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Mitigating Human-Wildlife Conflict in Nepal: A Case Study of Fences around Chitwan National Park

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Mitigating Human-Wildlife Conflict in Nepal: A Case Study of Fences around Chitwan National Park

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Contents

Foreword

The relationship between humans and wildlife is a challenging one. While people place boundaries around their homes, communities, and countries, wildlife does not recognize them. As people and wildlife increasingly find themselves living in competing space, a continual struggle for resources leads to human-wildlife conflict. Conflict between people and wildlife has been widely recognized as one of the most challenging issues for wildlife conservation. While Nepal's conservation efforts have been hailed globally, particularly its multiyear record of zero poaching of endangered rhinos and tigers, the increasing incidences of attacks on humans by wild animals and vice versa are seen as a big challenge for conservation. Several measures have been adopted by conservation managers and local people around protected areas to mitigate human-wildlife conflict.

Chitwan and Nawalparasi are districts within the Terai Arc Landscape where the first REDD programme is being developed by the REDD Implementation Centre to access finance from the Forest Carbon Partnership Facility. REDD+ has the potential to improve wildlife habitat and have a positive impact on biodiversity conservation; it also has the potential to increase human-wildlife conflict. Therefore, the mitigation and solutions for human-wildlife conflict must be better understood if REDD+ is going to succeed.

This research shows that mitigations and solutions for human-wildlife conflict are fraught with management challenges. Electric fencing as a mitigation strategy cannot be sustained unless good maintenance is practised. Compensation schemes should be revitalized to ensure efficient and timely payments, which will help increase the awareness and peaceful coexistence of local people with wildlife. Finally, effective coordination between national parks, district forest offices, community forest management committees, and local communities is of utmost importance to mitigate and minimize the conflicts between humans and wildlife. The findings and recommendations of this report need to be considered when designing REDD interventions.

I would like to thank the research team for producing this valuable report which will help make REDD+ implementation more sustainable and community friendly while meeting its emission reduction targets.

David J. Molden, PhD
Director General
ICIMOD

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Though only our names appear on the cover of this report, a great many people have contributed to its production. We owe our gratitude to all those people, who have made our project one that we will cherish forever.

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Time and space will not permit us to mention all names, but we are much grateful to the Chitwan officials, the NTNC-BCC staffs, and all who have contributed in diverse ways to the success of this study.

Acronyms and Abbreviations

BCC	Biodiversity Conservation Centre
BZCF	buffer zone community forest
BZCFMC	buffer zone community forest management committee
BZCFUG	buffer zone community forest user group
BZUC	buffer zone user committee
CF	community forest
CFMC	community forest management committee
CFUG	community forest user group
CNP	Chitwan National Park
DFO	district forest office
DNPWC	Department of National Park and Wildlife Conservation
FGD	focus group discussion
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HWC	human-wildlife conflict
ICIMOD	International Centre for Integrated Mountain Development
NTNC	National Trust for Nature Conservation
REDD	Reducing Emissions from Deforestation and Forest Degradation
TAL	Terai Arc Landscape

Executive Summary

Introduction

Finding solutions to human-wildlife conflict (HWC) is one of the complex challenges conservationists and local communities have to contend with for an enduring period. Biodiversity is crucial for enriching the forests including the existing flora and fauna species residing in the forest, which is a key element of the GIZ/ICIMOD REDD+ Himalaya Initiative. The Terai Arc Landscape (TAL) has been selected by the Government of Nepal for developing the REDD+ programme. This area harbours numerous wildlife corridors, and with the enhancement of habitats through REDD+ conservation activities, the wildlife population will increase. This will further exacerbate existing human-wildlife conflict. Therefore, to ensure and address such challenges, REDD+ mechanisms need to incorporate human-wildlife mitigation measures.

Measures employed to mitigate HWC in the buffer zones and adjoining areas of the Chitwan National Park (CNP) have ranged from traditional methods of shouting and watch towers to modern barriers such as electric fencing. Several kilometres of these electric fences have been constructed along the boundaries of the park and community forests in the buffer zones and adjoining areas of the CNP to mitigate conflicts from megafauna such as the elephant and rhino. Studies have found the electric fencing to be the most effective mitigation measure against the rhino and elephant, which cause a lot of property and crop depredation in the area, and there have been recommendations from studies and requests from local communities to expand the electric fencing. However, there have not been many empirical studies to assess the sustainability of the electric fences installed in the area. Thus, this study assesses the sustainability of the electric fencing as a HWC mitigation measure in the buffer zones and adjoining areas of the CNP.

The study employed various methods including mapping of the fences, observation, focus group discussions, and key informant and official interviews with conservationists in the CNP and NTNC-BCC to collect data. A total of 57 fences were visited and mapped in 54 community forests which are made up of buffer zone community forests and community forests under the district forest office.

Major findings

The study reveals the following:

- Only twenty-six percent of the electric fences installed in the area are in good condition and operating effectively, while the rest are out of operation due to technical faults, poor maintenance, and natural disasters such as flooding.
- The factors imperilling the sustainability of the electric fences are socio-political, economic, and technical:
  - Socio-political factors include poor maintenance culture, institutional/ structural inefficiencies, lack of awareness among the local populace, conflicting personal interests and societal objectives, and antagonism among management committee members.
  - Economic factors include limited and unsustainable financing mechanisms, and poverty and livelihood patterns.
  - Technical factors include improper design and construction materials of fences, a dearth of technical expertise for fence maintenance, placement/location, and erratic power supply.

Recommendations

For the sustainability of the electric fences in the buffer zones and adjoining areas of the CNP, the study makes the following recommendations:

- A sustainable financing mechanism for fence maintenance is needed. It is recommended that a human-wildlife conflict management fund be established in each community forest with specific allocation of funds from the CNP which can be used for the routine and general maintenance and construction of electric fences. There

should be capacity building for the various management committees on sustainable revenue generation mechanisms, such as ecotourism development.

- Institutional restructuring is needed. Efficient management structures would oversee the efficient and transparent management and use of the resources to maintain the fences routinely. This could be done by forming a subcommittee within each community forest management committee to be known as a human-wildlife management committee. These committees will be responsible for maintaining and managing the electric fences.
- Committees should receive technical training on the sustainable management and maintenance of the electric fences.
- Design and materials must be reconsidered before fences are installed at various locations. A comprehensive study on the local ecology and movement of destructive wildlife in the area must be carried out before the installation.
- Supplementary measures such as mesh fencing, reinforced cement concrete walls, and trenches should be implemented alongside the electrical fences to prevent crop damages from smaller species like the wild boar and deer.
- Well-structured and efficient management committees should be supported with financial and other incentives to organise sensitization and awareness campaigns for the local communities on the fences and HWC mitigation.
- Proper land use planning and cropping patterns based on the ecology and movement of wildlife in the area can help reduce pressure on the electric fence and frequency of HWC
- Diversification and improvement in the livelihoods of local communities through policy option at local, national and international levels could help bring a sustainable solution to HWC
- Alternative human-wildlife conflict mitigation measures such chilli fencing and beehive fencing which have been found to deter the African elephant, should be tested in Nepal to ascertain their efficacy against the Asian elephant.

Introduction

Background

Human-wildlife conflict (HWC) is one of the most complex challenges facing conservationists and local land users around national parks and wildlife reserves globally. This is especially the case, and worst, where people's livelihood directly depends on the forest products, agricultural activities, and other land uses in the buffer zones of the national parks as in the Chitwan National Park (CNP). Hutchins (2013) argues that the main reason for human-wildlife conflict is the quest for food, whilst Dickman et al. (2011) posit that the conflict results from a group of people holding different values (local people versus conservationists). The continuous growth of the human population and a concomitant shrinking of forest area have brought wildlife and humans together which further generates these conflicts (Madden 2004; Bowen-Jones 2012). The frequency and severity of human-wildlife conflict has continually increased over the years around the CNP resulting from crop damages and livestock depredation by park wildlife (Pant and Hockings 2013; Upadhya 2013).

Climate change mitigation strategies such as REDD+ and transboundary landscape conservation have the possibility of exacerbating human-wildlife conflicts. Even though REDD+ is focused on restoration and conservation of forests for carbon storage and sequestration, it has the potential to deliver additional benefits such as biodiversity conservation and benefits to rural communities who depend on the forest for their daily livelihoods (Miles and Dickson 2010). Thompson et al. (2009) argue that biodiversity plays a significant role in the resilience of forest-carbon dynamics globally. Strassburg et al. (2010) add that there is a strong correlation between global biomass carbon stocks and biodiversity richness and that this relationship is symbiotic. The role played by fauna, especially the large mammals, in natural ecological processes such as dispersal of seeds and pollination cannot and should not be underestimated in REDD+ mechanisms. Hinsley et al. (2015) adduce evidence to illustrate that biodiversity loss has negative consequences for forest composition, tree survival, and forest resilience, which may eventually attenuate forest carbon stocks in the long term. This makes biodiversity an integral part of REDD+ rather than an ancillary benefit. Within the GIZ/ICIMOD REDD+ Himalaya Initiative, the achievement of these co-benefits and conservation for forest carbon stocks is intended to be contemporaneous. Thus, with the enhancement of biodiversity, a possible snowballing wildlife population, and an embedded imperative to improve livelihoods of rural communities within a REDD+ programme, mitigation strategies for a consequential mushroom in human-wildlife conflict are deservedly noteworthy.

The Government of Nepal has selected the Terai Arc Landscape (TAL) for developing a REDD+ programme which will bring improvements in conservation and enhancement of biomass. TAL harbours many protected areas and also has many wildlife corridors that are in use by wildlife. As the forest quality improves as a result of REDD+ intervention, the wildlife population will increase and so may the frequency of human-wildlife conflict. The transboundary nature of the TAL also means that transboundary landscape conservation and wildlife issues are central. Evidence points to the fact that long-term conservation of species in isolated protected areas is unsustainable, which has resulted in a paradigm shift in the conservation discourse and policy from isolated protectionism to broad-based conservation of species at the landscape level with transboundary considerations (Phuntsho and Chettri 2008). There is evidence that advanced solar offset fencing in the Jhapa District of Nepal has increased elephant movement and human-elephant conflicts in the Ilam-Bahundangi border and adjoining areas (Basnet 2016). Thus this study also entails rudimentary information on transboundary wildlife conflict issues in and around the CNP.

Several measures have been adopted by conservation managers and local people around national parks worldwide to mitigate HWC and also improve livelihoods (Treves et al. 2006; Bowen-Jones 2012; Hayward and Somers 2012; Makindi et al. 2014). Technological advancements have made it possible for the use of electric fencing to mitigate HWC since the 1960s (Nyongesa Kassilly et al 2008); thus, in 2002, a large investment was made by the Government of Nepal to establish electric fencing in CNP to mitigate human-wildlife conflicts (Sapkota et al. 2014). The measures employed by local communities around CNP range from crop switching to electric fencing (Bailey, 2011).

Studies done to assess the effectiveness of electric fencing in mitigating HWCs have found it to be effective in minimising conflicts, especially from megaspecies like elephants and rhino (Hoare 2003; Gunaratne and Premarathne 2006; Kioko et al. 2008; Perera 2009). A study conducted by Sapkota et al. (2014) around the CNP found the electric fencing has not only been effective in reducing conflicts relating to crop and property damage, but has also generated socioeconomic and ecological benefits to the local people and wildlife respectively. The sustainability of the electric fencing as a HWC mitigation measure, however, has not been expounded. This study examines the sustainability of electric fencing as a mitigation strategy to human-wildlife conflicts in and around the Chitwan National Park.

