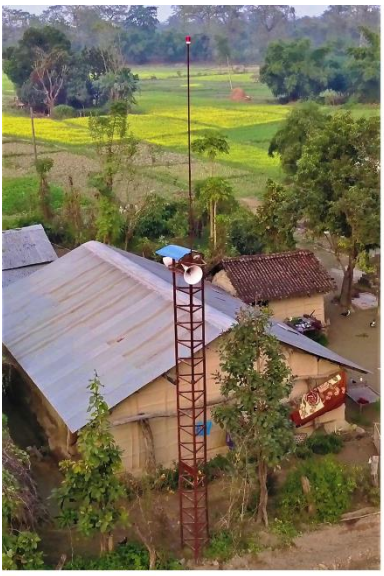
Assessing the effectiveness of the existing mitigation measures against human-elephant conflict in Khata Corridor, Bardia, Nepal

Study Report January 2022










Contact details for further information:

Ujyalo Nepal (Bright Nepal)
Thakurdwara Municipality - 2
Bardia, Nepal
Tel: +977 9858025755 (Mr. Ramesh Thapa)
Email: rameshkthapa@gmail.com

Cover photo: Krishna D Hengaju and Ramesh Thapa

Other Photos in the report: Sima Khanal and Krishna Hengaju

EXECUTIVE SUMMARY

Mitigation measures' evaluation refers to the study of status, effectiveness and functionality of existing mitigation measures that have been installed and established against Human Elephant Conflict in the study site. The report comprises the detailed analysis of how well the mitigation measures are functioning or being managed and the extent to which the objectives and goals of them are being met. The following facets include the overall goals of existing mitigation measures installed in and around Khata corridor:

1. *To discourage elephants movement in the settlement areas by using barriers.*
2. *To decrease the number of human elephant encounter which provokes the frequency and intensity of human casualties.*
3. *To decrease the number of events of crop raiding by elephants in the area.*
4. *To increase the involvement of people in conservation program by giving them the sense of security.*

Although the objectives sound theoretically promising, with increasing trend of human elephant conflict, the crux debrief on effectiveness of measures remain undetermined. It is a matter of fact that the solution to reduce human elephant conflict has long been sought by many conservationists all over elephant inhabiting countries. Mitigation measures such as solar fencing, Reinforced Cement Concrete, trenches, traditional measures, alternative cropping, watch towers, early warning system, miking are practiced in Nepal. Khata corridor is an important biological corridor, act as a connecting bridge for the movement of wildlife including mega fauna like Asian elephant, Bengal tiger, and one horned rhinoceros. It connects the Bardia National Park in Nepal and Katarniaghat Wildlife Sanctuary in India. The major settlements such as Dalla and Patharbhoji are the prime elephant conflict prone areas. Every year people face the problem of crop depredation & property damage caused by wild elephants. On the top of that, there is always a high risk of human death and causalities when there is sudden encounter between human and elephant. Many approaches have been adopted to mitigate the conflict between human and elephant in the area. This report encompasses understanding of status, strengths, weakness, opportunities, threats and perceived effectiveness and functionality of existing mitigation measures developed from a premeditated study in and around 2 villages in Khata Corridor. The study is based upon key informant interviews (n=14), field observation and household survey (~34% of total households). It was found that although the electric fences served its purpose in the beginning, the elephants were habituated to the physical barriers in no time. They hit the fences frequently to enter the settlements especially during months when paddies ripe. The remoteness of place is one additional reason out of many for untimely repair of the damaged electric fences. Along

with the poor condition of the fences, the community acceptance of electric fences is likely very less and so is the perceived effectiveness of electric fences against HEC. The fences were reported to have been destroyed by elephants and even the communities. The communities destroying the fences could be indicator of lack of ownership. The local understanding of effectiveness of locally built structures like watch tower is to be alert about elephants entering the farmlands and village area which comes at a cost of life risk due to their fragile condition. It was found that people practiced alternative cropping and perceived it to be effective. However, the fluctuating market condition, land degradation after alternative farming and extreme weather patterns are reported to be major factors adding up to failure of alternative cropping as solution to reduce human elephant conflict. Almost all existing mitigation measures in the study area are likely failure due to varied reasons like poor management, intelligence of elephants, decreased level of ownership by community, scarce resources and many more. As none of the other mitigation measures serve their objectives, communities are compelled to rely on using traditional method that are lethal to both humans and elephants like making sound, using fires, sticks and stones to chase elephants away from their farm/house area as they are the only option that seem to be effective to them. Preference and use of such lethal methods may instead out-turn escalated and magnified interaction resulting in hindrance of human elephant coexistence. Co-existence of human elephant in such shared landscape is only possible with careful mitigation interventions and increased level of awareness in communities with discouragement to use lethal traditional measures.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

BNP: Bardia National Park

BCP: Bardia Conservation Program

CBAPU: Community Based Anti-Poaching Unit

DNPWC: Department of National Park and Wildlife Conservation

FGD: Focus Group Discussion

HEC: Human Elephant Conflict

HWC: Human Wildlife Conflict

NTNC: National Trust for Nature Conservation

RCC: Reinforced Concrete

RRT: Rapid Response Team

TAL: Terai Arc Landscape

WWF: World Wildlife Fund

ACKNOWLEDGEMENT

We would like to express our deepest appreciation to all those who provide the support to complete this research and report. A special gratitude to Ms. Sima Khanal who supported in conducting all the field activities, data analysis and report preparation. Special thanks goes to Dr. Narendra Man Babu Pradhan (elephant expert), IUCN program Coordinator who reviewed and provided his inputs in making this report a better version.

Furthermore, we would also like to acknowledge with much appreciation the crucial role of Mr. Krishna Hengaju, IUCN program consultant who provided continuous guidance throughout the project period. Special thanks go to Dr. Rabin Kadariya, Conservation Officer, NTNC-BCP, Mr. Yajna Prasad Timilsina, Professor- IOF for facilitating me with guidance and moral support in every ways possible. Additionally, we would like to thank Mr. Govinda Tharu and Mr. Biru Tharu for helping the research team in conducting the field work.

Last but not the least, we would like to express our sincere gratitude to International Union for Conservation of Nature (IUCN Nepal) for leading and facilitating the research. We are very thankful to Global Nature Fund (GNF), Nature and Biodiversity Union (NABU), and Government of Germany, Federal Ministry for the Economic Cooperation and Development (BMZ) for the financial support to conduct this research.

INTRODUCTION

Human-Wildlife Conflict

In Nepal, the collective conservation efforts reflect a substantial increase in the wildlife population particularly of mega species like tiger, elephant, rhino and leopard in protected areas (Raubenhiemer et al., 2017). This exceptional biodiversity conservation success, together with the increasing population and demand of forest-dependent local communities residing in park vicinity, has escalated the cases of human-wildlife conflict (HWC) (Acharya, 2016).

HWC implies confrontation between humans and wild animals, usually resulting in crop and livestock depredation, property damages, human injuries, human kill, and retaliatory killing or capturing of wildlife (Dickman, 2010). Conflicts between people and wildlife have been widely recognized as one of the most challenging issues in wildlife conservation; (Treves & Karanth, 2003; Thirgood et al., 2005) and Nepal also faces a similar fate with HWC being a major problem in most protected areas (Dhungana et al., 2018; Gurung et al., 2008; Lamichhane et al., 2018; Silwal et al., 2017).

