Paper on "Human wildlife conflict"

MANAGING HUMAN WILDLIFE CONFLICT:
AN APPROACH TO MITIGATION & CO-EXISTENCE

Centre for Human Wildlife Conflict Management

प्रगतेः मूलं प्रकृतिः

Indian Institute of Forest Management

(An autonomous Institute under the Ministry of Environment, Forest & Climate Change, Govt. of India)
Bhopal (MP), India

MANAGING HUMAN WILDLIFE CONFLICT:
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From the Editors Desk

All through the civilization, humans and wildlife have co-existed in the landscapes, which formed habitat to both. This coexistence and dependence on the common resource in forested and non-forested landscapes has resulted in wide range of conflicts owing primarily to population imbalances and distortions in development. These occur in form of crop damage, property damage and threats to human lives in many areas. The human wildlife conflict is also seen as one of the biggest threats and challenge to the wildlife species and their conservation.

There is a wide range of wildlife species with whom the relationship of humans is turning agonistic. The nature and scale of problem varies across species and different landscapes. These include Blue bulls, Wild pigs, Elephants, Black buck, Tigers, bears, leopard, macaques, reptiles and birds. Lack of knowledge and preparedness to deal with such situation further complicate the of overall situation related to human wildlife conflict. There is a need to build on collaborative multi skate holder partnership, which should include researchers, scientists, NGO,'s, practitioners and affected communities to be able to tackle the problem effectively.

This edited book is the compilation of research studies carried out by researches, NGO's and practitioners across different parts of the country. The book highlights the need to holistically understand the multiplicity of interrelated issues with respect to prevailing human wildlife conflict scenario. I take this opportunity to thank all the contributors for sharing their research work for this book. Collective wisdom and efforts through multi-stakeholder partnerships will definitely pave way for Coexistence in times to come.

Dr. Yogesh Kumar Dubey

प्रगतेः मूलं प्रकृतिः

भारतीय वन प्रबंध संस्थान
पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय, भारत सरकार का स्वायत्त संस्थान
नेहरू नगर, भोपाल–462003, म.प्र., भारत

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Subhash Chandra, IFS
Director

Foreword

Human wildlife conflict management has emerged as multi-dimensional issue, affecting not only the conservation objectives but also the wellbeing of the local communities. The problem is no longer restricted to the Protected Areas but is spreading in adjoining forested and agricultural landscapes affecting local communities. The range of issues include crop depredation from animals like Elephants, Blue bull, Blackbuck, Wild pig etc. In many areas, loss of human life and injury from carnivores, elephant, gaur, wild boar etc. has turned local population against conservation. The conflicts are further accentuated by the loss of property, house breakage, livestock depredation and lifting by carnivores. Several wild animals also suffer heavily in such incidences of conflicts between humans and wildlife, as they have to face the anger and anguish in forms of electrocution by live wires, barbed wire fences and instances of poisoning.

As the landscapes are transforming the wildlife animals, also move in pursuit of finding suitable habitats that may or may not be inside the forests. In many cases, animals disperse and move into forest fringe area or human dominated landscapes.

In the light of above, it has become prudent to build nationwide repository of knowledge on various aspects and issues attendant to the human wildlife Conflict. This shall help to develop evidence based decision support programs to help combat and either minimize or mitigate the problems in the specific geographies with species-specific focus. The compilation of select research papers in this book were presented during the national conference on Human wildlife conflict held at Indian Institute of Forest Management Bhopal during October 22-23, 2021. The findings from these papers will definitely help in dealing with some of the important and emergent aspects in mitigating human wildlife conflict.

(Subhash Chandra)

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Foreword

Human wildlife conflict is the most serious impediment to the conservation of large mammals and, also, to the security of life and livelihoods of rural communities. While we all celebrate the rising populations of tigers and elephants in the country, more and more people pay the price for this success every day. Although this conflict is not new, as human beings and wild animals have lived together throughout history, never before people have been at the mercy of the government, as of now, to protect themselves against this growing menace. So much so that even shooing away a crow from your compound amounts to hunting and needs a permit from officials. Therefore, people have no option but to chase, snare or poison wild animals illegally.

Animal depredations may be tolerated by the people if wild animals provide some economic benefits to their victims. Such benefits can be produced only by putting in place systems of sustainable hunting and tourism. Not to speak of hunting, we feel like sinners even for allowing people to watch and photograph wild animals. Knowing fully well that wild animals shall survive only if human beings value their presence among them, some of us still keep animal rights above human rights when it comes to resolving human wildlife conflict. Surprisingly, we have never realised that this conservation paradigm violates the fundamental rights to life and property guaranteed by our constitution. It also amounts to culpable homicide and several other similar crimes by the State. No wonder, therefore, the crisis keeps spiraling rather than cooling off.

Despite the enormity of the situation, no agency in the country has cared to create a comprehensive picture of the crisis to help the policy makers take notice and act. Therefore, the creation of the Centre for Human Wildlife Conflict Management at IIFM is a welcome and timely initiative. I congratulate the Centre for organising this virtual conference and bring together a band of researchers, thinkers and wildlife managers to discuss and debate the subject. I hope there will be many more such conferences to help the country chart a course of human wildlife symbiosis, not just coexistence, before it is too late.

Dr. H.S. Pabla, IFS (Retd.)