Rationale for the Study

The study is undertaken as part of GIZ/ICIMOD's REDD+ Regional Programme which is supporting the protection and use of landscapes of the Himalaya and also contributing directly to ICIMOD's Transboundary Landscapes Regional Programme. The results are intended to prepare for a stocktaking of REDD+ incentives and to inform subsequent REDD+ plans and activities in the Terai Arc Landscape. The study also provides valuable information for policy makers, conservationists, and local communities on the future of electric fencing and the intricacies involved in using electric fencing as an HWC mitigation strategy. The significance of this study to academic debates on human-wildlife mitigation strategies cannot be understated.

Limitations to the Study

Household and individual interviews could have better solicited data on the perception of the people on the importance, effectiveness, and sustainability of the electric fences. Due to time constraints, however, the study relied on focus group discussions to collect this data. Although this method has the potential of influencing members of the group to agree with the answers of others, even though they might not share the idea, data solicited through focus group discussions, key informant interviews, and official interviews were found to be consistent; thus, the data collected is reliable. Also, due to language differences, an interpreter had to facilitate the focus group discussions. Even though the translation was marvellous and as accurate as possible, it limited the researcher's ability to explore and capture the variety of answers and views expressed instantaneously, expeditiously, and precisely.

Objectives of the Study

The main objective is to document and map out geospatially explicit boundaries of electric fencing against elephant and other crop-raiding wildlife, focusing on the working conditions and sustainability of these fences as a mitigation strategy to human-wildlife conflict. The following specific objectives guide the research:

- To assess the working condition and effectiveness of the electric fences against elephants and other crop-raiding wildlife
- To assess how the electric fences are managed, the existing financing mechanisms, and the challenges faced in the management of the fences
- To investigate the factors militating against the sustainability of electric fences as a mitigation measure to human-wildlife conflicts
- To assess the perception of the local people about the fences and the pros and cons of electric fencing as a mitigation strategy

Literature Review

Human-Wildlife Conflict

Human-wildlife conflict (HWC) is the confrontation between humans and wild animals, usually resulting in crop and livestock depredation, property damages, human injuries, and retaliatory killing or capturing of wildlife (Elliot et al. 2008). HWC is a contentious issue between conservationist and local communities in many countries where conservation initiatives are implemented (Hill 2004). It is also the "most widespread and complex challenge" currently facing conservationists globally (Shrestha et al. 2007:8). Fernando et al. (2005) argue that HWC results from the conversion and fragmentation of wildlife habitats by humans for agriculture, development projects, and animal husbandry, while Nelson et al. (2003) attribute the root cause of HWC to lack of and/or improper land-use planning.

In Nepal, HWC is a major problem in most protected areas and often results from the inability of local communities to access the local natural resources they were using from time immemorial before being legally barred from their use after the post–World War II legalization of protected areas (Lamsal 2012; Timalsina and Ranjitkar 2014). However, the frequency and intensity of park–people conflict mostly arise from crop and livestock depredation, human injuries caused by wildlife, illegal logging, illegal grazing and fodder collection, poaching, and poor relations between local people and protection units (Shrestha et al. 2007; Timalsina and Ranjitkar 2014). The greater one-horned rhinoceros (*Rhinoceros unicornis*), wild boar (*Sus scrofa*), Asian elephant (*Elephas maximus*), and tiger (*Panthera tigris*) are the main wildlife species involved in human-wildlife conflict in the buffer zones and surrounding areas of the Chitwan National Park (Sapkota et al. 2014; Silwal et al. 2016). While crop depredation by the rhino is a major source of conflict between wildlife and local farmers in the buffer zones and adjoining areas of the CNP (Bailey 2011; Sedhain and Adhikary 2016), crop and property destruction by the elephant is considered to be the most ubiquitous form of conflict due to the animal's behaviour, ranging pattern, and ability and propensity to cause destruction (Shrestha et al. 2007; Pant and Hockings 2013). Crop damages caused by the wild boar and deer (chital) in the CNP buffer zones cannot, however, be underestimated.

Human-wildlife conflict has resulted in economic losses, reduced food security, and livelihood options to farming households due to crop damages (Shrestha et al. 2007; Bailey 2011; Pant and Hockings 2013). However, the tendency to measure the impact of HWC to farmers from the perspective of direct economic losses alone often obscures the actual impacts, because HWC generates other costs to farmers in the form of time used in guarding fields, interruptions in children's schooling (Hill 2004), and increased risk of injury and disease contraction (Hill 2004; Carter et al. 2014). In the CNP buffer zone, some farmers have lost their economic livelihoods because they had to abandon their crop fields due to persistent wildlife destructions (Sapkota et al. 2014). Wildlife attacks on people, crop and livestock depredation, and property damages are obstacles to local communities' support for conservation (Silwal et al. 2016); thus, there is the need for solutions to HWC to ensure that local communities do not unjustly bear the adverse effects of conservation, which can result in opposition to conservation (Bowen-Jones 2012). Since vulnerability and access to the benefits of wildlife vary from community to community (Treves et al. 2006), delivering collective community-level benefits alone is not enough to captivate the interest and commitment of all individuals to tolerate and protect wildlife (Jones and Barnes 2006; Bowen-Jones 2012). Thus, to ensure the success of conservation efforts, there is the need to ensure the benefits to the local people are panoramic and all-embracing, since dissatisfaction from a single individual living with wildlife can lead to the failure of conservation initiatives (Hazzah et al. 2009; Bowen-Jones 2012).

REDD+, Biodiversity, and Human-Wildlife Conflicts

The REDD+ mechanisms can also favour biodiversity (Miles and Dickson 2010). Biodiversity protection is not a core objective of the REDD+ mechanism and as such, it is still principally viewed as a co-benefit (Hinsley et al. 2015). However, the REDD+ mechanism provides an opportunity for synergies in tackling two of the greatest challenges facing humanity, climate change and biodiversity, concurrently (Harvey et al. 2010; Miles and Dickson 2010; Strassburg et al. 2010; Magnago et al. 2015). Achieving biodiversity conservation as a co-benefit, however, depends on how a REDD+ project is planned (Miles and Dickson 2010). Some authors argue that biodiversity

protection should not be viewed as a co-benefit but rather an integral part of the REDD+ mechanism because of the important role biodiversity plays in long-term forest carbon stocks (Grabowski and Chazdon 2012; Hinsley et al. 2015; Osuri et al. 2016; Peres et al. 2016).

A study on the possibility of achieving carbon and biodiversity co-benefits in tropical forest fragments under the REDD+ reveals that there is "positive congruence between carbon stocks and Red-listed species, and the abundance and richness of endemic species, demonstrating vital co-benefits" (Magnago et al. 2015:1). Thus, they argue that important carbon and biodiversity co-benefits can be achieved by protecting larger forest fragments in hotspots of biodiversity. If REDD+ projects are to achieve and maintain forest carbon stocks in the long term, the biodiversity living in the forest must be protected (Hinsley et al. 2015) because rapid decimation of seed-dispersing animals leads to woodlands losing their vitality and ability to store carbon (Osuri et al. 2016). Over 70% of tropical forests in Africa, the Americas, and South Asia are primarily composed of animal-dispersed tree species which depend on the megafauna for regeneration; thus defaunation by hunting and other activities can have negative consequences for aboveground carbon stocks (Osuri et al. 2016; Peres et al. 2016). In fact, defaunation of the most harvest-sensitive species in the Amazon forest can lead to loss of over 5% aboveground biomass on average (Peres et al. 2016).

Biodiverse forests are more resistant to invasive species and invasion of pests that may cause tree mortality leading to loss of carbon stored in the trees (Hinsley et al. 2015). That is to say, the removal predators like tigers and herbivores like elephants can affect the natural ecological balance; thus, tree regeneration might also be affected, which will lead to long-term forest carbon losses (Hinsley et al. 2015). It is instructive to note that biodiverse forests are not just resilient in carbon stocks; they are also the most resilient ecosystems to climate change (Thompson et al. 2009). Thus, biodiversity protection within a REDD+ mechanism also provides indirect benefits to local communities and wider ecosystem benefits in the form of sustainable harvests and maintenance services such as erosion prevention, pollination, and water quality (Diaz et al. 2009; Hinsley et al. 2015). Larger vertebrates play a critical role in maintaining the full spectrum of tropical forest dynamics and as such, the conservation of biodiversity in a REDD+ mechanism is sine qua non to achieving longevity in forest carbon stocks (Peres et al. 2016).

Better conserved forests usually result in burgeoning wildlife populations due to favourable habitats, which may in turn lead to human-wildlife conflicts in the form of crop and livestock depredation and injuries to humans (Nzunda and Mahuve 2011). Consequently, unless measures are adopted by REDD+ mechanisms to mitigate these conflicts, the ultimate purpose of REDD+ will be derailed by local communities' resentment against conservation (Nzunda and Mahuve 2011).

HWC Mitigation Strategies and Effectiveness of Electric Fencing as a Mitigation Strategy

Human-wildlife conflict mitigation measures are direct methods, such as fencing, guarding, digging trenches, and removal of wildlife, and indirect methods in the form of compensation and incentives, local participation, research, and environmental education (Treves 2007). While direct methods reduce the severity and frequency of wildlife damages, indirect methods raise people's tolerance for conflicts with wildlife (Treves 2007). Osborn and Parker (2003), however, categorise HWC mitigation measures into passive methods (e.g., fencing and digging trenches) and active methods (e.g., noise making and patrolling of crop fields). Bowen-Jones (2012) views the most commonly used HWC mitigation strategies as preventive measures (e.g., fencing) and reactive measures (e.g., removing problem animals) but maintain that both measures only reduce HWC which still leaves some livelihood costs to local communities. Thus, he argues that financial mitigation measures that go beyond the mainstream compensation mechanism will help offset these remaining livelihood costs.

Measures employed by farmers to mitigate human-wildlife conflict in and around the buffer zone of the CNP range from erecting fences (electric, mesh, and barbed wire), trenches, and crop switching to more extreme measures such as the use of firearms (Bailey 2011; Sedhain and Adhikary 2016). Among all the mitigation measures, electric fences are seen to be the most effective so far in controlling conflicts from large mammals like the elephant and rhino (Hoare 2003; Osborn and Parker 2003; Gunaratne and Premarathne 2006; Graham et al. 2009; Hayward and Somers 2012; Sapkota et al. 2014; Sedhain and Adhikary 2016) and also seem to be the local people's favourite mitigation measure (Gunaratne and Premarathne 2006). In a study on electric fences in the buffer zones

and adjoining areas of the CNP, Sapkota et al. (2014) found the electric fencing to have reduced crop depredation from the rhino and elephant by 78% and livestock depredation by 30% to 60%; thus, they argue that electric fencing was the most useful measure for reducing crop and property damage from elephants and rhinos. Sedhain and Adhikary (2016) also argue that among all mitigation measures around the CNP, a combination of electric fencing and trenches is the most effective measure against the rhino.

The effectiveness of the electric fencing, however, depends on several factors, including the design (number of strands, number electrified, configuration, and so on), effectiveness of maintenance, commitment of local communities, and the behaviour and effectiveness of responses of fence-breaking animals (Hoare 2003; Gunaratne and Premarathne 2006; Graham et al. 2009). Also, community ownership and maintenance of the fences is critical for the sustainability of the electric fences (Pradhan et al. 2011; Sapkota et al. 2014).