Human-Elephant Conflict

Elephants are very intelligent flagship species. Their huge size, social behavior and emotions along with intelligence make them stand out in the animal kingdom. Human Elephant Conflict (HEC) is one of the major threats to elephant conservation. Human elephant conflict can occur due to negative interactions between humans and elephants causing increasing resentment of local residents towards conservation of the species. 21.5% of habitat used by elephant is reported to be lost in between 1930 to 2020 in Nepal (A. Ram et al., 2021). This leads to increase in the length of 'edge' for the interface between human and elephants while the elephant populations become compressed in insular refuges. Consequently, it leads to greater contact and conflict (Acharya, 2016) with humans as animals seek to fulfill their nutritional, ecological and behavioral needs.

The confrontation of elephants with communities include: *1. Crop loss. 2. Property loss, 3. Grains in Storehouse damaged 4.Human Casualties*. These losses can cause people to further harass and disturb elephants, increasing the harassed elephants' intolerance of people, and thus creating a vicious escalating cycle of HEC. Elephant is the most pervasive species causing more than 40% of the conflicts and responsible for 70% of human casualties in Nepal (Bajimaya, 2012). People in lowlands of Nepal are extensively dependent on

agriculture which is their major source of income. People fear elephants because they damage crops, destroy property, and cause injury and death (Parker et al., 2007). Despite of the fear, people continue to scare away elephants in the farmlands or villages, which are increasing encounter and accidental rates.

Nepal is one of the elephant range countries where migrating elephants from India frequently come. The population of wild Asian elephants in Nepal is distributed in four isolated sub populations. The sub populations of Elephants in Nepal are in patches which sum up to around 200 with 150 migrating elephants seasonally coming to Nepal (A. Ram et al., 2021). But the sad reality is that over the past decade, in Nepal HEC caused 274 fatalities and 138 injuries which sum 412 total cases of elephant attacks on humans for the period of 2000–2020 June (A. K. Ram et al., 2021). On the other hand, the retaliatory killing of elephants through trapping, electrocution and poisoning are reported in Nepal almost annually. Such human casualty and injury is catastrophic for both local people and elephant as research has suggested that people who experience negative impacts from attacks are less likely to support conservation efforts (Struebig et al., 2018; van de Water & Matteson, 2018).

Mitigation Measures in Nepal

A multitude of traditional methods have been employed since ages to reduce human elephant conflict. The mitigation measures that are seen practiced in Nepal can be jotted in 3 points:

Traditional methods: The methods range from chasing elephants by shouting, noise making, use of fire sticks, utensil-beating, torch lights, throwing stones to using vehicles, trained elephants, using local tree houses, use of chilli powder, tobacco powder.

Advance methods: Some of the mitigation measures like trenches, canals, biological-beehive, concrete and electric fences, miking system, use of drones, satellite telemetry, early warning system, alternative cropping practices.

Tolerance increasing methods: Relief funds, insurance schemes, radio broadcasting, Community involvement (Youth Groups), Community awareness.

However, there is no comprehensive strategy to guide mitigation measures in the country. Most of the measures for HEC mitigation in Nepal are reactive and implemented to control the crisis that develops after a major conflict incident (Pradhan et al., 2011). In order to effectively launch any conservation programs, there is a need to study the effectiveness of the persisting mitigation measures.

Purpose of Mitigation Measures

Mitigation measures have been used traditionally since long back. The purpose of installation or adoption of mitigation measures is to decrease the intensity and magnitude of friction of interaction between human and elephants. Some of them are pointed out below:

1. Barrier: The major purpose of building physical and biological barriers like electric fences, solar powered fences, biological barriers (bee-hives, are to discourage elephants from entering into farmlands and house area. The other purpose is that it sets psychological separation of boundaries for humans that their area is outside the barriers hence discouraging them at first hand to enter the jungle.
2. Alert: The use of radio telemetry, tree/built machans for night guarding, early warning system, sensor system and miking system is basically to be aware of the

elephants entering the settlement. The use of such methods is ideally done to get prepared to minimize the encounter rates and reduce the human casualties.

3. Discouragement: Cultivation of non-palatable crops that contrast to the traditional crops such as chamomile, lemon grass, cotton, mentha and onion, garlics and gingers is done with purpose of decreasing the number of events of crop raiding by elephants in the area by discouraging them. Similarly, the methods like using chili flakes, smoke, tobacco powder in wires and thrones in bars is done to discourage elephants and change the direction of its path.
4. Increase Tolerance: In order to increase the tolerance of people against the loss and damage caused by the negative human elephant interaction, methods like relief funds and insurance policy are provided which are actually not absolute mitigation measures.

PURPOSE OF THE STUDY

This study has attempted to develop such scientific baseline with the detailed evidence of mitigation measures, their effectiveness in the study area. To meet the aim of the study the research was attempted with the following objectives:

1. Identification of the existing mitigation measures along with the locally used methods adopted in the study area
2. Determine the status of the mitigation measures using SWOT
3. Understand the perceived effectiveness of mitigation measures by local communities

METHODOLOGY

Study Area

The study was conducted in and around Bardia National Park with in-depth study of mitigation measures in Khata Corridor.