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Contents

Evolving complexities, Trends and Challenges of Human-Elephant Conflict in Meghalaya: An assessment on conflict cases and management efforts

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Abstract

Human-wildlife interactions are inevitable as long as they both share the same space and resources for their survival. In this paper, we have compiled data procured from Meghalaya Forest Department specifically on Human Elephant Conflicts (HECs) from 2009-10 to 2020-21. This is because out of 10,538 conflict cases registered with the Department during the same period, a staggering 99.8 % of them are claimed to be caused by wild elephants. However, it is important to note that these figures underestimate the overall extent of damages because of underreporting and unawareness amongst the affected villagers. There are 1754 elephants and six main elephant corridors in Meghalaya. Therefore, HEC conflict represents a growing concern for the agro-pastoral community living near protected areas. A total of 10,515 incidents of HEC have been reported so far from 2009-2010 to 2020-2021. The four different types of conflicts observed are, viz. (i) crop depredation (95.3%, n=10,020 incidents), (ii) human deaths (0.63%, n=66 incidents) and (iii) human injuries (0.47%, n=50 incidents) and (iv) property damages (3.60%, n=379 incidents) but pattern of conflict seemed to gradually decrease after 2016 till 2020. As per government notification of 2018, the revised rates of compensation for human injury to loss of lives range from Rs.25,000/- to Rs. 5,00,000/- per case while crop and property damages have to be first assessed by officials before a compensation amount can be decided. In this paper, the trend of conflict cases, the viable corridors, affected villages, the challenges, and the foreseeable future for the HEC coexistence in the state are discussed.

Keywords: Human Elephant Conflict, Meghalaya, crop depredation, property damage

Introduction

Asiatic Elephants are one of the largest land mammals which require large contiguous habitats to ensure their population viability (Wilson& MacArthur, 1967; Choudhury 2007). Therefore, protected areas, as well as increased connectivity between wildlife habitats, are essential to facilitate safe movements (Simberloff et al. 1992; Hossen, 2013; Goswami & Vasudev, 2017). Ignorant of the human-made nation boundaries, they often travel to and fro adjacent countries in search of food, water, and shelter (Sarker et al, 2015). More than often, as human settlements expand, they mostly fall into a negative interaction or Human-Elephant Conflicts (HECs). The conflict between humans and elephants is not a new phenomenon in Asia and this issue has been recorded since 300 B.C. (Sukumar, 1994). However, community surveys and news reports

suggest that conflicts in Asia and Africa have increased in both frequency and intensity in recent decades to an unbearable level (Chartier et al. 2011). HEC is a major conservation concern, challenge and potentially dangerous pursuit in elephant range areasand its management is usually an expensive effort (Neupane, et al. 2017; van de Water & Matteson 2018).

The long-distance travel of widespread species such as elephants has been a clear sign that protected areas, important as they are, are inadequate. The strict boundaries of protected areas (PAs) do not offer the enormous space, heterogeneity of the landscape, and the connectivity of suitable habitats (Huang et al. 2019). With few restrictions and regulations, most of these areas outside of protected areas, connecting corridors are human-dominated landscapes, and there are no legal protection of these corridors in the Indian Legislature (Talukdar et al. 2020). Anthropogenic activities such as accumulation of forest resources, cattle grazing and human movement are frequently observed in these areas, which has contributed significantly to the reduction of wildlife corridors and the increase in conflicts between humans and elephants (Joshi & Singh, 2008). Therefore, it is also a great challenge to encourage local stakeholders to participate, as there are cases of significant harvesting and property damage by elephants in such areas with little human attack (Parker et al. 2007; Pant, 2013; Acharya, et al. 2016). A recent study in China (Huang et al. 2019) mentioned that elephants negotiate their survival risks with their resource needs by marauding agricultural lands for food. The same study also mentioned habitat suitability being negatively associated with socio-economic development. Although they are habitat generalists, some studies report that elephants prefer forest edges of evergreen and semi-evergreen forests (Sitompul et al., 2013; Huang et al. 2019; MoEF, 2018). There is also sufficient evidence suggesting that human-dominated land-use forest areas are much more suitable than intact forests as the former provides feeding opportunities for crops during the growing seasons (Huang et al. 2019). In such areas, several mitigation techniques have been tried, however, they are inadequately assessed to determine the appropriate combination of techniques and there is also a need for standardized study designs (Perera, 2009). A number of mitigation HECs measures such as viz., guarding crops from tree houses, noise production, fires, alarms, and satellite radio collars tracking elephant movements have been effectively used to some extent. (Venkataraman et al 2005; Rameshan 2007; WWF 2008).

Assessing trends and of the Human Elephant Conflict and determining whether, how and why HEC has changed over time will be an important step in managing landscapes where humans

and elephants can coexist (Redpath et al. 2013). Thus, to identify changes in HEC patterns, we must first understand past and current trends. Determining a baseline information is an important step in establishing mitigation actions. The lack of an appropriate "frame of reference" is a common problem in the evaluation of nature conservation measures worldwide (Pozo et al. 2017). This requires effective monitoring and evaluation systems in the areas of high HECs and is particularly relevant for human-wildlife conflict studies (McDonald et al. 2009; Treves et al. 2006). In the case of HEC, this not only affects our understanding of current impacts within a defined region but also limits our ability to make reliable predictions of future trends (Pozo et al. 2017). A comprehensive understanding of elephant movements and attacks is vital to encourage coexistence of wildlife and humans.

Meghalaya has the second largest population estimate of elephants after Assam in North East India and in the recent years, the trends of HEC conflict in the state has gradually risen. (MoEF& CC, 2017; The Times of India, 2018). In the state, notable works on elephant corridors (Tiwari et al. 2005; Tiwari et al. 2010), conflict and conservation management of elephants (Datta-Roy et al. 2009) in Meghalaya only dates back to a decade ago. There is no compiled information of HEC conflict in the state from 2010-2020. Thus, the need to study the trends of the current scenario. This study is an attempt to lay out a baseline report on the current spatial and temporal trends of HECs in the state of Meghalaya, Eastern Himalayas.

Study Area

Meghalaya is one of the eight states of North-East India, landlocked by Assam in northern and eastern and Bangladesh in western and southern region. It lies between 25°02' and 26°10' North and 89°45' and 92°47' South with an elevation range of 150 meters to 1950 meters above the sea level. It has a total geographical area of 22,429 square kilometers. The major rivers of the state are Manda, Simsang, and Ganol in Garo Hills and Myntdu, Umngot, Umtrew, Kopili, and Umiam in Khasi and Jaintia Hills. The forest type is mainly dominated by East Himalayan Moist Mixed Deciduous Forest followed by Khasi Sub-Tropical Wet Hill Forest (Champion and Seth, 1968; Forest Survey of India, 2019). It falls in the high precipitation region and the mean annual precipitation is in the range of 4,000 mm to about 11,500 mm and the wettest place in the world, Mawsynram, is in the state of Meghalaya. The western part of the state is warmer with average temperatures between 12°C and 33°C. The central highlands are relatively cooler with an average temperature between 2°C and 24°C. It has four wildlife

Divisions, namely Balpakram National Park (BNP) Wildlife Division, Khasi Hills Wildlife Division, Jaintia Hills Wildlife Division, and Garo Hills Wildlife Division. It has two National Parks, three Wildlife Sanctuaries and six identified elephant corridors (Figure 1).