Focus group discussion in Madi Municipality of Chitwan District

Methodology and Study Area

Data Collection and Analysis

Field visit

The field visit for the study was carried out prior to and during monsoon season. The site was visited twice. The main motive for the first visit was to obtain preliminary information on the location and distribution of electric fences and to meet the conservation officials and other stakeholders working on human-wildlife conflicts, which was carried out 21–25 August 2016. The second field visit was carried out 5–23 September 2016 to map the electric fences and conduct focus group discussions as well as key informant interviews with the local people and the park authorities.

Focus group discussions and interviews

The study relied mainly on focus group discussions (FGDs), key informant interviews, and official interviews, as well as observation and mapping for primary data collection. FGDs were held with the community forest management committees (CFMCs) together with local forest users and representatives of buffer zone user committees (BZUCs) in the Eastern Sector (Sauraha), and a general discussion was held with local forest users in the Southern Sector (Madi) of the CNP. Key informant and official interviews were held with officials at the CNP headquarters (Kasara), the Chief Warden of the Eastern Sector, and Conservation Officers at the NTNC-Biodiversity Conservation Centre (NTNC-BCC) in Sauraha.

FDGs focused on the management of the fences, challenges, and the perception of the people about the electric fences, their effectiveness, and sustainability. These discussions were held in selected community forest user groups (CFUGs) with a mixture of well-managed and poorly managed fences. This balance in the sampling of fences was purposively done to ensure that the different management strategies and challenges were represented in the final results. In all, 10 community forests (CFs) were sampled for the focus group discussions: Santi BZCF, Jai Hari Jana Chetana BZCF, Lamidamar BZCF, Manahari BZUC, Jankauli BZCF, Ganeshwor CF, Setidevi CF, Majhua CF, Saraswati BZCF, and Gundrahidhakaha BZCF.

Mapping

In mapping the electric fences, the Garmin GPSMAP 62s was used to track and pick points of all fences and their attributes recorded in a data sheet. The comprehensive mapping exercise covered all locatable electric fences in the buffer zones and adjoining areas of the CNP. In all, 57 fences were mapped in the buffer zone and adjoin areas of the CNP covering 54 community forests (Appendix I).

Secondary data collection

Secondary data on human-wildlife conflict, electric fencing, and other mitigation strategies was obtained from both published journal articles and unpublished research reports. The internet was a valuable source of published literature for this study and unpublished research reports were also obtained from ICIMOD and NTNC document shelves.

Data analysis

The analysis of the data involved transferring the field data from the Garmin GPSMAP 62s into the ArcGIS software to produce maps and distances of the fences and interpreting the maps manually. Other aspects of the data such as the condition, management, and sustainability of the fences and the perception of the people were analysed qualitatively and presented in write-ups but also with the aid of descriptive statistic tools in Microsoft Excel and tables, where appropriate. The analysis was preceded by a content analysis of the data at both basic (manifest) and higher (latent) levels to help make sense of the variety of data collected.

Study Area

The Chitwan National Park is the first national park of Nepal, established in 1973. In 1984, CNP was declared a World Heritage site by UNESCO. The park covers an area of 932 square kilometres with the buffer zone area of

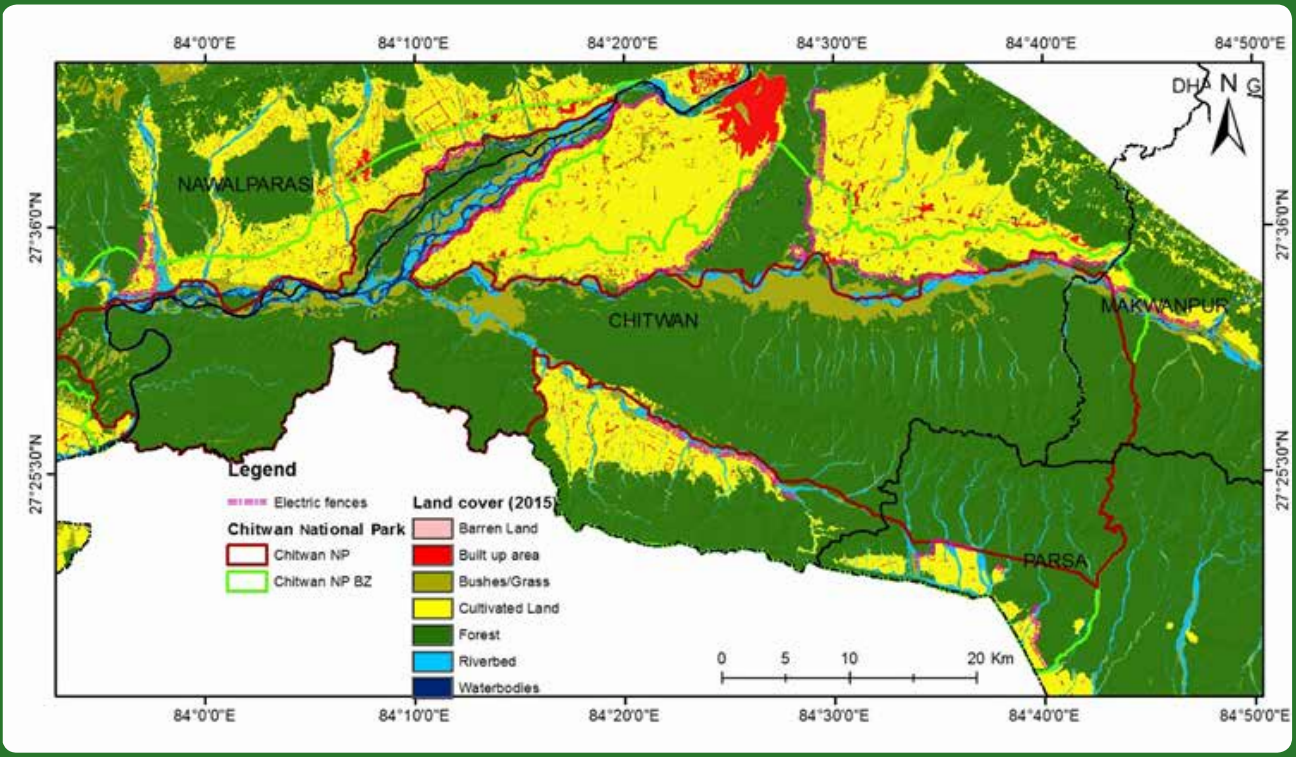
750 sq. km. (DNPWC, n.d.) and extends over four districts: Nawalparasi, Chitwan, Parsa, and Makwanpur. The core area lies between the Narayani and Rapti Rivers to the north and the Reu River and the Nepal-India international border in the south. The CNP is a hotspot for biodiversity conservation and lies in the southern region of Nepal in the subtropical lowlands of Terai. CNP harbours not only one of the world's largest mammals, the Asian elephant, but also one of its smallest, the Etruscan shrew (*Suncus etruscus*). It is also home to many globally significant, rare, and endangered wild animals such as the greater one-horned rhinoceros, Bengal tiger (*Panthera tigris tigris*), and gharial (*Gavialis gangeticus*). The park consists of 68 species of mammals, 56 species of herpetofauna, and 126 species of fish. A total of 544 species of birds have been recorded inside the park, including 22 globally threatened species (red-headed vulture and Bengal florican, for instance) (DNPWC, 2015). About 70% of the park vegetation is sal (*Shorea robusta*) forest. The remaining forests include grasslands, sal with chir pine (*Pinus roxburghii*) (which lies at the top of the Churia Range), and riverine forests. The riverine forest consists of khair (*Acacia catechu*), sisso (*Dalbergia sisso*), and simal (*Bombax ceiba*). The grasslands are mainly located in the floodplains of the river, with over 50 species of grasses including the elephant grass (*Saccharum* spp.) which is renowned for its immense height.

The CNP buffer zone programme started in 1996 with an area of 75,000 hectare (ha) spread out to three districts. The buffer zone area of the park consists of Beeshazari and associated lakes, which is a wetland of international significance. This wetland with an area of 3,200 ha has been listed by as a Ramsar Site since 2003 (UNESCO, n.d.).The Department of National Park and Wildlife Conservation (DNPWC) undertakes the management of CNP and the buffer zones. The park is divided into four management sectors: Eastern (Sauraha), Central (Kasara), Western (Amaltari), and Southern (Madi). The headquarters of the park, which is in Kasara, looks after most of the administrative activities. The Nepal army is responsible for the park security. Altogether there are 47 security posts among which 16 are park staff only and 13 are Nepal Army (DNPWC 2015).

The study area focused on all four sectors of the buffer zone as well as community forests (CFs), which are under the district forest office (DFO). The study area enlisted all the sectors where the electrical fences have been installed. The electric fences are erected along the boundaries of the CNP/community forests and farmlands/settlements. In total there are 22 buffer zone user committees (BZUCs) under which lie buffer zone community forests (BZCFs). During the study, a total of 57 fences were visited and mapped in 54 community forests which are made up of BZCFs and CFs under the DFO. The buffer zone community forest user group (BZCFUG) is responsible for using the community forest in the buffer zone. A buffer zone community forest management committee (BZCFMC) manages the BZCFs. The BZUC is responsible for coordinating activities between the CNP and the community forest user groups (CFUGs) and the development of the buffer zones. The map below shows the study area.