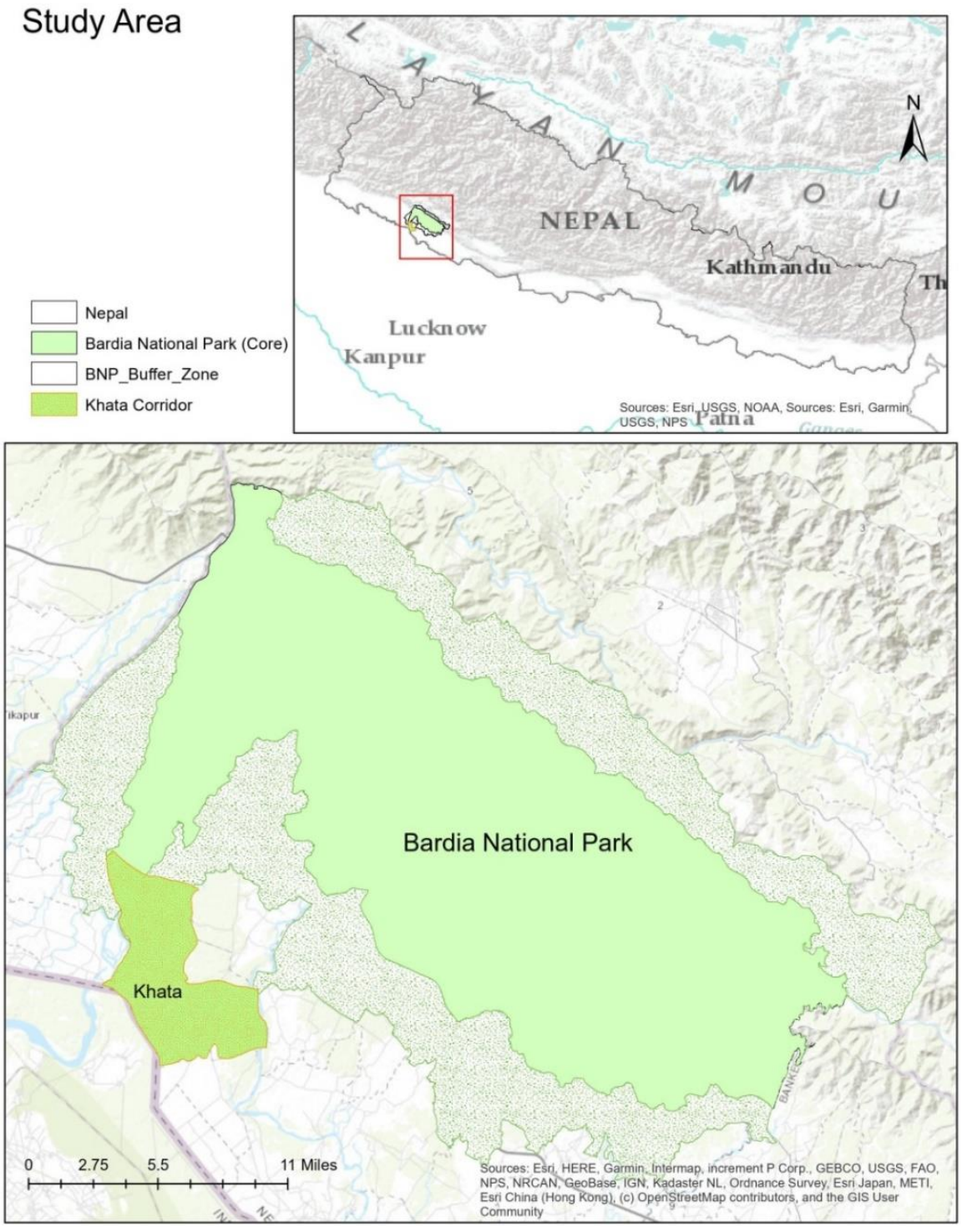


Figure 1: Map showing BNP and Khata Corridor

Bardia National Park and Khata Corridor

a. ***Geographical Location:*** Bardia National Park (BNP) lies in south-western lowland Nepal. The park was established in 1976 as a Karnali wildlife reserve with a small area, later in 1988 it was given the status of National Park with an extended area of its size 968 square kilometers. The lowest elevation of the park is 152 m in the Manaughat and highest elevation is 1561m in Banspani Peak. The national park is largest national park in lowland Terai of Nepal. It includes parts of Karnali River and Babai River in the Bardia District. The northern demarcation is the crest of Siwalik. To the Southern boundary lies the Nepalgunj-Surkhet highway, which disrupts the protected area. The buffer zone of the park was established in 1997 with and area of 327 km2 and later in 2011 it was extended to, an area of 507 km^2. Khata Corridor, which connects Bardia district of Western Nepal and Katarniyaghat Wildlife Sanctuary in India is an important biological corridor and covers an area of 92.5 km^2 with a forest area of 31.86 km^2 (Uprety et al., 2010).

   In recent years, there are growing movements of large cats like tigers and leopards in the Khata, biological corridor. Most importantly, Khata corridor is the traditional migratory route of wild elephants. Herds of elephants are seen moving from Katarniyaghat, India to Bardia, Nepal through the corridor which consists of areas of good forest, degraded forest, and agricultural lands. Elephants in Bardia usually migrate to the Katarniyaghat Wildlife Sanctuary during September and October, and return to Nepal as the monsoon approaches through this corridor. Two villages are proximal to Khata Corridor in Bardia to the near to the southern belt of Bardia National Park, i.e., Dalla and Pathharboji. There are approximately 220 houses in these two villages. The people depend mostly on agriculture and ecotourism for their livelihood. However the people residing in these villages are attributed to human-elephant conflicts.

b. ***Climate:*** The climate in BNP is sub-tropical monsoonal type with three distinct seasons: winter with cool and dry weather (late September to February), summer with hot and dry weather (February mid- June) and monsoon with hot and wet weather (mid-June to late September). The weather is mostly dry from October through early April. The temperature gradually rises from April till June and reaches up to a maximum of 45°C during May and June.

c. ***Floras and Faunas:*** The national park consists of a diverse ecosystem from early successional grasslands to climax staged forest dominated by *Shorea* trees. The park hosts 56 species of mammals, 484 species of avifauna, 52 species of herpeto-fauna, and 121 species of fishes (DNPWC, 2020). Bardia National Park is home to various endangered species such as the Royal Bengal tiger, the Asian elephant and the greater one-horned rhinoceros, Bengal florican, gharial, Ganges river dolphins, hornbills and grasses like *Imperica cylindrica, Saccharum spontanum,* and *Narenga perphrocoma*.

d. ***Socioeconomic aspect of communities:*** The settlements are very proximal to the boundary of the park. The indigenous community living around the park is mostly Tharu and others are Brahmin, Chettri, Yadav, Gurung and Magar. The majority of the people residing around the park area are farmers. The main crops grown here are paddy, wheat and maize. Other people are also involved in ecotourism and small enterprises. Methods

Field Survey

Extensive survey was conducted to identify and categorize the existing mitigation measures. The location of all the fences installed and watch towers (machan) were recorded using Garmin eTrex 10 GPS and their attributes noted in a data sheet and location maps were prepared. Furthermore, current status including its functionality, maintenance, ownership were noted for further analysis.

Focus Group Discussion and Key Informant Interview

The study mainly relied on key informant interviews and focus group discussions to obtain information of mitigation measures in the past and present. Key informants' interview (n=14) were carried with the representatives of municipalities, Khata coordination committee, park authorities, divisional forest officials, buffer zone forest user committees, community based anti-poaching units, local community leaders and farmers representative who have been living in the study area throughout their lives. These key persons were consulted before and during the survey to get the relevant information on the different types of mitigation measures implemented. The focus group discussions (FGD) mainly were centered to extract information required for SWOT analysis. The FGDs were done with different groups of people including conflict affected people, women, park authorities, youths from different villages adjoining Khata Corridor.

Household Survey

People perceptions towards conflict and mitigation measures always have a direct relation with perceptions towards potential risks rather than actual loss.

Out of the total household's size (N=220) in 2 villages (Dalla and Pattharbhoji) in Khata Corridor, sample size (n=74) was chosen using 95% confidence level, with 10% error level and 50% rate of occurrence (CBS 2012) and chosen household were thoroughly surveyed. A semi-structured questionnaire (attached) was used to interview the respondents to understand their perceptions towards the existing mitigating measures along with other variables like socio-economic status, demographics, proximity to park boundary, and so on. Their perception before and after establishment of fences were noted. Additionally, the perception of all categories of mitigation measures was noted developing standard questionnaires.

Secondary Information

All relevant articles, journals, newspapers, published and unpublished reports were used as secondary source of information. All relevant information collected were thoroughly reviewed and analyzed.

DATA ANALYSIS

The aspects of the data such as the condition, management, strengths, threats, opportunities and sustainability of the mitigation measures were analyzed. With the aid of descriptive statistic tools in Microsoft Excel and tables were prepared where appropriate. The sense of gathered data was organized by both manifest and latent level of content analysis.

For statistical analysis of the data obtained from household survey, SPSS was used. For categorical variables, frequencies were calculated. The average ranking of mitigation measures were calculated in reference to perception of people and significance of the ranking was done using K related Friedman ANOVA tests. Wilcoxon Sign rank t- test was used to observe difference between perceived fear before and after electric fences. Weighted means were calculated to find perceived effectiveness of each of the existing mitigation measures. Further, non-parametric Chi-square test of independence of attributes were conducted to check the association of perceived effectiveness and household variables like distance of the household to jungle, conflict experience, compensated status and involvement in awareness programs. Likewise, Binary logistic regressions were conducted to find factors and covariates that contribute significantly to preferences of elephant conservation. Maps were prepared using Arc Map 10.5 (study area and location of towers and fences).

SWOT Analysis

The data from the Focus Group Discussion (FGD) and Key Informant Interviews was carefully analyzed to list the strength, weakness, opportunities and threats (SWOT) of each of the mitigation measures based on the local scenarios. Secondary information collected is used to identify SWOT.

