008).

Wild elephants are long ranging species whose strict fidelity behavior follows a fix route of seasonal migration from Assam in India up to Eastern Nepal, passing through the foothills and plains of Jalpaiguri and Darjeeling of West Bengal (Lenin and Sukumar, 2008). The westernmost population of these elephants in Northern West Bengal, now separated from its counterparts in the western and eastern *daurs*, is generally residential but some inward and outward movement occur through contiguous and fragmented landscape within the district and also across western International boundary. Koshi Tappu Wildlife Reserve (KTWR) has witnessed an increasing number of migratory elephants entering its area since 2008 that have now come to reside permanently in the Park (Ram, 2014). Elephant Conservation Action Plan (2009) also confirms that migratory elephants in Eastern Region of Nepal have been increased.

Human wildlife conflict (HWC) is a complex interaction between humans and wildlife and represents the detrimental impact to both (Awasthi and Singh, 2015). It has become a burning issue in biodiversity conservation of Nepal. In highly populated countries of Asia including Nepal, human elephant conflict (HEC) poses serious threat to elephant survival in and around protected areas and corridor forests. In the lowland Terai region of Nepal, there is rapid migration of people from hilly regions that resulted in habitat fragmentation and became one of the major causes of crop damages by wild elephants (Shrestha et al., 2007) and overall increase in conflicts (Neupane et al., 2014). The resultant effects are interaction of wild elephants with human in the form of human casualties and injuries, crop losses, property damages, social fear and retaliatory killings of elephants (Acharya et al., 2016). Also, the relative economic loss of households who suffered from crop raiding is high in developing countries like Nepal because the farmers are poor and mostly depend on subsistence farming nearby forest areas. Official records of the DFO, Jhapa showed that during 2010-2012 elephants killed or injured 21 people, damaged 210 houses and other property worth NRs. 8 millions. This conflict is increasing because the number of elephants entering into human settlements of Jhapa has been increasing at recent years (Ram, 2014). Formerly these elephants were temporary migrants of India, spending 3-7 months in the eastern Nepal, before returning to India via Bahundangi VDC. During their migration these elephants are put at risk and subjected to danger. The movements of herd were largely restricted to the Bahundangi VDC and due to the spatial unequal distribution of wards of Bahundangi, all wards were not equally affected by the wild elephants. Ward 1, 2, 8 and 9 are damaged most by the elephants because of closeness to the Mechi River. Protected corridors linking forested areas are lacking between India and Nepal, so safety migration to and from Nepal is not insured. Elephant

population is indeterminate outside the protected areas of Nepal and no conservation measures have enacted to ensure their protection.

With the aim to mitigate HEC, 17 km solar powered fence has been installed in the international boundary along the Mechi river to deter the elephant movement across the international border with the support of World Bank and NTNC in 2015 (MFSC, 2015). Before the installment of solar powered fence, the large herds of wild elephants used to enter in to Jhapa in search of food and water, crossing the Mechi River, more frequently observed during paddy harvesting time (June/July and Sept/Nov). According to official record of DFO and newspaper report, it has been found that HEC cases have been sharply reduced after the fence installment (DFO Jhapa, 2016; KP, 2016). So, this study was aimed to assess the present condition of solar powered fence, different incidents of HEC (human causalities and injuries, crop and property damage) before and after the solar powered electric fence installment and evaluate the effectiveness of the fence in terms of saving the human lives, major crops (paddy and maize) and property losses. Furthermore, the monetary value of crop and property damages before the fence establishment was calculated.

Objectives

1. Assess the present condition of solar powered fence
2. Collect and analyze different incidents of HEC (human causalities and injuries, crop and property damage) before and after the solar powered electric fence installment
3. Calculate the monetary value of crop and property losses before fence installment
4. Evaluate the effectiveness of the fence in terms of saving the human lives, major crops and property losses.

Methodology

Study area

The study was carried out in Bahundangi Village Development Committee (BVDC) (26°44′24″N and 88°9′36″E) of Jhapa District, Eastern lowland Nepal (Mechinagar Municipality-1 to 4; Province number 1 at present) (Figure 1) (Shrestha and Koirala, 2015). It is a remote village located in the North-East corner of the district. It lies 10 km North from Mahendra Highway and occupies an area of 57.26 sq. km and is stretched North-South along the Mechi River that delineates the eastern boundary between Nepal and India (Karki, 2014).