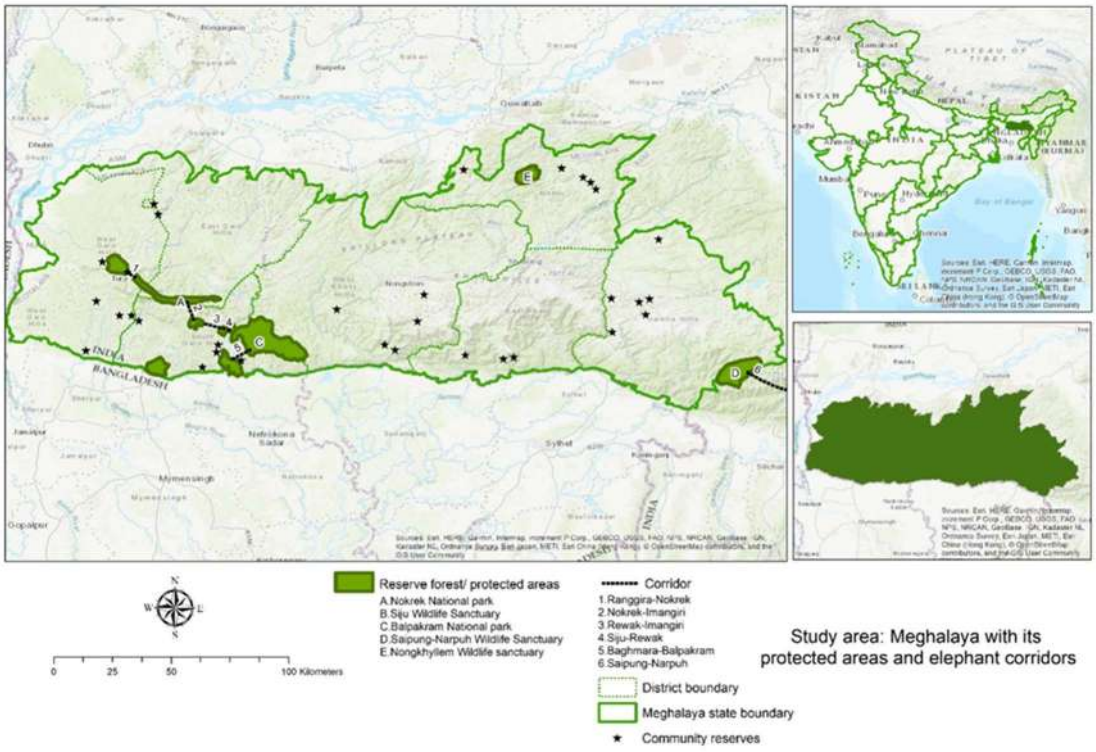

Figure 1: *Map of Meghalaya showing Community Reserves, Protected Areas and elephant corridors*

Some of the common trees of Meghalaya are *Pinus kesiya, Schima wallichi, Duabanga grandiflora*, *Tetrameles nudiflora*, *Shorea robusta*, etc. (Forest Survey of India, 2019). It is also home to some of the endangered mammals including Asiatic Elephants, Western Hoolock Gibbons, Dholes, Indian Pangolins, etc. (Lyngdoh et al. 2019). About 77 per cent of the state is forested but only 12 per cent of the total forest area comes under direct control of the Forest Department. A large chunk of the forest areas is primarily owned by individuals, clans, District Councils, village and community forests (CAG Report, 2017).

Methods

For the data collection, we procured data from the Meghalaya Forest Department from 2009-2021 on the following lines: (i) Overview of Human-Wildlife Conflict complaints submitted to the Department (ii) Overview of HEC conflict cases in all the four wildlife divisions of Meghalaya from 2009- 2021 (iii) Comparison and trends between the conflict cases in all the

divisions. Due to non-uniformity of earlier data, we only took in account the overview of cases from 2009-2010 to 2020-21 while the trends were compared from 2015-16 to 2019-20.

Results

According to the latest 2017 elephant census, the highest density of elephants is in BNP WL Division followed by Khasi WL Division (Table 1). Out of 10,538 conflict cases registered with the Department during the 2009-10 to 2020-21, a staggering 99.8 % of them are claimed to be caused by wild elephants. A total of 10,515 incidents of HEC cases have been reported so far from 2009-2021.These include 10,020 cases of crop depredation (95.3%), 379 incidents of property damages (3.60%), 66 human deaths (0.62%) and 50 cases of human injuries (0.47%). On an average, there are 5.77 elephant deaths, 5.08 human deaths and 3.85 human injuries per year from 2009-2021. The number of affected villages is the highest in Garo Hills, followed by Khasi Hills and BNP and the lowest in Jaintia Hills (Table 1).

Table 1: *An overview of elephant density, death and HEC conflict cases from the four forest wildlife divisions.*

Overview	Data for year	Forest Wildlife Divisions			
		Khasi Hills	Garo Hills	Jaintia Hills	BNP
Density of elephants	2017	0.12	0.02	0.03	0.54
Death of elephants	2009-2021	16	38	0	21
Human Death	2009-2021	5	49	0	12
Human injury	2009-2021	6	24	0	18
Crop Damage	2009-2021	4933	3475	1017	595
Property damage	2009-2021	125	193	0	57
Number of affected villages	2015-2020	90	92	11	62

The crop damage incidents decreased in Garo Hills from 2015-20 while the crop damage cases in Khasi Hills WL Division more or less remained static throughout 2015-2018 and slightly peaked from 2018-20 (Figure 2). BNP and Jaintia Hills WL division have similarly low number of recorded cases. The reason is that Jaintia Hills has the lowest elephant population and while BNP is already a PA. On an average, 149.953 hectares of crops are damaged per year (Table 2), the largest area being from Garo Hills and followed by Khasi Hills Wildlife Division. The common crops damaged are arecanut, cashewnut, banana, paddy, and other crops and the

mean compensation amount paid by the Forest Department from 2015-2020 for each crop damage case is Rs. 3825.17/-.