Livestock grazing in Buffer Zone Community forest

Map: Land-use map of Chitwan National Park and its buffer zone

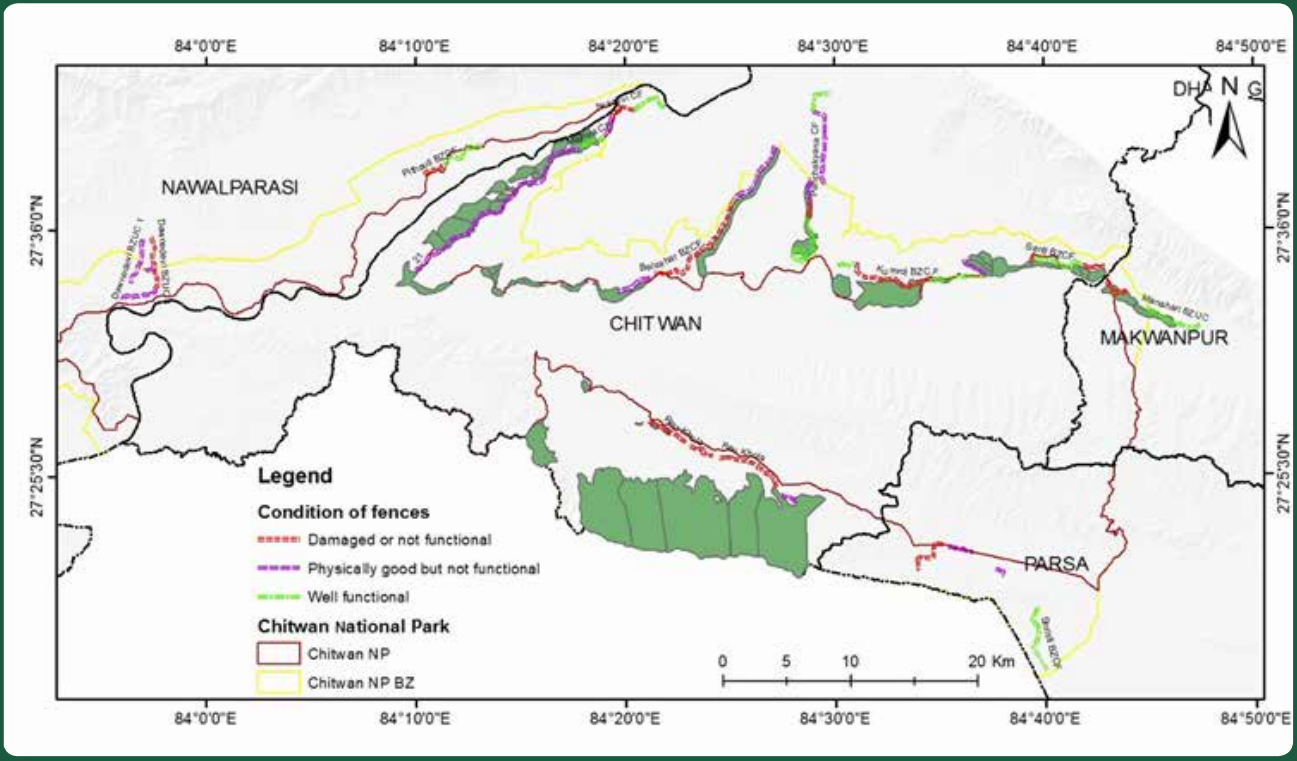


Researchers in action

Results and Discussions

Mapping

Map: Electric fences of Chitwan National Park



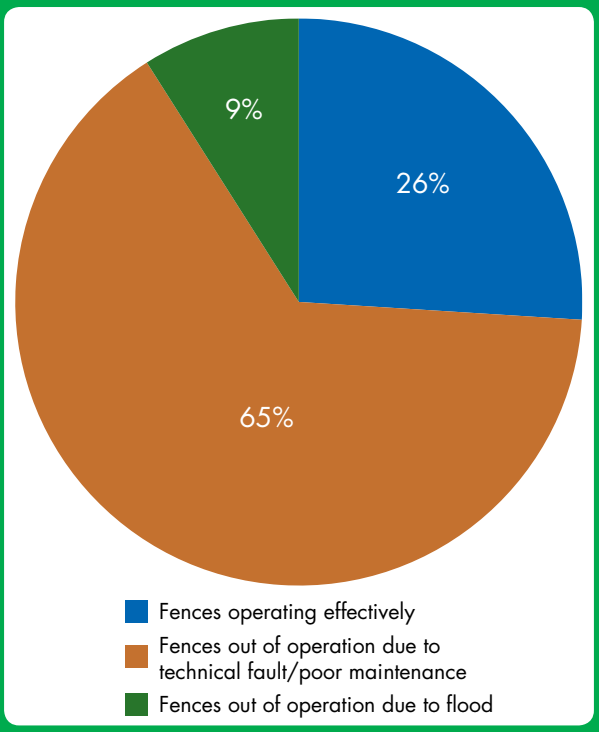
Status of the Electric Fences

Most of the fences (65%) in and around the buffer zones of the CNP are out of operation due to technical faults and/or poor maintenance; a few of them (9%) have been forced out of operation by the effects of flooding. In essence, only 26% of the fences around the CNP and adjoining areas are in operation. Figure 1 shows the status of fences in the buffer zones and adjoining areas of the CNP.

Condition of Fences

Only 26% of the 57 fences visited in the study area are in good physical condition and functioning effectively, while 21% are either completely damaged or in a very deplorable condition. Although the majority of the fences (53%) are in relatively good physical structure, they are non-functional and seem abandoned by their respective community forests management committees. This can largely

Figure 1: **Status of fences**



be attributed to poor maintenance culture, which in turn has links to financial and technical resource limitations, as well as management inefficiencies. Figure 2 shows the condition of the fences in the various community forests.

Construction Material Used for the Fences

With 91% of the community forests using wooden posts, regular checks for replacement of rotten poles is necessary for the sustainability of the electric fences. Only 7% of the electric fences are constructed with concrete posts, and only one fence has been constructed with metal poles. A majority of the wooden poles are old and weak — easy for the wild elephant and rhino to break. Even though most of the people think metal poles would be better, they cited the cost as prohibitive. Figure 3 represents the type of construction material used for the electric fences.

Supplementary Barriers for Mitigating HWC

It is evident from the mapping that 54% of the fences are still not capable of mitigating conflicts from smaller species like the wild boar and deer because there are no supplementary mitigation measures like mesh fences or concrete walls to curb these species. A combined 46% of the fences are supplemented with other mitigation barriers such as mesh, concrete wall, and barbed wire fences. The various additional protection measures are shown in Figure 4.

Figure 3: **Construction materials used for the electric fences**

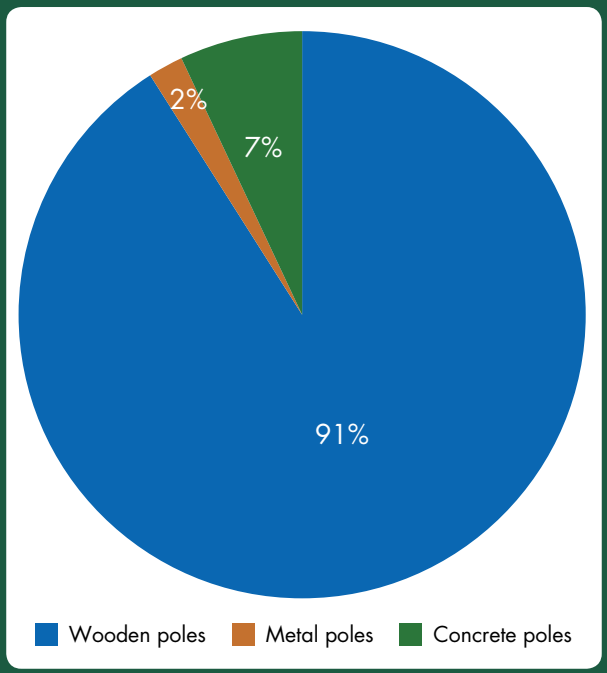


Figure 2: **Condition of fences**

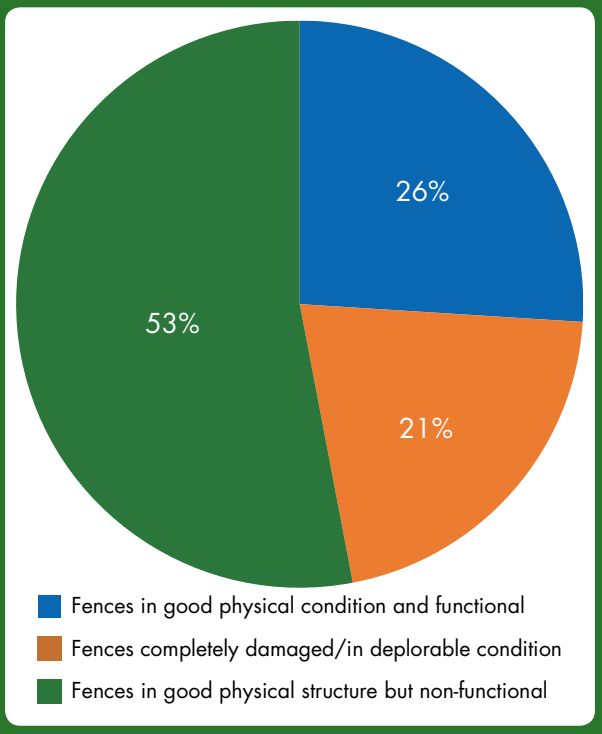
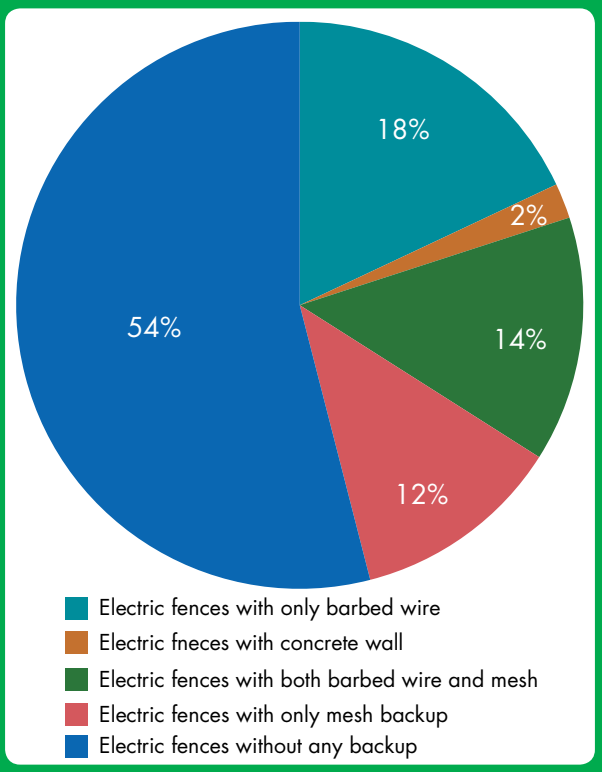


Figure 4: **Supplementary mitigation measures used**



Conflict Issues and HWC Hotspots

Effectiveness of the electric fences in reducing conflicts

Discussions with the community forest groups and official interviews with park authorities reveal that the fences have substantially reduced conflicts resulting from the megaspecies like the elephants and rhinos. In fact, it is reported that the electric fences have been very effective against the rhino and relatively effective against the elephant. The effectiveness of the electric fences is felt and appreciated mostly in areas where the rhino is the major source of conflict and where the fence is well-maintained. Discussions in areas where the elephant population is probably high and/or where more destructive elephants exist have revealed mixed responses. For instance, according to the Jai Hari Jana Chetana BZCF:

> For us, the fence is very important because it has prevented the rhino from coming; but at the same time, we think the electric fence is virtually useless for the elephant because even though we maintain it well, the elephant keeps destroying it. The issue is that the elephant here is very aggressive and even goes to the extent of using trees to break the fence. We have now nailed barbed wires on the trees along the boundary and the elephant has not been able to enter for the past two weeks. (N.K. Rimal, focus group discussion, 6 September 2016)

Similar concerns were expressed in Lamidamar BZCF where the whole fence has been damaged and out of operation for the past two years. They also contend that, even though the fence was continually destroyed by the elephant, it was very effective against the rhino because once the rhino saw the fence, it retreated immediately. Interestingly, Santi BZCF which shares a boundary with Jai Hari Jana Chetana believes that the electric fence in their area has been very effective against both the elephant and rhino. Thus, the effectiveness of the electric fencing also depends largely on the behaviour of the elephant, and we side with Gunaratne and Premarathne (2006) who contend that electric fencing should not be seen as a blanket solution for human-elephant conflict. The electric fencing can only be effective for the elephant if combined with other mitigation measures.

Conflicts still persist in all the areas resulting from the wild boar and deer and, sometimes, from elephants on rage that break fences to raid crops. The rhino is also reported to have damaged fences in some areas by kicking the poles with its foot, though most of the damages were reported to have occurred when the fence is out of operation or has low current. The electric fences are not also capable of preventing crop destruction from the wild boar and deer. Whilst the wild boar digs under the fences to enter farm lands, the deer jumps over the fences (the deer is reported to leap up to 8 feet in Setidevi CF). Even though crop destruction from these smaller species is comparatively minimal, raids from larger herds and persistent entering into farmlands usually result in huge crop and financial losses. Other mitigation measures such as mesh and bamboo fencing are considered viable options for protection against the wild boar and deer species.