RESULTS AND DISCUSSIONS

Human Elephant Conflict in Bardia

With largest elephant population of Nepal(Pradhan et al., 2011), and people settlements very close to the park in Bardia National Park (BNP), many human casualties and loss have occurred. From the year 2001 BS till 2020 BS 42 human deaths and 120 human casualties are recorded due to human elephant conflict. Last year alone, 466 crop raiding incidents, 4 human casualties and 1 human death have occurred in and around BNP (BNP, 2019). Majority of the incidents have occurred when the people were confronting the elephants to scare them away from their farmland. Similarly the records of compensation distribution in buffer zone from the year 2013 till 2020 reveal that elephants are the most pervasive species to have caused crop loses. The trend of crop loss is reported to be increasing while the trend of property loss looks decreasing (BNP, 2020). The trend of using modern technology to build houses could be one of the factors contributing to less property damage.

Mitigation measures to minimize human elephant conflict in Bardia

Fence with barbed wires

In the early 1993, elephants were noticed entering human settlements in Hattisar, Bankhet and Karmala area, thus barbed wires were installed extending from Mohanpur to Motipur. The fences seemed effective in the initial year but were destroyed soon after by elephants.

Machan with sound records

The traditional tree huts were used by farmers to scare away the elephants and nights guard the farms. In the mid-1993, machans with locally available woods and poles were built. Scaring devices were installed in the machans that played recorded noise of humans and different other species upon switching a button. The devices were successful in scaring away the elephants, but the elephants soon started withstanding the noise and entering the settlements. They might have been habituated to the sounds as they are intelligent animals.

Trenches

After the failure of barbed fences and scaring devices, trenches were excavated in areas including Chitkaiya, Gobrela, Motipur, Karmala, Bhurigaun, Pattharbhoji, and Khata which even served the purpose of outlet of rainwater from the jungle which was unintended. The trenches were difficult to maintain due to the monsoon water and unwanted weeds. Risks of animals falling into the trenches prevailed which became a matter of concern in the year 1999 after a young female elephant was found dead in one of the trenches near Gobrela. (strategic,_) On the other hand, the sandy soil in the area with surrounding vegetation removed and direct exposure to sunlight make the soil brittle, and hence vulnerable to be broken by elephants. Thus there are no more noticeable trenches around Khata except few trenches with vegetation which is noticeable in Pattharbhoji.

Fences around trenches

Combination of barbed fences, bio fence and trenches were installed in Bankhet region in the past which was successful but was difficult to maintain. Since the bio fences were in the farmland of local individuals and the barbed wire was installed by park, the responsibility of management of the combination became even more complex. The fence is now replaced RCC walls with huge investments.

Coconut ropes dipped in Mobil lubricant, Tobacco and Chili powder

The community members and park authority together prepared repellent ropes made up of coconut fibers dipped in burned over mobil lubricant, chili and tobacco powder. The combination repelled the elephants in the areas near Gobrela where this method was piloted, however, later failed as the smell no more remained for longer period of time.

Elephant dung and chili powder

The method of burning elephant dung together with chili powder was tested for about a year near Hattisar area where male elephants come to the breeding site looking for female elephants. In the initial test phase, the smell and smoke repelled and discouraged elephants. However, the elephants were seen carrying water in their trunk and putting out the fire of the dung. People noticed elephant to have become even more aggressive and hence the method was a failure.

Electric fences

The first electric fence in Nepal was installed in the Gobrela region of Bardia. The elephants didn't enter in the areas where there were electric fences. After that the electric fences powered by solar energy was installed with huge investments in certain locations. Human elephant conflict was controlled for short time period. The rhinos were noticeably discouraged from entering onto cultivated lands. However, lack of maintenance has hindered their success due to delayed repairing. Insufficient funds, scare resources and remoteness of the place are the major reasons for untimely and inadequate maintenance.

But more importantly, lack of ownership by local people has resulted in people taking fence post and wire for minor purpose like clothes hanger. This activity can be justified with the statement of Hardin where he mentions that a man seeks to meet his own needs over those of the commons (Hardin, 1968).

Alternative crop cultivation

Traditional cops were replaced by alternative non preferred crops like Mentha and Chamomile with motivation of park authority and Terai Arc Landscape projects particularly in area like Thakurdwara and Suryapatuwa. Later the trend was followed by people of villages surrounding Khata Corridor after installation of processing plants by organizations' collateral supports. Chilli, Turmeric, Lemon and Lemon grass cultivation was done by local farmers as they are non-palatable to elephants.

Market price fluctuation is the major reason of failure of the alternative crop cultivation which has discouraged the farmers. And now, the processing plants are messily shelved.

Gabion wires with stones

Walls with stones inside gabion wires have been installed in several locations alongside Khaura River in Thakurdwara, Shivpur and Pathharbhoji. Elephants haven't been able to cross these physical barriers. However, the foundation when not deep standing on the sandy soil in the region especially in the river banks is susceptible to erosion during the monsoon season. Additionally, the walls need huge investments and it is not easy to maintain the destroyed walls.

Fence: Pipe of G.I. pipe

Galvanized iron pipes placed horizontally with concrete vertical poles were established in Karmala and Hattisar region. But elephants destroyed such fence at several locations.

Reinforced Cement Concrete (RCC) Fences

Reinforced Cement Concrete wall with cemented vertical and horizontal structure was built in several locations of Hattisar. Although this method looks effective when installed with trenches and electric fences in neighboring region, it takes long time to construct the walls and is very expensive. The RCC fences in Kailashi region is reported to have been very effective.

Community Based Anti-Poaching units (CBAPUs) and Rapid Response team (RRT)

Rapid Response teams have been formed in 5 sub-committee of CBAPU out of many in buffer zone of Bardia National Park. They have crucial roles in scaring the elephants away from the farmlands.

Firing in air

The army officials sometimes use firing in air to scare problem elephants. Few of the inhabiting elephants living in the region that frequently enter the cultivated land have even become habituated with the firing sound.

Beehives fences

Beehives had been installed as pilot project to scare the elephants away as the elephants get discouraged with the buzzing sound of bees. However the project has not been continued as the farmers were discouraged in bee keeping after destruction by birds.

Loudspeaker miking

This system has enabled the villagers and members of RRT to warn any message related to elephant which helps the communities know about the elephants approaching settlements. This helps in preparedness of security of children and old aged individuals.

Mitigation Measures in practice in Khata Corridor

The categorical checklist of mitigation measures adopted by the communities in the study site to minimize human elephant conflict is highlighted below:

Table 1: Checklist of mitigation measures in study area

Categories	Mitigation measures
Fences	Electric fences, RCC fences, Gabion wire with stones
Tower	Machan, Tree houses
Traditional measures	Fire (masal, tire burning), sound, stone, burning chili
Community awareness	Hatti mero sathi, FM program, CBAPU, Miking
Alternative cropping	Mentha, Camomile, Lemon grass, garlic, turmeric, lemon, cotton

Fences: A Failure?

3 types of fences: Electric fences, RCC fences, Gabion wire with stones are observed in the study area.

In Kailashi, there is RCC wall whereas in Pathharboji area, the solar fences were installed in the year 2003 AD with collaboration of Terai Arc Landscape Program and community forests. There was active participation of local community members during the installation phase.