Table 2: Forest Wildlife Divisions and year-wise reported cases of crop damages.

	2015-16		2016-17		2017-18		2018-19		2019-20	
Forest WL Division	No. of cases	Area affected	No. of cases	Area affected	No. of cases	Area affected	No. of cases	Area affected	No. of cases	Area affected
Garo Hills	1720	1148.62	889	247.4	351	NA	104	NA	228	NA
Khasi Hills	342	127.3	419	47.64	164	106.96	315	124.69	415	257.31
Jaintia Hills	12	8	138	55.7	65	30.56	66	35.11	77	22.69
Balpakram NP	219	146.68	133	63.08	62	NA	99	NA	73	NA

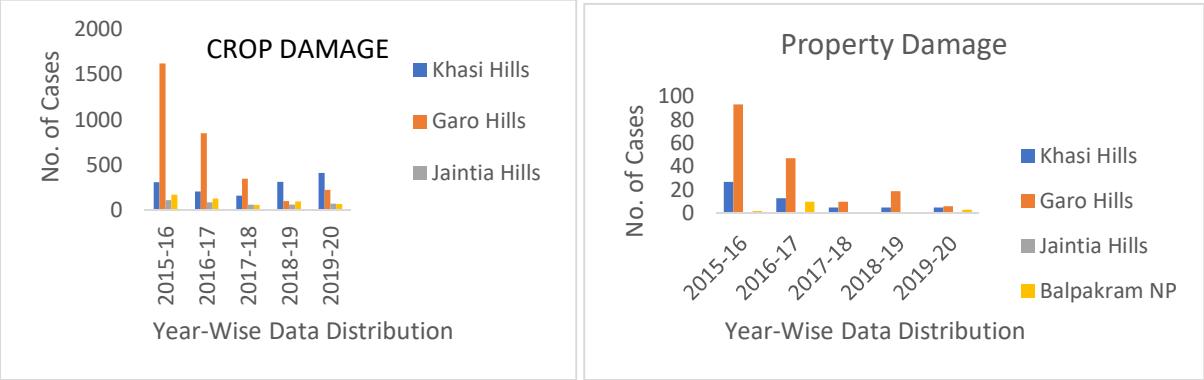

Figure 2: *Trends in Year-wise reported cases of crop and property damages in respective forest wildlife divisions from 2015-2020.*

In general, property damages appear to be decreasing, more sharply in the case of Garo Hills and steadily in Khasi Hills WL Division (Figure 2). There are negligible property damages in the Jaintia Hills and since BNP is a PA, HEC incidents are also less in this area. The mean ex-gratia payment was Rs. 12,061/- for each case. Human injuries and death are staggeringly high in Garo Hills (Table 1) and there have been 22 human deaths and 11 cases of injuries in just a span of 5 years (2015-2020). The fixed revised rate of compensation (2018) for human deaths is Rs. 5,00,000/- and human injury ranges from Rs. 25,000 - Rs. 5,00,000/- per person. Overall, crop and property damages seem to occur more in private agricultural lands of Khasi WL Division while human injuries and deaths occur in Garo Hills along the interstate (Assam) and Indo-Bangladesh border (Figure 3).

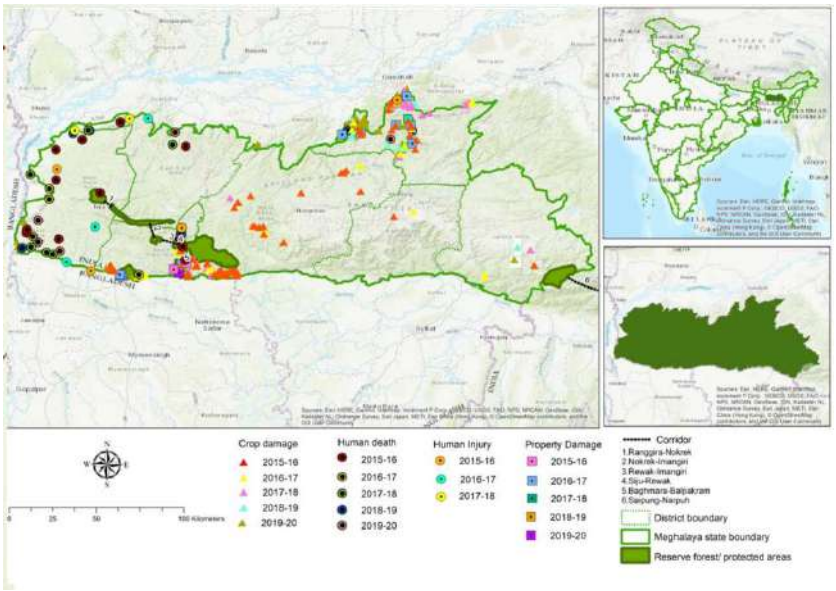

Figure 3: *Map of Meghalaya showing locations with HEC types and pattern from 2015-2020.*

Discussion

Through our study, we have attempted to compile and identify the patterns of HECs in the state. More than half of the conflicts recorded occur outside the protected areas and mostly along the Meghalaya-Assam and Indo-Bangladesh borders (Figure 3). For the interstate elephant movement, the Wildlife Trust of India (WTI), State governments and respective Forest Departments have pledged to co-ordinate and co-operate (Northeast Now, 2019). The Second "India-Bangladesh Dialogue on Trans-boundary Conservation of Elephants" held on 2017 also poses a positive initiative for conservation of these long-ranging species. The two nations have mutually agreed to develop protocols, regularly update on elephant migrations, facilitate trans-boundary movements, deployment of technology aids, establish response teams, share information on elephant locations, empower role of district authorities in elephant movements and provide all technical support (Meghalaya Forest Department, 2017).