The study area varies widely from around 60 m elevations in the south and 500 m to the north and average temperature varies from 16.4º C in winter to 30º C in summer, which is close to the tropical type of climate. Precipitation is 80 % during monsoon season. The maximum and minimum average annual precipitation is 3001-5500 mm and 801-1200 mm respectively. The tropical rain forest and tropical deciduous forest i.e. *Shorea robusta* dominant is present in the Jhapa district, particularly in the Jalthal forest.

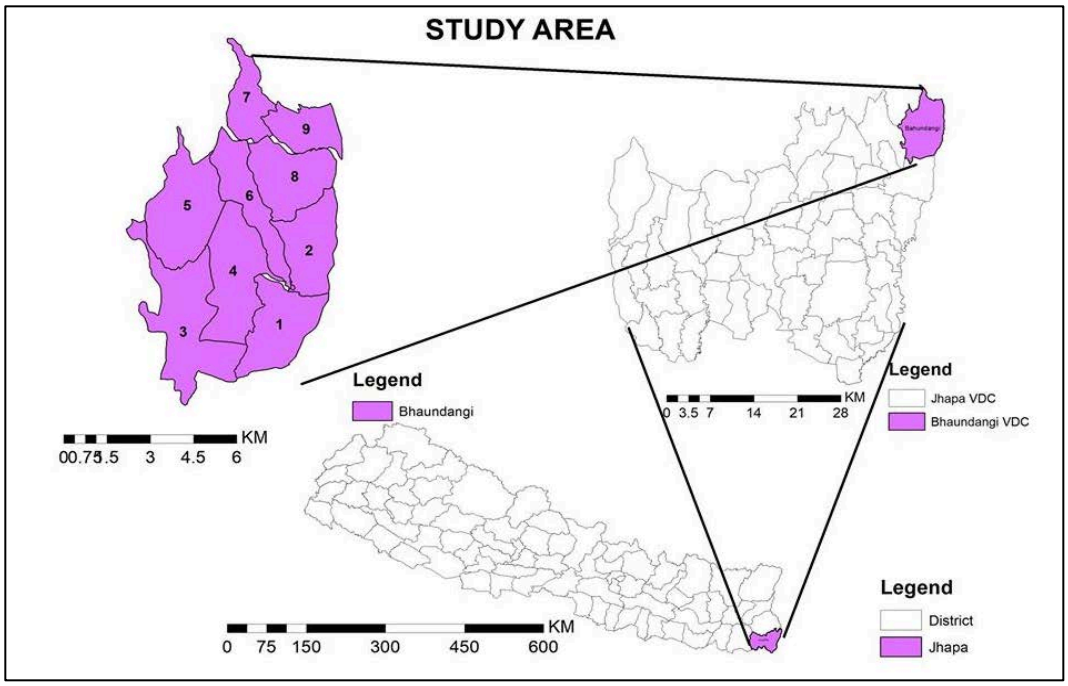

Figure 1: Map showing the study area- Bahundangi VDC (BVDC)

Though BVDC front line VDC were most affected, Shantinagar, Budabare, Dhaijan, Sanischare, Khudunabari, Arjun Dhara VDCs and part of Mechi Municipality were also affected from trans boundary elephant movements before fence installation. After the fence installation these herds were restricted to BVDC only because only few adult elephants entered the settlements by breaking the fence in evening or night and after consuming the ripe crops available within the border VDC (i.e. BVDC), they returned to the Indian forests early next morning. All wards are not equally distributed in BVDC. Ward number 1, 2, 8 and 9 are located in front line and therefore there is more probability of damage and loss incurred from wild elephants. Almost half of the area (largely ward 1, 2, 8 and 9) of BVDC lies within 3 km of solar fence while remaining half area (ward 3, 4, 5) lies in 3-6 km.

Data collection and analysis

Preliminary field visit

This visit was conducted to know which areas of BVDC were more affected in terms of human casualties, injuries, crop and property damage by trans boundary elephants before and after fence installation. During that survey, discussions were made with officials of DFO, Jhapa and local people.