In fact, one labor from every household was a compulsion during the installation phase as reported by focal respondents. The total cost of installation along with the wooden poles was about Nepali Rupees One Million and Five Hundred Thousand. Several maintenance tasks were reported from 2003 to 2014 by NTNC BCP. In the

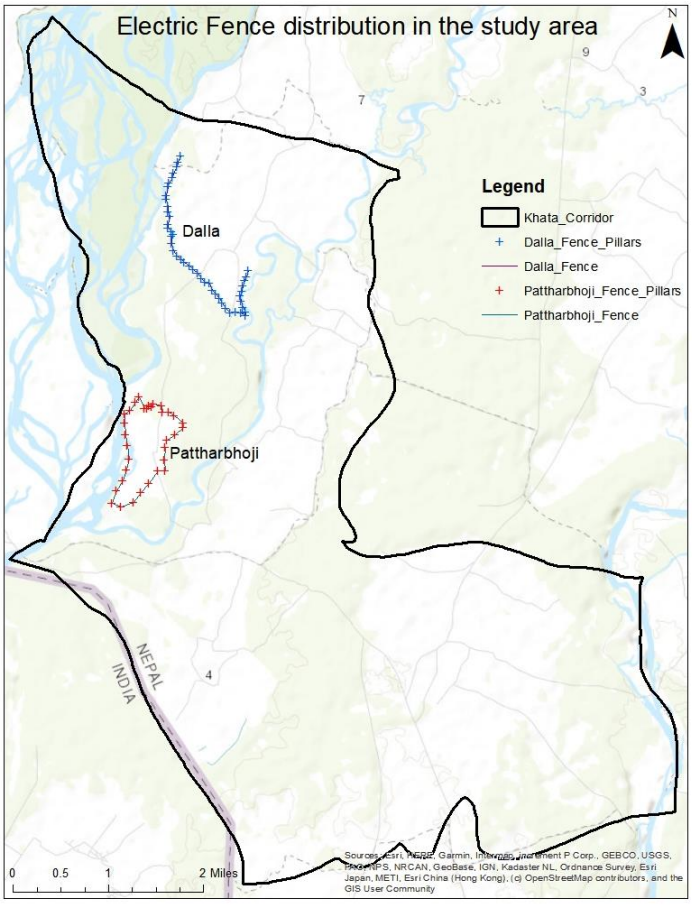


Figure 2: Solar Fence distribution in the study area

year 2014, the wooden poles were replaced by iron poles. Around Nepali Rupees One Million and Six Hundred Thousand was spent for the replacement of the poles.

During the survey, 96.8% of the fences in the Pattharbhoji village was observed non- functional and in poor condition. About 71% of the fences in the site didn't have either poles or electric fencing wires in them. Majority of the pillars were missing, numerous were in fallen condition or tilted or absent. Some of the wires were seen used by locals as hangers to dry clothes. additionally, the fences around Dalla village have vegetation underneath. The mesh wires between the poles are not in good condition.

Table 2: Condition of the solar fence in the study area

Village	*Length(KM)*	*Date of Installation*	*Number of Times repaired*	*Total Costing*	*Non-functional length*	*Additional information*
Pathharboji	5.60	2003	Once (wooden poles replaced by iron in 2014)	15 lakhs; 16 lakhs	5.46 km (pillars missing: only 5 pillars in upright position)	Terai Arc Landscape supported; local people participated in construction)
Dalla	4.3	2010	N/A	N/A	3.7km	Local people participated

75 respondents were interviewed who live in fringe area of Khata Corridor in which fences were installed in 2010 AD. They were asked to scale the conflict status before and after the electric fences, the scales taken were 1=decreasing conflict cases and 3=increasing conflict cases, while 2=static condition of conflict. Upon using Non-Parametric Wilcoxon sign rank test, the results seem to indicate that the there is an increase in conflict pattern (average rank of 11.69 vs. average rank of 17.5).

The Wilcoxon signed rank test shows that the observed difference between both before and after electric fence is significant at 99% confidence interval. Thus it might conclude that the respondents believe that the condition of conflict has not been better even after electric fences have been installed.

SWOT Analysis for Fences

Strengths • Physical and psychological barriers for people to enter jungle • RCC walls: effective against elephants • Electric fencing: effective against Rhinoceros and other mammals like chital. • Gabion wires with stones: effective in riverside	***Weakness*** • Electric poles and wires: destroyed by people and elephants • lack of repairing and maintenance • inadequate funds for installation of huge infrastructure • remoteness of the place: scarce and delayed resource availability • lack of ownership • riverside walls: susceptible to erosion (sandy soil) • dearth of trained technicians • divergent political interests in construction project leading to disputes
Opportunities • RCC walls in major conflict areas: sense of security to community • Employment opportunity to local people in maintenance and construction projects	***Threats*** • Shifting conflict to the adjoining settlements due to physical barrier in certain place • Sustainability issue with poor management: investment failure • Unethical with animal right perspective • May further make the elephant aggressive as elephants may take barriers as challenge

Figure 3: SWOT Analysis for Fences

Electric fences have been reported successful barriers against depredation (WWF, 2008). However, the effectiveness and durability of electric fences depend upon the maintenance and ownership of the fences. Good maintenance demands regular inspection and frequent maintenance both of which are not conducted in the site. The breaks in wires, missing poles, damaged poles and power supplies must be checked on a regular basis. Lack of ownership is indicated by the misuse of wires of electric fences, used as hangers to dry clothes by villagers . This shows that the local acceptance is not profound in the study area.

Although the electric fences have been installed in the study area by government and organizations, they are likely a failure. The electric fences are not managed and maintained hence resulting in non-functionality of it against HEC. The fences are destroyed by both local people and wild animals. Respondents believe that the condition of conflict has not been better even after electric fences have been installed. Ownership might be one of the possible reasons of electric fences in such condition. A study by (Nath et al., 1998) found government owned fences less effective in Karnataka. Study in neighboring country, India shows that individually owned fences were effective in reducing crop depredation from 80% to 20% (Jayant et al., 2007). However, no individual fencing is reported from the study site.

Alternative Cropping: A failure?

Theoretically, alternative cropping should be able to decrease attractiveness towards farm land and reduce crop raiding by elephants. However, there are a lot of critical issues the area that has discouraged local farmers from practicing farming substitutes.

Traditionally, the farmers of Dalla and Pathharboji cultivate rice, wheat, maize and seasonal vegetables. They are mostly dependent on traditional crops which are also palatable for the elephants and hence resulting human- wildlife conflict in the area. After 2015, the plantation of mentha (family: family Lamiaceae), chamomile (family: Asteraceae), lemon grass (family: Poaceae) are seen practiced in the study area.

Upon using Non-Parametric Wilcoxon sign rank test, the results indicates that the there was a decrease in conflict pattern (average rank of 30 vs. average rank of 25.26). The Wilcoxon signed rank test shows that the observed difference between both before and after alternative cropping is significant at 99% confidence interval. Thus we might conclude that the respondents believe that the condition of conflict had significantly been reduced after they practiced alternative cropping.

However, during the study 78.7% reported that they left alternative cropping (both Mentha and Chamomile) since last 2 years.

The responses reported by the local communities of no more planting the alternative crops were:

Price Fluctuation: From database of Community Cooperative, we found that only 26 households are practicing alternative cropping (Chamomile) out of 220 this fiscal year (2020/2021) while none have been planting mentha this year.

This also aligns with the fluctuating market price of Mentha plants mentioned in record file of Shiva Bahu Udeshiya Cooperative Private Limited.

Also, the rate of Chamomile in 2017 was 55000 per kg while the rate in the year 2018 was NPR. 31000 per kg.