Crop damages and property damages, as expected occurs mostly outside the protected areas and in agricultural lands. As mentioned earlier, only 12 per cent of the forest areas are under the direct control of the Forest Department and since Meghalaya falls under the Sixth Schedule of the Constitution of India, land belongs to the people, clans and communities. There is also a growing trend of community/ clan lands changing into individual-owned plots resulting in improper land use from an ecological standpoint. This is where different levels of governance pose difficulties in management of HEC. Whereas, majority of the lands belong to the people, wildlife issues are under the administrative control of the Forest Department and this poses a

dimension of conflict in management. Moreover, the trends of crop as well as property damages has gradually risen in Khasi WL Division from 2018 onwards and this could be a cause of concern for the locals as well as the elephants frequenting the area (Figure 2). The reason is most likely due to the high density of elephants in Khasi Hills WL Division (Table 1) which indicates that the elephants have lesser area to move about.

On another hand, attacks on humans are mostly in the transboundary areas, the reasons for which are still unclear. One of the possible reasons could be due to unexpected encounters along the borders which are paddy cultivated areas. Comparatively less HECs are reported from Jaintia Hills and the reason could be attributed to large scale mining and other developmental activities and there have been minimal elephant movement in the Saipung-Narpuh corridor in the last few years (Tiwari, 2017).

Conclusion and Recommendations

While in South Garo Hills there already exists an Elephant Reserve of a total area of 3500 sq kms, the proposal of an ER (1331 sq. kms) in Khasi Hills has not yet materialised (CAG Report, 2017). Therefore, there is an urgent need to provide some legal protection for this species in this forest division where there are high HEC incidents as well as high elephant population density per sq. km. Although the cases have decreased in Garo Hills, it is difficult to be absolutely certain that trend will be maintained in the future. Therefore, there is a need to stay on guard and even upgrade the conflict management policies. There are ample evidences that jhum cultivation in and around the corridors should be avoided (Choudhury, 2004; Perera, 2009). Land use and land cover of the forest area is rapidly changing into monoculture cultivation of specific crops and when other departments or NGOs initiate or implement such cultivation schemes, there should be in consultation and co-ordination with the Forest Department so that eco sustainability can be advised in the project.

Community Reserves are partially protected under the Indian Legislature (IWPA, 1972) but there is no legal protection on animal corridors (Talukdar et al. 2020). We must, however, laud the Forest Department on its rapid response in providing ex gratia payment of compensation via ad hoc relief in death and grievous injuries with imprest fund being available with the DFOs. In the recent CAG report (2017), it states that one of the reasons for the rise of HEC conflict in the state is due to lack of adequate manpower and mobility The efforts initiated between the two nations of India and Bangladesh to alleviate the transboundary migration issue

of elephants, is a positive step but has to be followed up and updated regularly. To some extent we have successfully attempted to map high conflict areas (Figure 3) but, we also believe that the figures and magnitude of the HECs could be underreported since this information is solely based on complaints submitted to the Forest Department. Therefore, we encourage more on-ground work to be done in order to get a more accurate information. All in all, there is also a dire need for a comprehensive land use policy from an ecological perspective whereby vulnerable ecosystems such as riparian zones, cave regions are legally prevented from developmental activities such as mining and monoculture cultivations.

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Lack of scientific intervention and increasing human-bear conflicts pose serious threats to the future survival of bears in India

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Abstract

India, one of the 17 megadiversity countries of the world, is home to four out of the total eight bear species of the world. The sloth bear is endemic to the Indian sub-continent with its current distribution in India, Sri Lanka and Nepal. The species has extirpated from Bangladesh and is extremely rare in Bhutan. Sun bear distribution in North-East states is the westernmost distribution range of the species, however, only scanty information exists on its distribution. In the case of Himalayan brown bears, the distribution range includes Jammu and Kashmir (UT), Ladakh (UT), Himachal Pradesh and Uttarakhand. The Asiatic black bear range extends across the Himalayan range in India. However, the distribution of all these bear species is patchy due to the loss and fragmentation of their respective habitats. There have been few detailed studies on these species across their geographical distribution range in India. Most of the information available is based on anecdotal records and due to the severity of human-bear conflicts. The nature of conflict varies from species to species and includes human casualties, crop damage and livestock depredation. Systematic efforts to monitor the species and their habitats are completely lacking. Since bears have not been accorded with the same status as it is for other flagship species there is hardly any scientific intervention to understand the ecological needs of the species and critical changes in their habitats in human-dominated landscapes outside the protected areas. Given the above-mentioned challenges conservation of various bear species in India requires immediate species-specific scientific interventions to monitor the status of both the species and its habitats.

Keywords: sloth bear, sun bear, Asiatic black bear, Himalayan brown bear, crop damage, livestock depredation.

Introduction

India, regardless of the fact that it has only 2.4% of the world's land area is among the 17 megadiversity countries of the world and accounts for about 7-8% of the recorded species of the world. Out of the total eight bear species worldwide four species of bears, with varying degrees of distribution, occur in India. These species are sloth bear (*Melursus ursinus*), Himalayan brown bear (*Ursus aractos*), Asiatic black bear (*Ursus thibetanus*) and Malayan sun bear (*Helarctos malayanus*). Available information indicates that sloth bears are the most widely distributed species in the country, Asiatic black bears distribution extends across the Himalayan range in the country whereas, sun bears distribution is limited to North-East states

and Himalayan brown bears distribution is limited to a few States and Union territories. Though bears are distributed widely in more than 26 states and Union Territories of the country mostly their distribution is patchy and a significant bear population exists outside the Protected Area network in a degraded and rapidly changing heterogeneous landscape. Detailed and updated information on the status and distribution of different bear species are lacking which is one of the biggest challenges in formulating any sound conservation and management plan for both the species and its habitats.