Major field works

The field observations and surveys were conducted to identify the condition of the solar fence and monitor the crop and property damage areas. Based on the past official records of district forest office, Jhapa, the affected settlements of front line wards of BVDC were purposively selected and 100 households within those settlements were randomly selected for questionnaire survey. The questionnaires were prepared focusing on the

human elephant conflict information from 2014 (before fence installment) and from 2017 (after fence installment). A questionnaire survey was conducted to analyze the average monetary value of crop and property loss per households per year before and after the fence establishment. In addition, key informant interviews were conducted with 30 local people who had been affected by HEC in the newly fenced areas to understand the in-depth situation of conflict and know the effectiveness of the solar fence and relief compensation mechanism. Besides, to triangulate information obtained from households survey and key-informants interviews, 4 representative group discussions (GDs) were made with local people (one from each affected wards: 1, 2, 8 and 9 of BVDC) regarding mitigation measures being applied and the effectiveness of solar powered fence and challenges in driving away elephants. For each GDs, participants were jointly from the local youth club, school teachers, political representative, representative from CFUG and civil society. Furthermore, participatory field observation for HEC incident points, particularly fence damage sites were surveyed. Signs of crop damages, elephant's dung and footprints were taken as the indicators for their presence in the settlement areas. All those affected sites were visited and crop and property damage information were recorded by asking with local people.

Estimation of monetary value of crop and property loss

Out of the total sampled households (N=100), the amount of crop losses due to elephants before fence installment was converted into monetary values based on the examination of the local market during the year 2014. The average monetary value was computed for 5 major crops practiced by the local people in the study area. Similar to the crop damage, the amount of property damage due to elephants before fence installment was converted into monetary values based on the examination of the local market during the year 2014. The average monetary value was computed for 4 major types of properties of local people in the study area.

Secondary data collection

Secondary data was collected from official records of DFO, Protected Area (PA), Department of National Parks and Wildlife Conservation (DNPWC), NTNC etc., published scientific literatures, articles, reports and books.

Data Analysis

The data was analyzed using MS Excel, SPSS and Arc GIS. Most of the calculations and interpretations were performed using MS Excel while the prevalence of crop and property damages in 4 different wards of Bahundangi VDC were tested using Pearson's Chi-Square test of independence in SPSS. The significance of test was set at $P \leq 0.05$ (i.e. 5% level of significance). Among 4 categories of properties, the statistical tests were not performed for cowshed and other properties as they had minimum expected count values less than 5, and so could not fulfill requirements for chi-square tests.

Results

Condition of Solar powered electric fence

The fence was in poor condition due to lack of proper maintenance by the fence management committee as the cost of maintenance was reported expensive. There were no proper mechanisms to monitor and maintain the fence. Besides, some adult elephants were very clever and used dead dry logs to destroy the fence and sneak into the field as reported by the respondents. Bahundangi VDC was used as a major route to smuggle a wide range of goods during the night time as it lies in the foothill and away from the district headquarter, and there was no border security mechanism in the VDC to control such illegal activities. During night time, the smugglers used to disconnect the power fence in some places that allowed wild elephants to break the fence easily and enter into the agriculture fields. Besides, in some places, the fence was found covered by grasses and climbers (Figure 2).

Figure 2: Grasses and climbers covering solar-powered fence in Bahundangi VDC

Effectiveness of the fence

After the fence installation in 2015, it was found that the elephants had changed their behavior and adapted as opportunistic raider and they raided the crops along the fringes of Mechi River and immediately return to the Indian side. In June 2016, 116 elephants including 34 calves entered Jhapa but were not reported to move beyond the boundaries of Bahundangi (DFO Jhapa 2016). After the installment of solar fence, the huge herds of trans boundary elephants were sharply decreased. Subsequently, the number of incidents of conflict (human casualty and injury, crop, property damage and retaliatory killings of elephants) was sharply decreased from 747 cases (before fence installment) to 30 (after fence installment) in 2016 with the percentage decreased of 96.13%.

Crop damage information

Among different types of crops, the two major crops planted by the households were paddy (79%) and maize (62%) (Table 1). Among the surveyed households, 45% had experienced paddy crop damaged by wild elephants before fence installment that was sharply reduced to 3% of households after fence installment. Similarly, 29% of households had experienced maize crop damaged by wild elephants before fence installment that was sharply reduced to 2% of households after fence installment. Thus, the overall crop loss was noticeably reduced by around 93% after fence installment in the study area. From chi-square test of independence, it was found that there were significant differences on prevalence of paddy crop raided by wild elephants in 4 wards ($\chi^2_{3,100} = 14.02;\ p \leq 0.05$) but not with maize crop ($\chi^2_{3,100} = 7.14;\ p \geq 0.05$). Additional information for other crop types are mentioned in Table 1. On average each household lost crop equivalent to approximately USD 95 due to transboundary elephants each year (Figure 3) where the most affected crop was paddy.