Human-wildlife conflict and hotspots

Notwithstanding the electric fencing, several areas in the buffer zones have become prone to human-wildlife conflict due to poor condition of fences, incomplete fence coverage, or the behaviour and movement of wildlife (Table 1). Even though this study did not comprehensively investigate wildlife ecology and movement in the area, a cursory examination of data, observations, discussions, and interviews reveals certain community forests are exposed to frequent human-wildlife conflict. That is not to say other areas are not affected by human-wildlife conflict; in fact, the presence of a fence in a community forest indicates there are conflicts because the fences were installed on a demand-driven basis. Also, this list is not exhaustive but gives a clear indication of areas where urgent considerations need to be given to HWC mitigation efforts. A comprehensive study on the ecology and movement of wildlife in the area could better inform decision making on the type and design of HWC mitigation measures.

Other wildlife and conservation conflicts

Human-wildlife conflicts mostly result from crop and property destruction from wildlife and retaliatory killings of wildlife by humans (Elliot et al. 2008). Another dimension of human-wildlife conflict that has not been given much attention is unprovoked and unintended killings of wildlife by domesticated animals. For instance, in the Gundrahidhakaha BZCF, a group of domestic dogs is reported to have killed six deer in 2016 alone. The first approach to the problem was poisoning the dogs but this effort was halted after animal rights groups protested.

Table 1: **Hotspots and major conflict species**

Conflict-prone areas	Major species of conflict	Remarks
Manahari BZUC (Ramauli-Pratapapur-Gyamire BZCF)	Elephant, Tiger, Wild Boar and Chital (deer)	Elephant is very destructive (damaging metal poles) No protection from wild boar and deer Fence is new and in good condition but out of operation due to technical fault
Lamidamar BZCF	Elephant, Rhino, Tiger, Wild Boar and Chital	Fence completely destroyed by wild elephant Livestock depredation by tiger
Jai Hari Jana Chetana BZCF	Elephant, Rhino, Wild Boar, Chital and Monkey	Elephant very aggressive and continually destroys fence Fence in good condition
Dawnedevi BZUC	Rhino, Tiger, Wild Boar and Chital	Routes, dung, and footprints of the rhino were common all over harvested maize farms Parts of fence damaged by flood, and fence is out of operation
Nanda Vauju BZCF	Rhino, Wild Boar and Chital	Fence in poor condition and out of operation
Krishna Sar BZCF	Rhino, Wild Boar and Chital	Fence in poor condition and out of operation
Kuchkuche BZCF	Elephant, Wild Boar and Chital	Incomplete fence coverage has resulted in increased crop damages at the end of the fence
Setidevi CF	Rhino, Wild Boar and Chital	Destruction of fence by flood has exposed crops to frequent raiding by rhino
Bansakti BZCF 2	Elephant, Wild Boar and Chital	From GPS points 1622 to 1624 is a hotspot for elephant destruction because it is close to a favourable habitat for elephants Fence out of operation
Saraswati BZCF	Elephant, Tiger, Wild Boar and Chital	Fence in bad condition and out of operation for about a year now

The second option was to use birth control measures to reduce the number of the domestic dogs, but it has not been successful because of a lack of funds and difficulty in identifying the owners of some of the dogs. This situation might not be unique to Gundrahidhakaha BZCF.

During the period of the field survey, reports were received of a tiger attack on humans resulting in injuries and death in Thori and Kumroj respectively, as well as rhino attacks and resultant injuries on humans in Gundrahidhakaha BZCF.

There is resentment against the construction of electric fences in Ward 7 (Rajay community) of the Manahari BZUC. The local people uprooted and threw away electric fence poles. Although the reasons for their defiance have not been formally established by this study, informal discussions with a ranger at NTNC-BCC and interactions with local people at neighbouring communities reveal that the electric fence is seen by some as a barrier to the illegal sand-mining and stone-mining activities they undertake in the Parsa Wildlife Reserve lands. It was also observed that crops were cultivated at the start of the Manahari BZUC electric fence on lands that are supposed to belong to the Parsa Wildlife Reserve, despite the fact these communities have been resettled by the Government of Nepal. Thus, this area is not only a hotspot for HWC but conflict between local people and conservationists may arise. Further consultation and sensitization is needed to captivate the commitment of local communities to conservation in the area.

Another noteworthy conservation conflict issue was observed at Dawnedevi BZUC in the Nalwalparasi area. During the field work, the team coincidentally encountered a gathering of CFUGs under the Dawnedevi BZUC signing a petition against ownership and management of the buffer zone. Informal discussions with the Vice President of the Dawnedevi BZUC revealed the user groups have resolved to disown and relinquish the buffer zone management responsibilities because the CNP has failed to honour commitments they had agreed with the users. This area harbours many wildlife species, including the rhino, which is observed to be a major source of HWC. Extensive footprints, routes, and dung of the rhino were observed in harvested maize farms in the area. Thus, if the buffer zone management disintegrates, human-wildlife conflicts are likely to increase and wildlife decimation would be a possibility in this area. Further consultations are needed to find an amicable solution to this discord.

Transboundary wildlife conservation issues

Transboundary issues are an integral part of conservation given wildlife movement across national borders in search of food. Barriers to reduce HWC have resulted in an increase in cross-border HWCs in other national parks in Nepal (Basnet 2016). This study did not find any increase in transboundary movement of wildlife or increase in

HWCs owing to the construction of electric fences around the CNP. However, during a focus group discussion with representatives of BZUCs of the eastern sector of CNP, there were reports of the capture and translocation of rhinos and tigers belonging to Nepal into Indian zoos when these species cross the border to India. Similar concerns were expressed at a focus group discussion with the management committee of Gundrahidhakaha BZCF. They also claim that rhinos that roam across the border to India are classified as Indian rhinos. However, all these claims are only anecdotal and an empirical investigative study to authenticate their veracity is important for transboundary landscape and wildlife conservation policy and cooperation to avert any possible transboundary conservation conflicts between Nepal and its neighbouring countries.

Management/maintenance of the electric fences

From the discussions held, all community forests have similar management and/or maintenance strategies structurally, financially, and technically. While some of the fences were installed by organizations, departments, and agencies like National Trust for Nature Conservation (NTNC), district forest office (DFO), Tarai Area Landscape (TAL) programme, and USAID/Hariyo Ban, others were installed by the CFUGs themselves with funding and technical support from the CNP through the BZUCs. However, all management and maintenance responsibilities for the fences have been transferred to the various CFUGs who then form their own working committees to discharge them.

Structural/institutional strategies

All the fences are managed and maintained by a working committee, usually the CFMC; only one community forest (Jai Hari Jana Chetana BZCF) has a subcommittee dedicated to this purpose. It is refreshing to discover that the CFMCs are gender balanced and that disability groups are well represented (Table 2). All CFs have ensured and created the necessary environment for the participation from all groups in the management and maintenance of the fences and the community forests at large. Also, each community forest has a guard or guards in charge of monitoring the community forest and reporting damages relating to the electric fence to the management committee. Fence/forest guards are paid from the revenue generated by the CFMCs.

Members of the committees come from the various users. Membership to all committees is by nomination, except Majhua CF which holds elections every three years and gives every user the opportunity to stand for election. All committee members serve on a voluntary basis. However, committee chairpersons are given refund for mobile phone airtime usage. The voluntary nature of the work of the committees could be one of the reasons they approach the maintenance activities of the electric fences with a lackadaisical attitude. Information on the composition of committees in Saraswati BZCF and Gundrahidhakaha BZCF could not be obtained.

Sources of funds and revenue generation strategies

One critical aspect of the management and routine maintenance of the fences is funding. From the discussions, it was discovered that most of the community forests do not have a special allocation of funds for fence management and maintenance. There is an allocation of funds from the BZUCs and district forest office (DFO) to the CFMCs for

Table 2: **Composition and tenure of working committees**

Community forest	Composition of CFMC				
	Male	Female	Disability	Total	Tenure
Santi BZCF	6	7	0	13	5 years
Jai Hari Jana Chetana BZCF	4	5	0	9	3 years
Lamidamar BZCF	4	3	1 (F)	7	5 years
Manahari BZUC	11	2	0	13	NA
Jankauli BZCF	9	4	0	13	5 years
Ganeshwor CF	26	6	3 (M)	32	NA
Setidevi CF	7	5	5 (3M, 2F)	12	NA
Majhua CF	17	9	1 (M)	26	3 years
Saraswati BZCF	NA	NA	NA	NA	NA
Gundrahidhakaha BZCF	NA	NA	NA	NA	NA

their general conservation activities and management of the community forests, from which the CFMCs decide to use part for the maintenance of the fences; however, some of the community forests have their own mechanisms of generating revenue (Table 3).

Table 3: **Sources of revenue to the community forests**

Community forest	Sources of revenue					
	BZUC/DFO	Sale of Timber/ Fuelwood	Ecotourism	Recreational spots	Levying users	Donors/ NGOs
Santi BZCF	✓	✓	×	×	✓	×
Jai Hari Jana Chetana BZCF	✓	×	×	×	✓	×
Lamidamar BZCF	✓	×	×	×	✓	×
Manahari BZUC	✓	×	×	×	×	×
Jankauli BZCF	✓	×	×	✓	×	×
Ganeshwor CF	✓	✓	✓	✓	×	✓
Setidevi CF	✓	✓	×	×	×	×
Majhua CF	×	✓	×	✓	×	×
Saraswati BZCF	✓	✓	×	×	×	×
Gundrahidhakaha BZCF	✓	✓	✓	✓	×	✓

Only two community forests (Gundrahidhakaha BZCF and Ganeshwor CF) have relatively sustainable revenue generation mechanisms; it is thus not coincidental that these two community forests have the best-managed and well-maintained fences among the sampled community forests. It is worth noting, however, that the management committees of Mahjua CF and Ganeshwor CF have made annual allocations of 50,000 and 26,000 Nepali rupees (in 2016, 466 and 242 US dollars) from their total revenues respectively for the maintenance of the electric fences. Gundrahidhakaha BZCF also has allocations for fence management and maintenance, though the exact figures could not be obtained. The other community forests have no allocations for fence management/maintenance and only use reactive measures when fences are damaged. From the discussions, all the CFMCs raised the concern that financial allocations from the BZUCs are inadequate to take care of both conservation activities and fence management/maintenance. The fact that there is no specific allocation for fence maintenance/management from the BZUCs and DFO means that priority is given to other conservation and forest management activities at the expense of fence maintenance.

It is also apparent from the discussions that most of the management committees have not put in place creative measures to generate their own revenue to augment the financial allocations from the CNP through the BZUCs. Both group discussions and official interviews revealed that the CNP allocates 30% to 50% of its revenue as required by law to the BZUCs. The BZUCs then distribute these resources amongst the various community forests under their respective jurisdictions. However, the revenue generation mechanisms employed by most of the community forests are not sufficient and sustainable enough to meet the maintenance requirement of the electric fences and/or construction of supplementary barriers to mitigate HWC. While the CFMCs of Ganeshwor CF and Gundrahidhakaha BZCF generate (relatively sustainable) revenue through ecotourism and recreational centres such as picnic spots (in Ganeshwor), other CFMCs such as Santi BZCF, Lamidamar BZCF, and Jai Hari Jana Chetana BZCF could only rely on contributions from forest users for fence maintenance. If other community forests improve their conservation and tourism development activities, they could also attract financial support from donors and NGOs as witnessed in Ganeshwor CF and Gundrahidhakaha BZCF, which have received financial support from WWF, CARE Nepal, and FECOFUN for their conservation activities, which they use part of to support the electric fence maintenance.