Summary of available information on bears in India

The sloth bear is endemic to the Indian subcontinent. Sloth bears inhabit a variety of habitats including dry and moist deciduous forests, scrublands and grasslands at lower elevations. It is the only bear species having morphological adaptations for myrmecophagy and a major part of their diet is insects and termites (Joshi et al., 1997; Bargali et al., 2004). The sloth bear is widely distributed in India and reported from 19 states (Sathyakumar et al., 2012) in India. However, the distribution is patchy and reliable information on the status of species across its range is completely lacking. The rangewide population estimates vary from 10,000 to 20,000 (Garshelis et al., 1999; Yoganand et al., 2006) however, these estimates are not considered reliable. The sloth bear is the most described species of bears in India that too mainly because of conflict with human beings (Bargali et al., 2005; Debata et al., 2016; Dhamorikar et al., 2017; Garcia et al., 2016; Mardaraj 2015; Sharp et al., 2020; Singh et al., 2018). In India, wildlife research and habitat management practices are primarily focused on protected areas and flagship species such as tigers and elephants however, a significant proportion of the sloth bear population exists outside the protected areas (Akhtar et al., 2004; Sathyakumar et al., 2012; Yoganand et al., 2006). Scientific information on such habitats and the status of sloth bears in such areas is hardly available. However, making a significant step forward efforts have been made under all India tiger population estimation project as other than providing detailed information on tiger population the report also provides information on occupancy of sloth bear populations in sampled areas, however mostly protected areas (Jhala et al., 2020). Habitat loss, degradation of available habitat, retaliatory killings due to human-sloth bear conflicts and trade in body parts are posing serious threats to sloth bear populations across their distribution range. The historic range of sloth bears in India has contracted by 39% in the past 50 years (Karanth et al., 2010). The current distribution range of sloth bear exists in India, Nepal and Sri Lanka, whereas, the species is very rare in Bhutan and has extirpated from Bangladesh.

The Asiatic black bear, with its distribution range extending across 11 states and one Union Territory, is also a widely distributed bear species in India. Its distribution range includes forested hills ranging from 1200 m to 3300 m (Prater, 1980) spreading throughout the Himalayas in north India and the Eastern Himalayan ranges and the hills of northeast India (70 m to 4300m) (Charoo et al., 2009). Asiatic back bear distribution range overlaps with that of sloth bear in lower altitudes (below 1200m), Malayan sun bear and Himalayan brown bear (above 3300m) (Bargali, 2012; Charoo et al., 2009; Choudhury 2011). There has been few detailed studied on Asiatic black bear in Dachigam National Park, Jammu & Kashmir (Charoo et al., 2011; Manjrekar 1989) whereas limited information is available from other areas of their distribution range (Bargali, 2012; Sathyakumar & Choudhury 2007). Demand for trade in body parts, conflicts with human beings and habitat degradation are among the main threats to existing black bear population in India (Bargali, 2012; Charoo et al., 2011; Choudhury, 2011). Degradation of habitat to meet the demand of developmental activities and local community dependency of forest resources are resulting in increased chances of encounter of human beings which in turn resulting in retaliatory killings. The Asiatic black bear is reported raiding villages for stored fruits and honey in Pir Panjal range of Jammu and Kashmir (Singh, 2007) and causing crop damage and livestock killing in Dachigam landscape in Jammu and Kashmir (Charoo et al., 2011). Likewise, incidents of livestock killing are also reported from higher altitudes in Uttarakhand (Bargali, 2012).

The subspecies of brown bear found in India is known as Himalayan brown bear (*Ursus arctos isabellinus*). In India, the Himalayan brown bear is reported to be distributed in the subalpine and alpine regions (>3300m) of the Greater and Trans-Himalayan regions of the States of Himachal Pradesh and Uttarakhand (Bargali, 2012; Rathore, 2008; Sathyakumar, 2001) and two Union Territories Jammu & Kashmir and Ladakh (Sathyakumar, 2001). Other than a detailed study on brown bear in Kugti Wildlife Sanctuary in Himachal Pradesh (Rathore, 2008) there is limited information available from other parts of its distribution range (Sharief et al., 2020). Habitat loss and human-brown bear conflict are the main threats to brown bear population across its range in the country. Existing populations are reported to be in very low densities and there is limited information available on nature of conflict from few areas on its range. Brown bears are reported to attack on sheep and goat herd and showing aggression to shepherds. Brown bears also reported causing crop damage to various crop species during April to November. In Himachal Pradesh the brown bear population is severely affected by poaching mainly by nomadic graziers to retaliate sheep and goat predation (Rathore, 2008). Likewise,

human-brown bear conflict and retaliatory killing is also reported from Ladakh (Chavan et al., 2021; Maheshwari et al., 2021) and Jammu and Kashmir.

The Sun bear with the short sleek coat is the smallest bear among the Ursidae. Sun bear distribution in India is limited to North-East states only. Except for Tripura, the sum bear is reported from Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur and Mizoram (Chauhan & Singh 2006; Choudhury, 2011; Sethy & Chauhan 2012). Sun bear sightings are rare and most of the information on sun bear from these states is based on questionnaire surveys of villagers, indirect evidence and camera traps. Habitat loss due to activities such as tree felling, shifting or jhum cultivation, construction of roads, coal mining and construction of dams is the main threat to the sun bear in North-East India. In addition, incidents of sun bear hunting or poaching for trade in body parts, meat consumption and retaliatory killings have been recorded from different part of its distribution range (Chauhan & Singh 2006; Choudhury & Rengma 2005; Sethy & Chauhan 2012).

Legal status of bear species

To protect the bears from illegal hunting and poaching efforts have been made at the local and international level by the concerned government and international conservation organisations. The sloth bear, sun bear and Himalayan brown bear are listed under Schedule I of the Wildlife (Protection) Act, 1972 whereas, the Asiatic black bear is listed under Schedule II of the Act. Other than the Himalayan brown bear which is categorized as “Least Concern” (McLellan et. al., 2016), the remaining three bear species are included in the “Vulnerable” category of IUCN Red List of Threatened Species (Dharaiya et al., 2016; Fredriksson et al., 2008; Garshelis & Steinmetz 2016). In the case of CITES, the Himalayan Brown bear comes under Appendix II, whereas, other bear species are included under Appendix I.