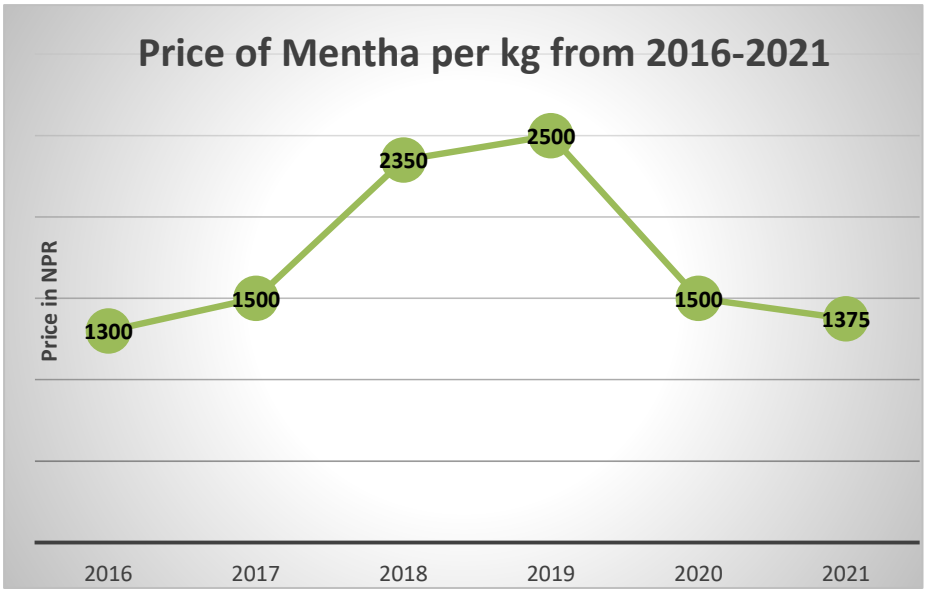


Figure 4: Price of Mentha per KG from 2016-2021

Erratic Rainfall Destroying Crop: This could be one of the probable reasons of people not preferring alternative cultivation in the study area. Weed infestation and early monsoon rainfall has also been reported as major reason of mentha plantation failure in India (Kumar et al., 2021).

Land Degradation: Land degradation was noticed by some of the local farmers after mentha plantation for some years. Researches have shown that the microbial diversity in fields continuously cropped with Mentha for 4 years will be low affecting soil quality (Misra et al., 2019).

Although the results show that the people perceive alternative farming were effective when they were practiced by them few years before, studies have shown that it is unlikely to have a remarkable impact unless the buffer area is completely homogenous (Fernando et al., 2008).

SWOT Analysis for Alternative Cropping

Strengths • Communities perceive alternative cropping to be effective. • Decreased crop damage by elephants and other animals like Rhino, Chittal • Decreased financial loss and its psychological stress on marginalized farmers	***Weakness*** • Market instability • Poor market study • Lack of value addition mechanisms • Intensive care/irrigation required
Opportunities • Alternative Livelihood option • Can be long term solution for crop raiding • Decreased negative perception of farmers about elephant conservation	***Threats*** • Early monsoon: affecting the alternative crops. • Middleman benefited abnormally, farmers paid less in unstable market • Local traditional crops discouraged • Effect on self-sufficiency in terms of food security (traditional crops) • Decreased productivity of land

Figure 5: SWOT Analysis for Alternative Cropping

Towers, trenches and miking: Likely failure?

25 watch towers and tree houses to watch elephants and night guard are there in two villages. All of them have been built by collaborative efforts of government and local communities.

Effectiveness and Local Perception

All of the observed machans were usable. However none of them seem maintained. The fragile old wooden planks seem to be decaying status. The reported use of the towers and tree houses are for early warning system, night guarding and making noise to scare the elephants away from the farmlands.

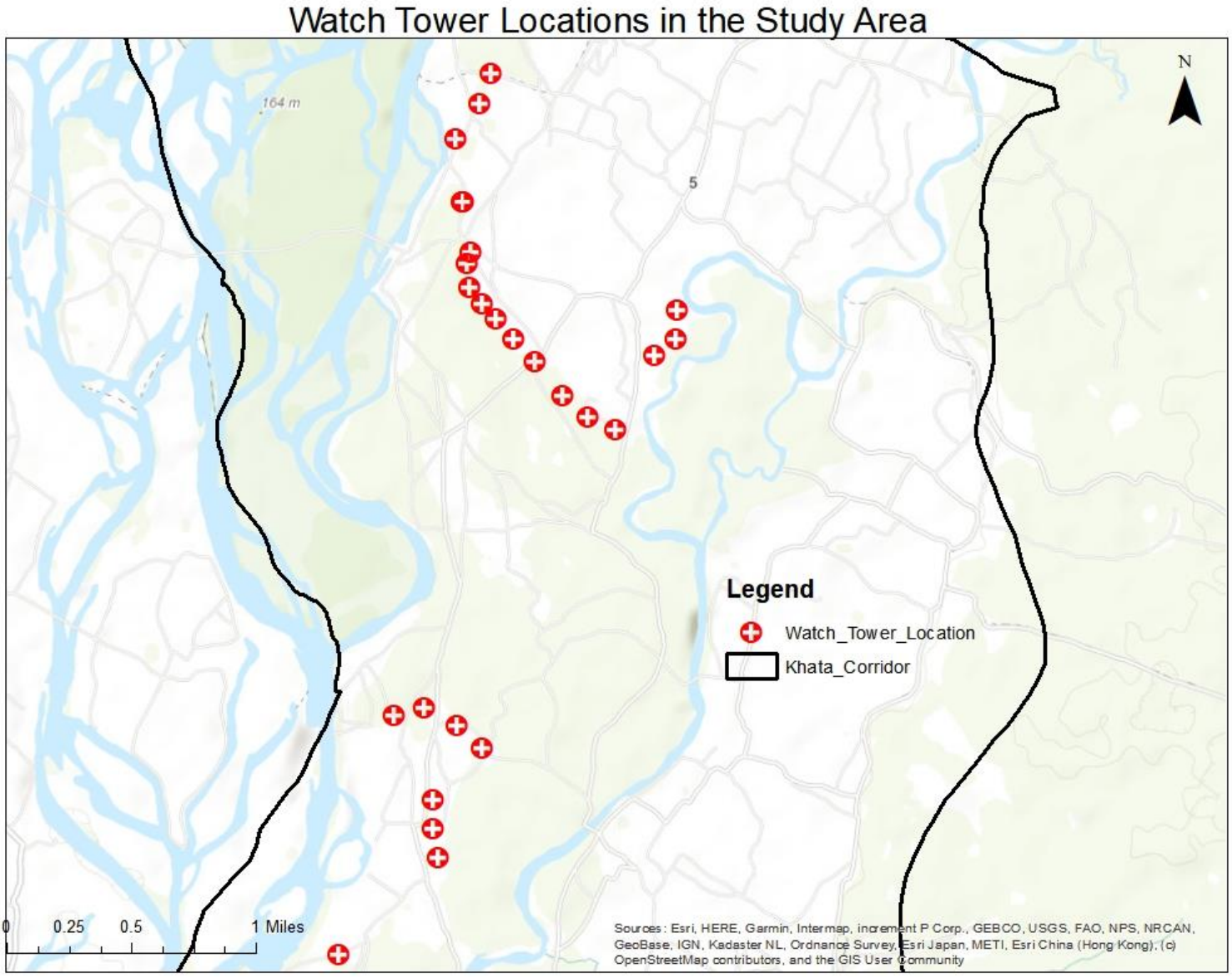


Figure 6: Watch Towers in the study area

Using 5 point LIKERT scale, the perceived effectiveness of watch tower was found to be neutral. (Mean=2.47, SD= 1.464), i.e., they neither think that watch towers are effective nor think they aren't. 85.3% of the respondents reported the limited use of machans in merely getting prior information of elephants coming to farmlands but ineffective to stop them from coming.