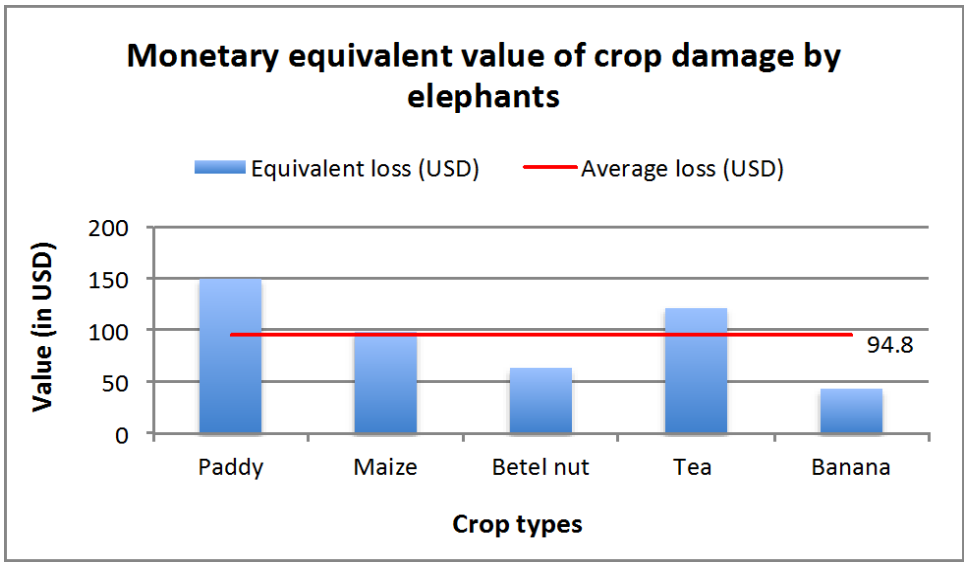

Figure 3: Monetary equivalent value of crop damaged by wild elephants

Table 1: Households' information on the major crops planted and raided before and after the solar powered fence instalment. The 5 major crops are listed below based on the information that at least 5 households had planted the crops in the study area.

	Annual crop raided information before fence instalment (in 2014)				Annual crop raided information after fence instalment (in 2017)			
Crops	Frequency of HHs (planted)	Percent of HHs (planted)	Frequency of HHs (crop raided)	Percent of HHs (crop raided)	Frequency of HHs (planted)	Percent of HHs (planted)	Frequency of HHs (crop raided)	Percent of HHs (crop raided)
Paddy	79	79	45	45	79	79	3	3
Maize	62	62	29	29	62	62	2	2
Betel nut	33	33	13	13	33	33	1	1
Tea	7	7	3	3	7	7	0	0
Banana	5	5	3	3	5	5	0	0

Property damage information

Similarly, among different category of properties, the two major properties severely damaged by elephants were house/hut and stored grains (Figure 4). Among the surveyed households, 32% had experienced house/hut damaged by wild elephants before fence installment that was sharply reduced to 2% of households after fence installment (Figure 4).