Threats to bear species in India

Though the sloth bear is the most widely distributed bear species in India but systematic efforts to evaluate the status of species in wild or their habitat did not get the required attention from research and conservation agencies. Available records on population estimation are based on questionnaire surveys (Garshelis et al., 1999) are quite old and need to be updated. Nearly half of the population of sloth bears in India is reported to occur outside protected areas (Garshelis et al., 2008; Puri et al., 2015; Yoganand et al., 2006) and such populations are exposed to

conflict with local communities. Incidents of human-sloth bear conflicts are reported from across the sloth bear distribution range in India (Bargali et al., 2005; Debata et al., 2016; Dhamorikar et al., 2017; Garcia et al., 2016; Mardaraj, 2015; Sharp et al., 2020; Singh et al., 2018). Human-sloth bear conflict in terms of crop damage and human casualties reflects the adverse impact on sloth bear populations across its range. The sloth bear has already vanished from the bulk of its range in Assam and northern West Bengal. Degradation of habitat is resulting in patchy distribution and isolation of population in low densities. The historic range of sloth bears in India has contracted by 39% in the past 50 years (Karanth et al., 2010).

The Asiatic black bear population estimation indicates 5400 to 6750 individuals in the country (Sathyakumar & Chouduary, 2007) but there has been no such evaluation for decades. Available information indicates that demand for trade in body parts, conflicts with human beings and habitat degradation are the main threat to the existing black bear population in India (Bargali, 2012; Charoo et al., 2011, Choudhury, 2011).

In India, the brown bear population are reported to be in very low densities and there is limited information available on the nature of the conflict. Habitat loss and human-brown bear conflict are the main threats to the brown bear population across its range in the country (Chavan et al., 2021; Maheshwari et al., 2021; Rathore, 2008).

Incidents of sun bear hunting or poaching for trade in body parts, meat consumption and retaliatory killing have been recorded from different parts of its distribution range (Chauhan & Singh 2006; Choudhury & Rengma 2005; Sethy & Chauhan 2012,). Habitat loss due to activities such as tree felling, shifting or jhum cultivation, construction of roads, coal mining and construction of dams is the main threat to the sun bear in North-East India.

Management Implications

Bears are among well-known species and they occupy a special place in different cultures and play an important role in several indigenous societies (Kemf et al., 1999). In India, bears have been revered as objects of worship for centuries and described in epic Ramayana as "Jambavan" the king of Himalayas. Bears have coexisted with local communities for thousands of years but overexploitation of forest resources to meet the demand of increasing human population and developmental needs have exposed them to direct conflict with human beings for resource sharing.

To protect its biodiversity India has a network of about 1000 protected areas covering about 5% of the total geographical area of the country. However, as it happens globally charismatic species have always been considered on priority both in terms of receiving the public's attention and as a focus for research and conservation (Kruuk, 2003). In India, most of the conservation initiatives are focused on conservation and management of protected areas which are primarily aimed at the conservation of charismatic species such as tiger, rhino and elephant. Considering tiger conservation focus on the protection of protected areas may be justified (Karanth & Gopal 2005; Walston et al., 2010), however, it cannot be justified for species such as bears having significant distribution outside the protected areas and where their interface with humans is high.

Although India is home to four bears and these species are widely distributed across several states, lack of information on status and distribution and overlooking bears in conservation priority at the policy level remains a serious constraint in bear conservation. Bears are bestowed with the same level of legal protection as it is for other charismatic species but they do not find a place among the species identified for priority conservation by the concerned government agencies, conservation organisations and institutions making research and conservation grants.

However, there have been some efforts in the last few decades where conservation organisations particularly a few civil society organisations came forward and gave attention to bear conservation. There has been a remarkable success in bear conservation wherein civil societies organisations in support of government and political leadership successfully curbed the dancing bear trade which had been there since the late Vedic era (1000-700 BCE) (D'Cruze et al., 2011; Seshamani & Satyanarayan, 1997). Another such serious and concerted effort was by releasing a National Bear Conservation and Welfare Action Plan in 2012.

For an effective bear conservation planning information on species spatial distribution, habitat-use patterns, human-bear interaction and anthropogenic factors is crucial, however, looking at the available information, which is primarily available due to human-bear conflict, bears are data deficient and available information is unreliable or scarce. Updated information on bear habitats and their ecological requirements is crucial in planning long term conservation strategies especially in multiple-use landscapes outside the Protected Areas.

Bears are a key indicator of ecosystem health they inhabit (Servheen et al., 1999). Outside the protected areas bears are the umbrella species (Puri et al., 2015) and maintenance of their

habitat will also provide ideal habitat to many other species in such habitats. Protection of natural habitats for bears will also provide multiple crucial ecological benefits to human populations in terms of a clean and safe environment to abating adverse impacts of climate change.

In conclusion, considering the status and threats to bears in India, it could be summarized that there is an urgent need for immediate policy interventions to consider bears as a priority conservation species, launch systematic scientific monitoring and implement conservation initiatives using both species-specific and site-specific conservation approaches.