Trenches are found in very poor condition in some locations of Pattharbhoji. The perceived effectiveness of watch towers is neutral in the study area. Although the use of watch towers along with mobile patrols and electric fences are practiced in parts of India (Fernando et al., 2008); the use of watch towers in the area is risky as they are in fragile condition and elephants can easily destroy them in the studied two villages. In a nearby village, Thakurdwara, an old male was killed by elephant while guarding his crops in Machan (Thapa, 2010)

SWOT Analysis for Tower, trenches and miking

Strengths • Towers: Effective to guard farmlands; local resources and materials can be used • Trenches: Effective if proper dimension which can't be crossed by elephants is designed; with partial technical assistance locally doable • Miking: Effective to get prepared about upcoming probable conflict	***Weakness*** • Towers: Poor condition; no maintenance • Trenches: prone to being destroyed as the sandy soil is weak. • Miking: familiarity on technology and limitation of number could be hindrances of its access to everyone
Opportunity • Time to get prepared and keep old aged and children in safer place • Decreased sudden encounters • generate and disseminate timely and meaningful warning information to reduce the possibility of harm/loss	***Threats*** • Towers: threat to life of guard (poor structure) • Trenches: Risk of animals and children falling into the pits

Figure 7: SWOT Analysis for Tower, trenches and miking

Traditional Measures: only way out?

There are several traditional measures of scaring away elephants from the village area to defense crop and houses adopted by local farmers in the area. Some of them include: Fire weapons, spears (masal, tyre burning), sound, stone, and sticks.

The respondents were asked to rank the effective mitigation measures based on their personal experiences. The mean rank of existing mitigation measures to control HEC perceived by people was highest for Fire weapons and Burning tire i.e., 5.32, second highest was for shouting and making noise i.e. 3.84 and third was for Electric Fences i.e., 3.56, fourth was for Night guarding and watch towers (3.34), fifth was for alternative cropping (2.55) and least ranking was for using sticks, stones to scare them (2.39).

The preference and use of lethal traditional measures is high in the study area which can lead to unintended results. The methods are harmful as they harass the elephants. When people adopt lethal methods to further harass and disturb elephants the intolerance of harassed elephants towards people may increase. In fact, it has been observed that the elephants become habituated with traditional methods like fire and indeed it shifts conflict to neighboring area (Barnes, 1999; Hoare & Du Toit, 1999; Nelson et al., 2003; Nyhus & Tilson, 2000; O'Connell-Rodwell et al., 2000; Osborn & Rasmussen, 1995; Sutton, 1998; Nelson et al., 2003), as they are intelligent animals and can be even more aggressive once habituated.

Table 3: Ranking of Mitigation Measures

Rank	Mitigation Measure	Mean Rank
1st	Fire Weapons and Burning Tires	5.32
2nd	Shouting and Making Noises	3.84
3rd	Electric Fence	3.56
4th	Night Guarding, Towers and trenches	3.34
5th	Alternative Cropping	2.55
6th	Stones, Sticks	2.39

By using Friedman ANOVA test, the average ranking of mitigation measures in reference to perception of people differ highly significantly for each of the measure (chi-square value showing high association, with value=119.893 and p-value<00.01 and df=5)

However, the preference of such lethal methods can result in unprovoked attacks. Human safety is compromised while adopting such measure. Elephants could be traumatized and can be injured.

WAY FORWARD AND RECOMMENDATIONS

Human elephant conflict has become hindrance to the co-existence of both elephant and human in the same landscape. Although the existing mitigation measures sound theoretically possible against HEC, the existing mitigation measures are likely a failure, lacking ample contemplation of management, inadequate consideration of local dynamics and ineffective inclusion of multiple aspects (cultural, social, behavioral, ecological, economical and psychological) of both local communities and the gentle giants, elephants. With huge investments, poor maintenance and failure to consider multiple aspects in management of contemporary measures; the people in the study area are at increased risk of casualties and injuries as they are compelled to use lethal measures like fire, sound, stone and sticks on elephants as their only way outs which demands immediate intervention.

Hence, attitudinal change in human beings could be one best solution to increase possibility of human elephant coexistence in the area since it is observed that the local people practice lethal mitigation measures that could increase the intensity of the conflict. Two studies, one in Nepal (Karki, 2018) and one in Bangladesh (Hossen, 2013) have concluded previously that most of the incidents in HEC occur due to human negligence and ignorance. About 75% of the human causalities (death and injuries) due to elephants can be minimized by addressing the issues of human negligence and ignorance (Karki, 2018). The situation needs to be addressed with immediate actions. However, single effort with consideration of one facet of the problem would be incomplete effort. The recommended suggestions for various stakes those are responsible are discussed under the headlines below:

Government and non-government organizations

A) Generation of effective framework incorporating multiple dynamics of human elephant interface to improvise existing mitigation measure.
B) Consideration of behavioral, physiological, psychological aspects of elephants along with social, cultural, economic and political aspects of local communities while introducing any new mitigation measures.
C) Most importantly, an intervention must be introduced to reduce HEC through an attitudinal change in human beings, leading target communities to internalize the fact that conflict can be minimized considerably by responsible human behavior.

For researchers (including universities and research institutions)

D) Detailed research in concluding single or combination of mitigation measures and enough information on the acceptance of the community, applicability in the site, beneficiaries (both human and elephants), anticipated strengths, probable future hurdles for failure of the mitigation measure.

Local people and communities

E) Collaboration with efforts from governmental and non-governmental organization and ownership of the efforts.

F) Attitudinal change while living in shared landscape with elephants with responsible behaviors.

REFERENCES

Acharya, K. P. (2016). A Walk to zero poaching for rhinos in Nepal. *Department of National Parks and Wildlife Conservation, Kathmandu, Nepal*.

Bajimaya, S. (2012). Managing human-wildlife conflict in Nepal. *Acharya, KP and Dhakal, M.(Eds.)*.

Barnes, R. F. W. (1999). Is there a future for elephants in West Africa? *Mammal Review*, *29*(3), 175–200.

Dhungana, R., Savini, T., Karki, J. B., Dhakal, M., Lamichhane, B. R., & Bumrungsri, S. (2018). Living with tigers Panthera tigris: patterns, correlates, and contexts of human–tiger conflict in Chitwan National Park, Nepal. *Oryx*, *52*(1), 55–65.

Dickman, A. J. (2010). Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal Conservation*, *13*(5), 458–466.

Fernando, P., Kumar, M. A., Williams, A. C., Wikramanayake, E., Aziz, T., & Singh, S. M. (2008). *Review of human-elephant conflict mitigation measures practiced in South Asia*. WWF Gland, Switzerland.

Gurung, B., Smith, J. L. D., McDougal, C., Karki, J. B., & Barlow, A. (2008). Factors associated with human-killing tigers in Chitwan National Park, Nepal. *Biological Conservation*, *141*(12), 3069–3078.

Hoare, R. E., & Du Toit, J. T. (1999). Coexistence between people and elephants in African savannas. *Conservation Biology*, *13*(3), 633–639.

Hossen, A. (2013). *Human-elephant conflict in Bangladesh; causes and intensity of fatalities.* Institutt for biologi.

Jayant, K., Mehta, P., Boominathan, D., & Chaudhuri, S. (2007). A study of manelephant conflict in Nagarhole National park and surrounding areas of Kodagu district in Karnataka. *India, Final Report, Envirosearch, Pune*.

Kumar, D., Kumar, R., Singh, A. K., Verma, K., Singh, K. P., Kumar, A., Singh, V., Kaur, P., Singh, A., & Anandakumar, T. M. (2021). A novel and economically viable agro-technique for enhancing productivity and resource use efficiency in menthol mint (Mentha arvensis L.). *Industrial Crops and Products*, *162*, 113233.

Lamichhane, B. R., Persoon, G. A., Leirs, H., Poudel, S., Subedi, N., Pokheral, C. P., Bhattarai, S., Thapaliya, B. P., & de Iongh, H. H. (2018). Spatio-temporal patterns of attacks on human and economic losses from wildlife in Chitwan National Park, Nepal. *PloS One*, *13*(4), e0195373.