Technical management/maintenance of the fences

Generally, technical maintenance of fences among the sampled CFs is much more reactive than proactive. Only Ganeshwor CFMC has a routine maintenance plan where fence wires are stretched, rusts cleaned, and falling posts strengthened once every two months. Only one of the community forests sampled (Ganeshwor CF) has a trained technician to repair electric fence machines when they are faulty. Even though the Setidevi CF has a trained person

to manage the fence and repair minor damages, he does not have the requisite technical knowledge to install and fix damages on electric fence machines. Most of the CFMCs rely on external technicians to repair and fix damages on both the fences and fence machines.

However, all but two of the sampled community forests regularly cleared bushes along the fences. Bushes have not been cleared at Lamidamar BZCF because the fence has been completely destroyed nor at Setidevi CF because weeds on flood from the Narayani River have rendered the electric fence inoperable for the past two months.

Maintenance/management challenges

The foremost challenge all the CFMCs face is financial. The routine and technical maintenance requirements of the electric fences far outweigh the financial capabilities of most of the CFMCs. Even in CFs such as Ganeshwor and Gundrahidhakaha that have relatively sustainable and high annual turnovers, inadequate funding is reported as the greatest challenge in maintaining the electric fences and putting in place supplementary measures to improve their effectiveness and sustainability. Santi BZCF, Jai Hari Jana Chetana BZCF, and Lamidamar BZCF claim they must levy households for fence maintenance because the money they get from the BZUCs is woefully inadequate.

Another challenge is the threat of physical danger faced by the fence and forest guards who monitor the fences and the community forests. Rhino attacks and injuries to fence guards were reported in Ganeshwor CF, whilst there were reports of tiger attacks resulting in the death of a fence/forest guard in Majhua CF (a fence guard lost his life from a tiger attack in 2014). A rhino was reported to have attacked and broken the backbone of a fence guard during monitoring and the guard is currently hospitalized. The situation is even more perilous as none of the fence and forest guards in the sampled community forests is covered by insurance. This has obviously affected the guards' ability to report damages for timely maintenance.

Also, all the CFMCs have complained about the lack of technical expertise to maintain the fences. Damages and technical faults on power fence machines have to be fixed by external technicians who must travel long distances to do the work. In Saraswati BZFC in the Madi sector, they complained about the difficulties in securing technicians and construction materials for the fences, which have to come from India. Similar concerns were raised in the Majhua CF about the unavailability of construction materials like insulators and the difficulties in transporting these from Kathmandu. There are also complaints about faulty and old inverter batteries/energizers to power the electric fences which are affecting the effective operation of the fences. Moreover, the power supply from the national grid is so erratic that it cannot be relied on to effectively and efficiently operate the fences. Significantly, some CFMCs do not have a clear idea of the right approaches for managing the fences. As reported in the Ramauli-Pratapapur-Jyamire BZCF (Manahari BZUC):

> Our challenge is that we don't know how to manage the fence well; the previous committee was told not to let the wire touch the ground and grasses, but now we are told to let it touch the ground, so we don't know which approach is the best and we don't even know the voltage the electric fence requires to work effectively. We want them (NTNC) to give us training on the technical aspects of the fence so that we can fix damages and technical faults by ourselves. (K. Rai, focus group discussion, 7 September 2016)

Whilst the fence is new in this area, this statement gives credence to the fact that no formal training is offered to the people on the technical details of the electric fences and best management/maintenance practices.

Frequent destruction of poles and wires by wild elephant was reported to be a serious challenge to the maintenance of the fences. In the Lamidamar BZCF, continual destruction of fences by wild elephant has resulted in the local community abandoning the fence, which is now completely destroyed. According to the management committee members:

> We used to maintain the electric fence regularly five years ago but the wild elephant kept destroying it. We decided to nail the wires on the big trees along the boundary but the elephant again used branches and trunks of medium trees to destroy the fence. So we became fed up and stopped maintaining the fence because we have exhausted all our energies and options. (R.B. Thapa, focus group discussion, 8 September 2016)

The above concern is not only peculiar to Lamidamar BZCF but represents a threat in other community forests too. The wildlife species which frequently destroy fences and the periods of destruction are captured in table 4.

From table 4, it is important to note that the elephant comes earlier in Lamidamar BZCF and Manahari BZUC because these two areas are dominated by maize farms. It is also evident that most destruction of fences and crops occurs where and when the crops are matured (nearing harvest). However, most of the damages on the fences by the rhino are said to occur when there is no electric current on the fence. All elephants and rhinos usually destroy fences and crops during the night.

Some CFMCs also bemoaned the lack of cooperation from community members who sometimes damage fences to enter the forest for fuelwood and fodder. In Jai Hari Jana Chetana BZCF, it was revealed that users whose crops are far from the boundaries do not actively participate in the fence maintenance activities because they do not suffer frequent crop destructions. There are also reported cases of damages from humans or theft of poles and wires by community members. For instance, in 2013, as many as 35 poles and 45 poles were stolen in Santi BZCF and Majhua CF respectively, while stealing of wires and breakages to enter the forest are still persistent in Setidevi CF. These actions show that people have placed their individual interests above the community interest and benefits.

Table 4: **Fence and crop destruction species**

Community forest	Period of destructions (fence and crops)	Species
Santi BZCF	September and October	Wild Elephant
Jai Hari Jana Chetana BZCF	September and October	Wild Elephant
	November and December	Rhino
Lamidamar BZCF	June–January	Wild Elephant
Manahari BZUC	July–September and January– February	Wild Elephant
Jankauli BZCF	November–January	Wild Elephant
Ganeshwor CF	November–February	Rhino
Setidevi CF	June–October	Rhino
Majhua CF	May–June and October–February	Rhino
Saraswati BZCF	September and October	Wild Elephant
Gundrahidhakaha BZCF	October–January	Rhino

Measures adopted to ensure sustainability of fences and reduce conflicts

The discussions reveal that most of the measures the various CFMCs employ are limited and, to a large extent, still remain plans and intentions because they do not have the necessary resources to execute them. There are however some laudable efforts which could be replicated in other community forests (Table 5).

Socio-political factors threatening the effectiveness and sustainability of the fences

Poor maintenance culture. The attitude of the local communities and the management committees towards maintenance of the fences was observed to be poor in most community forests where fences have been constructed. In spite of the financial challenges and technical deficiencies, it is expected that the clearing of weeds and vegetation around fences, which does not require technical knowledge, could be done in all community forests with electric fences by organizing communal labour. This was not the case in most community forests with fences, however, as tall grasses and climbers (*Mikania micrantha*) that have grown around the fences have not been cleared. Also, it was discovered that of all 10 sampled community forests where discussions were held with the management committees only Ganeshwor CF does routine maintenance in the form of stretching wires, cleaning rusts on the wires, and strengthening poles once every two months. The poor maintenance culture was also a concern expressed by officials during key informant and official interviews. While the tall grasses and climbers around electric fences lead to leakage of current and weakening of the effectiveness of the electric fence, a general lack of routine maintenance could lead to worsening of simple technical faults and an eventual collapse

of the fences. As Hoare (2003:2) notes, "a fence is only as good its maintenance, which has to be continual and meticulous".

Table 5: **Measures to ensure sustainability of fences/reduce conflicts**

Community forest	Measures/Plans
Santi BZCF	Marked and cut holes on wooden poles which has prevented the stealing of fence poles They plan to construct mesh fence to curb crop damage from the wild boar and deer, and have requested funds from the BZUC
Jai Hari Jana Chetana BZCF	Mesh fence partly installed to control wild boar and deer They nailed barbed wire on big trees along the boundary to prevent wild elephant damages They plan to change wooden poles to metal posts but have no money
Lamidamar BZCF	They nailed the fence wire to big trees along the boundaries but the elephant destroyed it with branches of trees They plan to change the wooden poles to bigger ones
Manahari BZUC	They have started tree plantation in the community forest to create a suitable habitat for the elephant to move from the park into the forest which they believe will reduce crop depredation They plan to construct mesh fences to help control the wild boar and deer when funds are available
Jankauli BZCF	They are constructing a concrete wall atop which they intend to place electric fence to control the elephant, rhino, wild boar, and deer
Ganeshwor CF	Eight groups of people clear bushes around the fence and each group is awarded NPR10,000 (in 2016, USD93) annually They have trained someone who does the technical work on the fence daily
Setidevi CF	They talk to the local people about not damaging the fence and fine violators NPR500–NPR1,000 (in 2016, USD4.60–USD9.30)
Majhua CF	They have not yet instituted any mechanisms to protect the fences
Saraswati BZCF	They have not yet instituted any mechanisms to protect the fences They have yet to contact supplier in India for construction materials and technical support for repairing the fence
Gundrahidhakaha BZCF	They plan to construct mesh fences and also dig trenches along the fences Because there no elephants, they plan to plant bamboo along the fences which will control the deer and wild boar in the long term

Newly constructed mesh fence at Kumroj BZCF

Barbed wire nailed on trees along boundaries to protect crops from destructive wild elephants at Jai Hari Jana Chetana BZCF

Weeds overgrowing an electric fence in Kumroj BZCF

Wet clothes hung on electric fences by local people

Lack of community awareness. A large majority of the local people do not understand how the electric fence functions and how their activities affect its operation. Drying and hanging of wet clothes on the electric fences is common in all four sectors of the buffer zones. During focus group discussions in the Madi area, a member said, "I have seen the fence but I did not even know that it uses electric current on it until today". This could explain why the hanging of clothes and bending of fence wires by local people is rife in various community forests. Officials also described a lack of awareness as one of the major challenges. The people's commitment and care towards the electric fences can only be achieved if they understand the purpose and benefits of the fences and how they function. Sensitisation and awareness campaigns must be conducted.

Antagonism amongst management committee members. The BZUCs are governed by representatives who are elected from amongst the presidents of the various community forests. It was revealed during key informant and official interviews that local political groupings with divergent opinions on conservation form alliances from various community forest management committee levels. Thus, anti-conservation groups do not put much effort into or support the electric fencing construction maintenance activities, because they want the management to fail so they get the opportunity to lead. This antagonism has consequences for the efficient delivery of the responsibilities of the various committees. It may also have far-reaching repercussions for the local communities' commitment and support for the maintenance of the electric fences, which may result in the fences' eventual failure.

Personal interest versus community interest. The pursuit of individual interests at the expense of the broader community objective to protect property and crops has the potential to derail the effectiveness and ultimately the sustainability of the electric fences in the area. For instance, in the Manahari BZUC, a few individuals have failed to cooperate with the construction of the electric fences because it interferes with their illegal sand-mining and stone-mining activities; they have continued to enter the reserve for the sand and stones even after the construction of the fence. Similarly, all community forests where focus group discussions were held, except Ganeshwor CF and Manahari BZUC, reported theft of wires or poles. Intensive consultations, meticulous monitoring, and implementation of punitive measures against culprits can go a long way to reduce these activities.