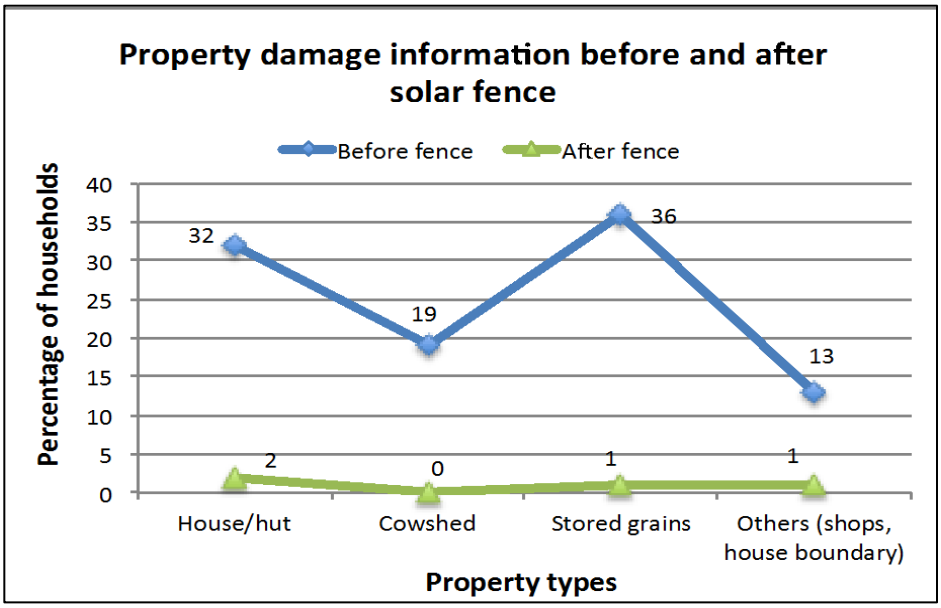

Figure 4: Households' property damage information before and after solar fence

Similarly, 36% of households had experienced stored grains damaged by wild elephants before fence installment that was drastically reduced to 1% of households after fence installment. Thus, the overall property loss was remarkably reduced by around 96% after fence installment in the study area. There were significant differences on prevalence of house/hut damages $(\chi^2_{3,100} = 16.54;\ p \leq 0.05)$ by wild elephants among 4 wards. Similarly, the stored grains loss significantly differed among 4 wards $(\chi^2_{3,100} = 10.77;\ p \leq 0.05)$. Additional information for damage of other property types is mentioned in Figure 4 and 5. Based on analysis, it was identified that on average each household lost property equivalent to approximately USD 8 annually (Figure 5) where highest valued property damaged by elephants was house/hut.

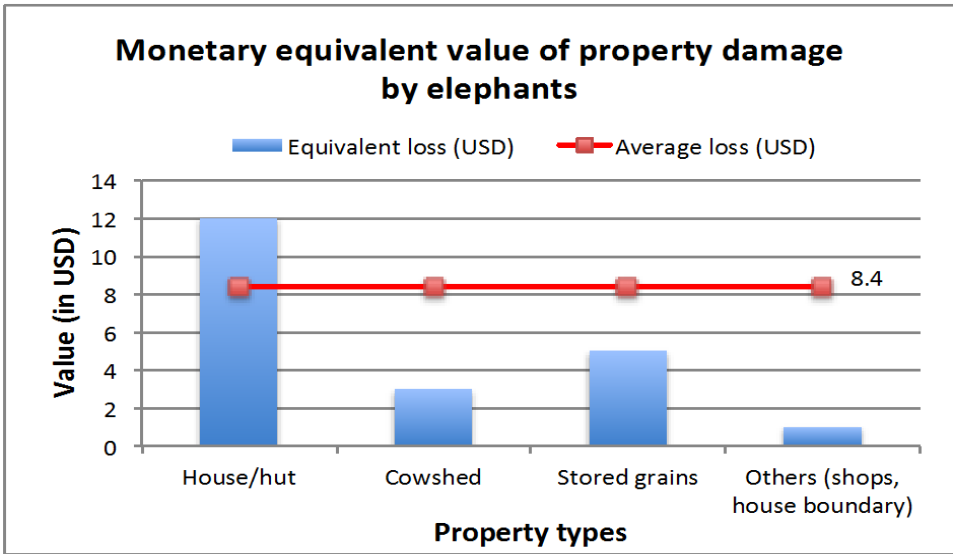

Figure 5: Monetary equivalent value of property damaged by wild elephants

Conclusion

To our knowledge, this is the first study attempted to evaluate the effectiveness of solar powered electric fence in reducing the incidents of HEC in Jhapa district Nepal. Though the incident of HEC particularly crop and property damages were not completely eradicated after fence installment but there were no human attacks in the study area. In spite of the fact that the fence was not in proper condition due to poor maintenance and care. The smugglers used to break the fence and use the routes for passing through the Nepal and India border as well as the fence was covered by the grasses and climbers in some places. Thus, additional guarding mechanisms alternative or unpalatable crops should be established for the effectiveness and sustainability of the fence.

Statement of interest

None

Permits

Fieldwork was performed with the required permits from the District Forest Jhapa, Nepal.

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