Misra, P., Maji, D., Awasthi, A., Pandey, S. S., Yadav, A., Pandey, A., Saikia, D., Babu, C. S., & Kalra, A. (2019). Vulnerability of soil microbiome to monocropping of medicinal and aromatic plants and its restoration through intercropping and organic amendments. *Frontiers in Microbiology*, *10*, 2604.

Nath, C. D., Sukumar, R., & Caudhurī, D. L. (1998). *Elephant-human conflict in Kodagu, southern India: distribution patterns, people's perceptions and mitigation methods*. Asian Elephant Conservation Centre.

Nelson, A., Bidwell, P., & Sillero-Zubiri, C. (2003). A review of human-elephant conflict management strategies. *People & Wildlife, A Wildlife Conservation Research Unit, Born Free Foundation Partnership*.

Nyhus, P. J., & Tilson, R. (2000). Crop-raiding elephants and conservation implications at Way Kambas National Park, Sumatra, Indonesia. *Oryx*, *34*(4), 262–274.

O'Connell-Rodwell, C. E., Rodwell, T., Rice, M., & Hart, L. A. (2000). Living with the modern conservation paradigm: can agricultural communities co-exist with elephants? A five-year case study in East Caprivi, Namibia. *Biological Conservation*, *93*(3), 381–391.

Osborn, F. V, & Rasmussen, L. E. L. (1995). Evidence for the effectiveness of an oleo-resin capsicum aerosol as a repellent against wild elephants in Zimbabwe. *Pachyderm*, *20*, 55–64.

Parker, G. E., Osborn, F. V, & Hoarse, R. E. (2007). *Human-elephant conflict mitigation: a training course for community-based approaches in Africa (Participant's Manual)*.

Pradhan, N. M. B., Williams, A. C., & Dhakal, M. (2011). Current status of Asian elephants in Nepal. *Gajah*, *35*, 87–92.

Ram, A. K., Mondol, S., Subedi, N., Lamichhane, B. R., Baral, H. S., Natarajan, L., Amin, R., & Pandav, B. (2021). Patterns and determinants of elephant attacks on humans in Nepal. *Ecology and Evolution*, *11*(17), 11639–11650.

Ram, A., Yadav, N., Kandel, P., Mondol, S., Pandav, B., Lakshminarayanan, N., Subedi, N., Naha, D., C., S. R., & Lamichhane, B. (2021). *Tracking Forest Loss and Fragmentation During 1930–2020 in Asian Elephant (Elephas Maximus) Habitats in Nepal*. https://doi.org/10.21203/rs.3.rs-717308/v1

Raubenhiemer, D., Aryal, A., Acharya, K. P., Dhakal, M., Shrestha, U., & Wright, W. (2017). *Global lessons from successful rhinoceros conservation in Nepal*.

Silwal, T., Kolejka, J., Bhatta, B. P., Rayamajhi, S., Sharma, R. P., & Poudel, B. S. (2017). When, where and whom: Assessing wildlife attacks on people in Chitwan National Park, Nepal. *Oryx*, *51*(2), 370–377. https://doi.org/10.1017/S0030605315001489

Struebig, M. J., Linkie, M., Deere, N. J., Martyr, D. J., Millyanawati, B., Faulkner, S. C., Le Comber, S. C., Mangunjaya, F. M., Leader-Williams, N., & McKay, J. E. (2018). Addressing human-tiger conflict using socio-ecological information on tolerance and risk. *Nature Communications*, *9*(1), 1–9.

Sutton, W. R. (1998). The costs of living with elephants in Namibia. *Proceedings from the Workshop on Cooperative Regional Wildlife Management in Southern Africa*, 57–71.

Thapa, S. (2010). Effectiveness of crop protection methods against wildlife damage: a case study of two villages at Bardia National Park, Nepal. *Crop Protection*, *29*(11), 1297–1304.

Thirgood, S., Woodroffe, R., & Rabinowitz, A. (2005). The impact of human-wildlife conflict on human lives and livelihoods. *CONSERVATION BIOLOGY SERIES-CAMBRIDGE-*, *9*, 13.

Treves, A., & Karanth, K. U. (2003). Human-Carnivore Conflict and Perspectives on Carnivore Management Worldwide. *Conservation Biology*, *17*(6), 1491–1499. https://doi.org/10.1111/j.1523-1739.2003.00059.x

Uprety, Y., Boon, E., Poudel, R., Shrestha, K., Rajbhandary, S., Ahenkan, A., & Tiwari, N. (2010). Non-timber Forest Products in Bardiya District of Nepal: Indigenous Use, Trade and Conservation. *J Hum Ecol*, *30*, 143–158. https://doi.org/10.1080/09709274.2010.11906283

van de Water, A., & Matteson, K. (2018). Human-elephant conflict in western Thailand: Socio-economic drivers and potential mitigation strategies. *PloS One*, *13*(6), e0194736.

ANNEXES

1. Result from Ordinary Probit Regression

Parameter	B	(p-value)	Exp(B)	More/Less Likely	Percentage
College	1.654	.207	5.225	More likely	4.220
School	.642	.361	1.900	More likely	0.900
Illiterate #	0a		1		
Distance to fences from household (far)	-.431	.030**	.650	Less likely	0.350
Distance to fences from household (near)#	0a		1		
Sex of respondent (female)	-.874	.040*	.417	Less likely	0.583
Sex of respondent (male) #	0a		1		
Village (Dalla)	1.547	.080*	4.698	More likely	3.690
Village (Pathharboji)	0a		1		
Main source of income (agriculture)	1.225	.052*	3.403	More likely	2.400
Non- agricultural source of income #	0a		1		
Has got compensation	1.245	.560	3.470	More likely	2.470
Has not got compensation #	0a		1		
Conflict experience (No)	1.078	.104	2.937	More likely	
Conflict experience (yes)#	0a		1		
Awareness activities (never participated)	-.614	.001***	.541	Less likely	
Participated in activities #	0a		1		
Age of respondents	-.042	.092*	.959	Less likely	0.041
Total land holdings in square meters	1.004E+00	.974	2.729	More likely	1.720
Food production subsistence for how many months	.197	.015**	1.218	More likely	0.985

2. Community Perception towards Elephant

Ordinary probit regression was used to develop best predictive model to find variables that cause the varied elephant preference by community members. Several models were run to test the best fitting model with lowest AIC. Following result was obtained:

The findings suggest to one direction, that is older generation gather more conflict experiences or information and hence prefer elephants less. The number of months that the food is sufficient for also decided preference of elephants. The result implied that if the food is enough for more of the months of the year, i.e., they have good land and food; people don't develop increased level of negative perception. The people of Dalla village significantly prefer elephants nearly 4 times more than people from Pathharboji. This could be justified with the fact that people of Dalla run community homestay and are part of beneficiaries of ecotourism. Also, despite of the human elephant conflict the people living near to the jungle still like elephants. There can be further future researches to explore the preference of people living proximal to jungles towards elephants. However one of the reasons could be their emotional attachments with the wild animals.

SN	Variables	Result	CI
1	People who have participated in EC Programs	More Likely to Like	99%
2	Increase in Age of Respondent	Less Likely to Like	90%
3	Higher the amount of Production	More Likely to Like	95%
4	Respondents from Dalla	More Likely to Like	90%
5	Nearer the Jungle	More Likely to Like	95%

3. Weighted Mean of Effectiveness of Mitigation Measures

	Mean	Std. Deviation
Effectiveness of Electric fence	2.17	1.267
Effectiveness of Watch tower	2.47	1.464
Effectiveness of Traditional measures	3.15	1.291
Effectiveness of CBAPU	2.28	1.214