Institutional/structural inefficiencies and mistrust. It was discovered that most of the CFMCs have not been proactive or efficient enough to ensure the fences are managed and maintained properly. Apart from Jai Hari Jana Chetana BZCF, which has a fence maintenance subcommittee, most of the fences are managed by the CFMCs. The low levels of community awareness and revenue generation in the community forests can largely be attributed to management ineffectiveness and inefficiencies, as well as lack of transparency. Some management committees seem to have lost touch with the local users, keeping them in the dark about the electric fences and other management issues, leading to mistrust among the local users. For instance, in the Jankauli BZCF, the local users seem to be unaware of the management committee's contributions to maintenance of the electric fences, claiming they do not know if there is a management committee. They indicated they organize themselves to clear weeds around the fences without any effort from the CFMC. A member of the committee claims they are working, but informal discussion reveals the committee is dormant and the CNP has taken the management responsibility because the committee had failed to renew the community forest management. The inefficiency of the management committees was also a concern expressed by officials during key informant and official interviews. Where there is efficient management such as in Ganeshwor CF, Bagmara BZCF, and Gundrahidhakaha BZCF, the fences were seen

to be well maintained and in good condition. Restructuring and institutional reforms in the management committees would ensure management effectiveness and efficiency in maintaining and ensuring sustainability of the fences.

Economic factors threatening the effectiveness and sustainability of the fences

Limited and unsustainable financing mechanisms. Most of the community forests have not been able to meet the routine maintenance requirements largely because of financial constraints. The BZUCs do not have a specific allocation to the CFMCs for the maintenance of the electric fences. This financial challenge is compounded by the fact that most of the CFMCs have not put in place creative and sustainable methods of revenue generation to ensure sustainable management and maintenance of the electric fences. Most of the sampled community forests blame the poor maintenance of the fences on the lack of sufficient financial resources. Only 2 of the 10 sampled community forests have relatively sustainable revenue mechanisms. It was observed that where there is relatively sufficient and sustainable revenue such as in Ganeshwor CF, Gundrahidhakaha BZCF, and Bagmara BZCF, fences have been well maintained and are functioning effectively. Sufficient and sustainable financing also makes it easier to implement supplementary conflict mitigation measures such as mesh and other fencing mechanisms. Hoare (2003) argues that most electric fences against wildlife fail in the long term because the people are unable to meet the routine maintenance requirements. Thus, sustaining the electric fences would depend on meeting their routine maintenance requirements, and this is also largely dependent on sustainable financing.

Poverty and livelihood patterns. The poor economic conditions of the local communities around the CNP have unavoidably led to their high dependence on the forest resources for energy and income (Lamsal 2012). This constitutes one of the serious threats to the sustainability to the electric fences as it leads to humans damaging the fences to enter the forests, and also stifles their ability to contribute financially to the maintenance and construction of electric fences. It was discovered during discussions with the CFMCs that most of the electric fences operate at night not just because all wildlife come only in the night, but also because during the day local users are allowed to enter the forests for fuelwood, fodder, nutritional, and other livelihood needs. All community forests that recorded human damages of fences attributed it to local users entering the forests through illegal openings for fuelwood and fodder. Entry through illegal openings was observed along most of the electric fences during the mapping exercise. With the electric fences blocking the easy and habitual movement of people into the forests, frequent forest users such as fodder cutters are more likely to have a relatively negative perception about the electric fences. Thus, if alternative livelihood options remain scarce and extreme poverty lingers, the commitment and contribution of such users towards the sustainability and construction of new fences, as well as conservation in general, will ultimately deteriorate.

Technical factors threatening the effectiveness and sustainability of the fences

Improper design and construction materials. The design and quality of materials used to construct the fences make them vulnerable to elephant and rhino damages. Most of the fences have been constructed with wooden poles, most of which are rotten because of termite attacks and poor quality of the wood. It was observed that most of the fences have not been stoutly constructed to be able to resist wildlife attacks. Design flaws such as vertically fixed poles and non-galvanized poles also make it easy for the rhino and elephant to hit the posts with their feet, with the elephant even able to uproot the poles with its trunk. Most of the electric fences have the same layout and design in the different parts of the buffer zones, even though the intensity of conflicts and behaviour of wildlife might differ from area to area. This indicates that there were no effective preliminary studies on the density of the crop-raiding wildlife population, their local ecology, and movement patterns in the various areas before the fences were installed. A one-size-fits-all approach to the layout, design, and construction material for electric fencing can derail the effectiveness and sustainability of fences at different locations.

Dearth of trained technicians. Most of the community forests do not have the technical know-how to maintain the fences. Technical faults that occur on fence power machines have to be fixed by external technicians who in most cases are the suppliers of the machines and batteries. The use of the inverter batteries/energizers and power converters also means that the technical faults occur frequently and result in the breakdown in the functioning of the electric fences, thus giving the wild elephant and rhino the opportunity to break the fences within these periods. Hoare (2003) notes that where the power supply involves the use of solar panels or batteries, the maintenance problems are much more serious and frequent. With most of the community forests using solar and batteries due to

Low quality/rotten wooden poles used as structures for electric fences

power rationing from the national grid, there is a need for trained technicians who will immediately attend to minor faults and general maintenance requirements of the electric fences to avoid their eventual breakdown.

Proximity to crop lands. The majority of the fences have been constructed close to crop lands. A concern about this layout was raised in the Manahari BZUC where crops share boundaries with the electric fence. They indicated they had requested the authorities to create a buffer of at least 30 metres between the crop lands and the fence, which was not heeded. In most of the community forests, the buffer between crop lands and the electric fences on average is between 1 m and 10 m. Once they have set their eyes on the crops, wild animals like the elephant and rhino are more likely to damage fences to raid crops with the electric being the only barrier. Also, it seems the behaviour, movement, and density of elephant and rhino populations was not considered before the installation of the fences at various locations. This has the tendency of putting undue pressure on certain fences, which eventually leads to their collapse. For example, the electric fence at Lamidamar BZCF has been completely destroyed by very aggressive wild elephants.

Proximity to river banks. It was also observed that a significant number of the fences have been destroyed by flood because they have been constructed along and close to river banks.

Erratic power supply. The load shedding on Nepal, which is worst in rural areas, makes it difficult for the community forests to power the fences to work efficiently. Most of the community forests lamented the difficulties in getting regular power from the national grid which forced them to resort to the use of inverter batteries. Most of these batteries are old and cannot produce sufficient power but have not been replaced due to financial constraints. Some

Proximity of crop fields to electric fences in Santi BZCF and Manahari BZUC

batteries have also developed technical faults but have not been repaired due to unavailability of technicians and/or difficulty in finding external technicians to repair them. The rhinos and elephants take advantage of the low electrical current or lack of current to break these fences. It was also observed that some of the few community forests using solar to power the fences have encountered technical faults which they are unable to repair.

SWOT Analysis of the Electric Fencing in CNP

Strengths

Effective against megaspecies

The electric fences have been very effective against the rhino and relatively effective against the elephant depending on its size and behaviour. A review of literature, focus group discussions, and official interviews reveals that the electric fencing has significantly reduced human-wildlife conflicts resulting from the rhino and elephant. Comparatively, the electric fencing has been the most effective solution thus far to crop depredation caused by the rhino and the elephant. Local communities also believe the electric fences can be effective against the wild boar if the strands of electric fence wires are increased and the spacing between the strands reduced.

Serves as a barrier between local communities and forest/wildlife

The electric fencing also has helped reduce the movement of people into the forests and national park. It has helped reduce illegal logging and other activities the communities undertake in the national park and the community forests, thus also reducing the frequency of wildlife attack and injuries on humans in the surrounding communities. In Ganeshwor CF and Bhimboli CF, where the electric fences operate 24 hours a day, it helps prevent illegal loggers and wood pickers from entering the forest frequently. Discussions and interviews with local people and officials reveal that the electric fencing serves as not only a physical barrier to the rhino and elephants in the area but also a psychological one. It seems the electric fences have inculcated an instinct in the rhino that prevents it from breaking the fences to destroy crops even when the fence is out of operation or lacks power. This has helped reduce crop raids and human attacks from the rhino.

Weaknesses

Ineffective against smaller wildlife species

The electric fences, in their current state of design, are only able to curb destruction from larger mammals like the rhino and elephant. Smaller species such as the deer and wild boar are reported to continually damage crop fields even after the construction of the fence. Whilst the wild boar digs under the fences to escape electric shocks, the deer usually jumps over the fences into crop lands to graze. Some are also able to pass between two strands of wires that are largely spaced. The electric fencing alone, unless combined with other mitigation measures, is ineffective against the wild boar and deer, whose population is widespread in all areas around the CNP.

Technical knowledge and financial commitment required for effective operation

The local people need to have the requisite technical knowledge and financial commitment to operate and maintain the electric fences efficiently and effectively. As outlined in the management challenges, all management committees need some technical training and capacity building on creative sustainable revenue generation to be able to meet the maintenance requirements of the electric fences.

Unintended wildlife death or injury

Another flaw in the electric fences is the accidental wildlife deaths that could result from electric shocks. The deer seems to be the most vulnerable species to electrocutions from electric fences due to its behaviour. Cases of electrocution of deer were reported during interviews at the CNP headquarters and in focus group discussions with BZUC representatives and the Chief Warden in the eastern sector of the CNP. Deer that try to jump the fences become trapped between the strands of the fence wires. Poor design has also contributed to deer deaths in the Gundrahidhakaha BZCF. Similar concerns were raised during focus group discussions with local people in the Madi area, who claimed that the electric fences could lead to wildlife losing their pregnancies as a result of possible shocks. These claims, however, remain to be established as they were only anecdotal. Also, a rhino died by electrocution from an electric fence on private land in the Kumroj BZUC, while another rhino was reported to have

died from electrocution in the Setidevi CF. Accidental electrocutions and other unintended consequences should be considered in the design of both the electric and mesh fences.

Opportunities

Sustainable solution to HWC if supplemented with other mitigation measures

The electric fencing provides an opportunity for construction material and design reconsiderations and supplementary mitigation measures, which if achieved in their appropriate locations will significantly reduce — and in the most optimistic scenario completely eradicate — human-wildlife conflicts. For instance, in the Gundrahidhakaha BZCF, the management committee is very confident that their plan to implement supplementary mitigation measures such as mesh fences and trenches along the electric fences will help them achieve their zero HWC target by 2018. Thus, if investment is made in other areas to improve the design and construction material, as well as implement supplementary measures, human-wildlife conflicts could be drastically reduced.

Good perception in local community about the electric fences

It was unanimous in all community forests where discussions were held that the local communities have a very favourable perception of the electric fences and see them as an important and sustainable solution to crop depredation from wildlife. Also, an interview with the Chief Warden for the eastern sector reveals that the local communities generally also have a good attitude towards wildlife even when their crops are being destroyed. Thus, getting the commitment of the local communities to support the electric fencing can easily be achieved if efforts and sensitization activities on the electric fences are increased.

Willingness of local communities to participate and contribute

The electric fencing has instilled confidence and a sense of security in the local people and is believed to be the best solution to mitigate crop and property depredation caused by the elephant and rhino. The local communities are zealous about the electric fencing and wish to see it expanded to cover all areas; thus, we agree completely with Gunaratne and Premarathne (2006) that the electric fence seems to be the local communities' most preferred solution because it serves as a shield from the dangers of the elephant and rhino. During focus group discussions, local people in the Madi area expressed their willingness to contribute in whatever manner possible towards the maintenance and construction of new fences. This was corroborated in an interview the Chief Warden of the eastern sector who stated the local people are always ready to provide free labour for the construction of the fences. This is a good omen for local communities' ownership and commitment to ensuring the sustainability of the fences.

Diversity of wildlife species in and along all buffer zones/community forests

The presence of diverse animal species like the elephant, rhino, and deer in all buffer zones and community forests in the area provides an opportunity for tourism development that could provide sufficient and sustainable revenue for the maintenance and construction of new fences. If investments in tourism are made in all areas, tourism revenue could ameliorate the financial hurdle, which is seen as the most pressing challenge in the sustainability of the electric fences.

Threats

Adaptability of larger species like the elephant

Even though the electric fences have contributed to reducing conflicts from rhinos and elephants, they are relatively ineffective in preventing aggressive and destructive elephants from entering crop fields, as the animals are more intelligent and adaptive. There are reported cases of elephants using their feet to knock down electric fence poles and also sometimes charging the fences directly with force. In the most extreme cases, the elephants use the trunks and branches of trees to destroy the fences. These attacks mostly happen when the elephants and rhinos become habituated to the fence after a couple of months or years, but some elephants are considered to be "habitual fence breakers" (Gunaratne and Premarathne 2006; Hoare 2003; Hoare 2001). Thus, the electric fence eventually becomes ineffective against elephants with these kinds of behaviours, which results in local communities losing confidence and abandoning the electric fences, as in the Lamidamar BZCF, where the persistent destruction of the electric fence resulted in the local communities abandoning it, even though the fence was able to control crop destructions from the rhino.

Mesh fence destroyed by a wild elephant after damaging the electric fence in Jai Hari Jana Chetana BZCF

Incomplete fence coverage

Some areas have not been covered by the electric fencing. Wildlife can still enter crop lands at the end of the fence (Hoare 2003). The animal could even walk back into the areas that the fence is supposed to guard. Crop depredation by wild elephants was reported at the end of the electric fence at Kuchkuche BZCF and also at Setidevi CF, where the rhino is reported to enter settlements and crop lands through an opening at the end gate of the electric fence. This issue could exacerbate conflicts in local communities in these areas and consequently defeat the whole purpose and effectiveness of the electric fences.

Unsustainable financing mechanisms

Most community forests in the area do not generate sufficient revenue to meet the maintenance requirements of the fences. Besides, there is no specific allocation for fence management from CNP and most community forests relied and continue to rely on external organizations for the construction of the electric fences.

Recommendations and Conclusion

Recommendations

Establish well-structured and efficient funding and revenue generation mechanisms

In a cursory examination of the fences and responses from the management committees, the successes and benefits of the electric fences were observed to positively correlate with the availability of resources and financing mechanisms adopted the CFMCs. Thus, if the electric fences are to be sustained, each community forest should be allocated a human-wildlife conflict management fund. This special fund will enable the management committees to maintain the electric fences and also implement supplementary HWC mitigation measures. Furthermore, the various community forests need to employ sustainable revenue generation mechanisms that will enable them to have enough resources to establish and maintain electric fences and other mitigation measures. For instance, revenue from tourism development has enabled community forests such as Bagmara BZCF, Gundrahidhakaha BZCF, and Ganeshwor CF to effectively and efficiently manage the electric fences and implement other mitigation measures. If this practice is adopted by all other community forests, which are rich in biodiversity and varied species of megafauna, they could easily attract tourists if recreational facilities and other hospitality services, including the road networks, are developed in these areas. A capacity building for the various community forest management committees on sustainable revenue mechanisms can help them generate the resources for the management of the electric fences and human-wildlife conflicts in general.

Restructure institutions

Institutional inefficiency is one of the major threats to the sustainable management and maintenance of the electric fences. Institutional revitalization through restructuring could help ensure sustainable management of the fences. It is recommended that each community forest have a human-wildlife conflict management subcommittee that will be responsible for managing the human-wildlife conflict management fund, implementing HWC mitigation measures, maintaining the electric fences, and sensitizing local communities on the mitigation measures and HWC in general. Selecting management committees through a participatory process of elections and providing them with financial and other incentives would help improve their effectiveness, efficiency, transparency, and accountability.

Train local committees to maintain fences

There is the need for capacity building of the management committees on the technical management and maintenance of the electric fences. Most of the management committees do not have the technical knowledge and capacity to fix even minor damages and technical faults on the electric fences and have to rely on external support for the maintenance of the fences. Each committee should have at least two persons who are trained and equipped on the technical management and maintenance of the electric fences. Most electric fences fail in the long term because of the inability of the local people to meet the routine maintenance requirements of the fences (Hoare 2003); thus, if the capacity of the management committees is built on the technical and routine maintenance mechanisms of the electric fences, they can effectively manage the fences to ensure their sustainability.

Reconsider design and construction of fences

The effectiveness of electric fences depends on the design and layout (Graham et al. 2009; Hoare 2003; Gunaratne and Premarathne 2006). The design and materials used in the construction of the electric fences in the area make them vulnerable to wildlife destructions and also generate negative consequences. The evidence of poor design was confirmed during focus group discussions with representatives of the BZUCs and with the Chief Warden in the eastern sector of the CNP, who stated: "The fault also lies in us. We have not carefully designed and planned the electric fences accordingly". Thus, there is the need for design and material reconsiderations for construction of the electric fences and mesh fences. The design and construction of fences should be preceded and informed by a study of the local ecology, concentration, and movements of the targeted species of wildlife. This will ensure the installation and mitigation measures are appropriate for the targeted destructive species of animals. The use of local knowledge on wildlife movement and mitigation measures could also help in determining the design and materials

for construction of electric fences. A design in which poles lean outward can prevent rhinos and elephants from kicking the bases of the posts with their feet. Fabricated and extended electrified wires galvanizing the posts of the electric fences could substantially reduce the breaking and uprooting of poles by the elephant with its trunk as it will suffer electric shocks. In areas where wooden poles are used, frequent and routine monitoring is needed to ensure rotten poles are replaced. Replacing all poles with metallic and concrete poles could better strengthen the fences, even though they are more expensive than wooden poles.

Implement supplementary mitigation strategies

The electric fences as a stand-alone mitigation measure cannot and should not be seen as a lasting solution to human-wildlife conflicts. Sedhain and Adhikary (2016) note that, supplementing the electric fences with trenches makes the electric fencing the most effective mitigation measure to HWC resulting from the rhino in the buffer zones of the CNP. Thus, implementing supplementary measures such as trenches, mesh fencing, and reinforced cement concrete walls would both fortify the electric fences and prevent crop damages from smaller species like the wild boar and deer. The types of animal species and their movements in the various localities should be considered before construction.

Raise community awareness about the fences

There is significant lack of awareness amongst the local people about how the electric fences function and how their own activities affect their operation. The management committees should be given the necessary support, financial, and other incentives to carry out sensitization and awareness activities in their various jurisdictions. Well-structured and efficient human-wildlife conflict management committees could assume the responsibility of informing the local people about the electric fences and other human-wildlife adaptation and mitigation measures. This will save the park authorities time and human and financial resources.

Implement proper land-use planning and cropping patterns

In Nepal, communities in areas with relatively good land-use patterns experience half the economic losses and damages from HWC than communities in areas with improper land-use patterns (Elliot et al. 2008). Thus, proper land-use planning could help reduce pressure on the electric fences and human-wildlife conflicts in general. As suggested by Elliot et al. (2008), land uses that do not attract wildlife could serve as a buffer between wildlife habitats and conflict-prone land uses. A study on the behaviour, local ecology, and movement of wildlife in the area can inform and should precede a comprehensive land-use planning exercise that involves all the stakeholders in the buffer zones and adjoining areas of the CNP. An interview with the Chief Warden of the eastern sector of the CNP reveals that horticultural activities, growing perennial crops such as banana in areas of the buffer zone, and fish farming through construction of fish ponds in the southern sector of the CNP have helped reduced human-wildlife conflicts in those areas. Perennial crops such as banana are reported to be relatively non-palatable to the mega species and obviously do not suffer destructions from the wild boar and deer.

Also, experimental cropping in Sri Lanka has found citrus species such as orange to be non-palatable to the Asian elephant; a change of cropping from paddy to orange plantation has helped reduce human-wildlife conflicts and improved the livelihood of local farmers in the area (Corea 2016). Experimental cropping could also be tried in Nepal to find non-palatable crops, but interventions should be made to create markets for such produce if successful. Government intervention and policy as well as activities of civil society and corporate businesses can help create both local and international markets for such produce.

Improve livelihood options for local communities

For a sustainable solution to human-wildlife conflict, the livelihoods of the local people must be improved concurrently with conservation initiatives. This is what Treves et al. (2006) describe as the fundamental challenge of finding a sustainable solution to HWC. However, the diversification of livelihoods of local communities through policy options at local, national, and international levels could go a long way to achieving this. The positive perception and friendly attitudes of the local communities towards wildlife and conservation could boomerang if their livelihoods continue to deteriorate and extreme poverty persists.

Experiment other HWC mitigation measures

Alternative human-wildlife conflict mitigation measures such chilli fencing and beehive fencing which have been found to deter the African elephant, should be tested in Nepal to ascertain their efficacy against the Asian elephant. This should be done in areas where the elephant is the most destructive wildlife. There are beehive fencing trials already in Sri Lanka, which experiments in Nepal could take a leaf from. The chilli fencing has been found to be effective in dissuading elephants from entering fenced crop fields (Chang'a et al, 2016). A manual on how to make a chilli fence has been prepared by (Chang'a et al., 2015) which can easily be accessed on internet.

Conclusion

Finding solutions and mitigation measures to complex human-wildlife conflict requires the "systems thinking" (Richmond, 1994; Arnold and Wade, 2015:675) approach. Electric fencing as a human-wildlife mitigation strategy cannot and should not be seen as a blanket solution, because many dynamics and requirements are involved in the construction and maintenance of the fences. A comprehensive study on the local ecology and movement of wildlife should precede the design and installation of electric fences. Also, a study on the perception of the local communities about electric fencing and their commitment to manage and maintain it routinely should inform any decision to construct new fences or refurbish and maintain existing fences in the area.

Alternative human-wildlife mitigation measures such as chilli fencing and beehive fencing, which have been shown to effectively deter the African elephant, could be tested to ascertain their efficacy against the Asian elephant. With beehive fencing being tested by a PhD student in Sri Lanka, similar research in Nepal, if successful, would help to improve the livelihoods of local communities as people will benefit from honey harvesting or chilli farming to augment their income.

A delay in compensation payment to victims of wildlife attacks was a concern expressed by officials during interviews. The compensation scheme should be revitalized to ensure efficient and timely payments, which will help increase the tolerance of local people for wildlife. An arrangement that ensures the BZUCs make prompt payments to the victims, where the payments will later be reimbursed by the CNP to the BZUCs, is an option that can ensure victims get the timely financial support needed.

Regular and effective coordination also is needed between the DFO and the CNP in wildlife management. Even though the DFO is much more concerned with the management and distribution of forest resources, it is inevitable that these forests serve as habitats for a lot of wildlife which need to be protected. An effective coordination between these two departments that ensures a shared responsibility in the allocation of resources for the management of human-wildlife conflicts will go a long way to strengthen the mitigation measures and ensure their sustainability.

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