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What is escalating Human – Bluebull/Nilgai interface issues in Northern India? An insight into the complex problem

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Abstract

Bluebull or Nilgai is a large herbivore, having a very wide distribution range and an endemic species of peninsular India. The present distribution ranges from Himalayan foothills, southwards through central India, down to southern part of Andhra Pradesh and expending in many part of arid and semi-arid part in west and absent in the north-east India, and the southernmost part of the peninsular region. Nilgai mainly occurs around human habitation and crop fields. Generally, found in variety of habitats, ranges from plains, undulating hills, scattered trees to the cultivated plains, whereas avoids dense forest and steep hilly terrain. In Rajasthan and Haryana, its distribution is wide and found almost all kind of habitats. Its population is high in outside of protected areas as compared to national parks and sanctuaries. They can be easily observed in the double cropping agriculture landscape areas. Their food choice also have wide spectrum of plant species and consuming almost every standing crop in the field. This is one of the largest wild herbivore, lives in moderate to large herds (all age group) and with the availability of better irrigation facilities in its distribution range, there breeding season also expended upto 8 months a year. Along with this, high nutritious crops and lack of predator (any) in these agro-ecosystems ensuring the high survival rate of fawns. In last 2 decades, this problem is escalating every year and responsible for high economic losses to the farmers. Additionally, in many parts of India, they enjoy complete protection, being regarded as a relative of cow, close to Lord Shiva and hence considered sacred by various communities. Northern states, especially Haryana, Madhya Pradesh, Rajasthan and Uttar Pradesh account for a large population (about 60%) of the total nilgai population in the country. The conflict issues laid a big divide between the farming communities and created uproar to formulate some policies to mitigate this problem. Very interestingly Bluebull/Nilgail can be classified one of the top human-wildlife conflict animal of northern India, if not for whole country. How an endemic antelope species become a problematic wildlife species? It gives us an insight to rethink on our conservation policies, religious believes as well as economic loses to the marginal farming communities.

***Keywords**:* Bluebull/nilgai conflict, human-wildlife interface, agro-ecosystem, economic loss, wildlife conservation.

Introduction

Bluebull or Nilgai (*Boselaphus tragocamelus* Pallas, 1766) is the largest antelope in Asia, about the size of horse. An adult male stands upto 140 cm at shoulder height (Walker 1968, Prater 1971). Average body weight could be around 250-270 kg (Prater, 1971). Nilgai calves and cows (female) are light brown in colour. The light brown colour of male calves begins darker from tenth month and they develop black legs and brownish grey shoulders by the end of two-year age. Adult nilgal bulls (male) are steel-grey or blue-grey in colour with black legs, which is developed by the fourth year (Sheffield *et al*., 1983). Both the sexes have dark and white markings on their heads, ears, under-parts and tail, and prominent white vibrissa spots on the head. At the midpoint on the ventral side of the neck is a tuff of hair, more pronounced in bulls than in cows (Sheffield *et al*., 1983). Only male nilgai have horns which are short (15- 20 cm), stout, conical and smooth in nature. All individuals have dark and white markings on their heads, ears, under-parts, fetlocks, and tail. In Rajasthan, it is locally called as *Rojara*, whereas in Haryana and Panjab it is being called as *Roz.*

It is an endemic species of peninsular India and antelope of grassy plains along with sparsely forested areas as well as a common animal of scrubland-grassland mosaic habitats. In past, they were used to found all over the Indian Subcontinent, from the peninsular tip to the drier areas of Central India as well as the Himalayan foothills and all the way upto the Central Bangladesh beyond the Ganges-Brahmaputra barrier

The present distribution of nilgai ranges from Himalayan foothills, southwards through central India, down to southern part of Andhra Pradesh and upto semi-arid part in west and absent in the north-east India, and the southernmost part of the peninsular region. It has been also reported from Pakistan, especially near the Indian border (Mirza and Khan, 1975, Roberts, 1977), In Nepal, it is widely distributed in protected areas of Terai region at Indo-Nepal bordering zone, the southern plain of Nepal. It occurs in seemingly viable numbers in Koshi Tappu Wildlife Reserve in the east, Parsa National Park in the middle, and Shuklaphanta National Park and Bardia National Parks in the west (Aryal, 2007, Aryal et al., 2016, Khanal et al., 2018). In past upto 1970s, nilgai used to be found in few area of Bangladesh like Panchagarh, Thakurgaon and Madhupur villages, which had a good habitat for this antelope. Later it becomes extinct due to excessive hunting and habitat loss. Surprisingly, in 2018, lone nilagi was spotted in Ranisankail area of Thakurgaon, followed by 5 more nilgai reported from

Thakurgaon, Naogaon, Panchagarh and Chapai Nawabganj districts (TBS Report, 2021), as this antelope is claiming its old distribution range, which makes its present eastern most distribution limit. The introduced population also successfully breeds in U.S.A., Mexico and South Africa (Lever, 1985).

Nilgai mainly occurs around human habitation and crop fields. Generally found in variety of habitats, ranges from plains, undulating hills, scattered trees to the cultivated plains, whereas avoids dense forest and steep hilly terrain (Blanford, 1888). In Rajasthan, its distribution is wide and found almost all kind of habitats. Its population is high in outside of protected areas as compared to national parks and sanctuaries. The can be easily observed in the double cropping areas. In many parts of India they enjoy complete protection, being regarded as a relative of cow, close to Lord Shiva and hence considered sacred by various communities. Northern states, especially Haryana, Madhya Pradesh, Rajasthan and Uttar Pradesh account for a large population (about 60%) of the total nilgai population in the country (Sankar et al., 2004).

General ecology

Nilgai are social animals, and lives in small groups ranging from one to ten, whereas their group size varies seasonally. In Sariska, seasonal group size varied greatly, from two to 43 individuals, with a mean group size of 4 individuals per group (Sankar, 1994). There are total three distinct kind of social grouping was recorded (Schaller, 1967), (i) one or two cows with young calves, (ii) three to six adult and yearling cows with calves, and (iii) all male groups of different age classes, varying in number from two to 18. A group of all male class was recorded with a maximum 27 individuals from Khimsar region (Distt. Nagaur, Rajasthan) during a survey in winter season (*S. Dookia Per. Observ.*). Their social structure and number of family members changes constantly during breeding and non-breeding season.

The sex ratio in Nilgai population is always females biased with an average of 0.4 to .89 male: 1 female in wild, whereas in captivity it was ironically same as male (Jarvis, 1968). The female: calf ratio for free ranging nilgai is 1: 0.23 to 0.48. The higher number of young in nilgai, as compared to sympatric ungulates can be attributed to twinning and strong defence of calves by cows making them less vulnerable to predation (Kyle, 1990, Sankar, 1994).

The rutting season varies from place to place, Schaller and Spillett (1966) reported during the rainy season (June to October) and breeding activity occurred from October to February, with

a peak in November and December. It has a gestation period of between eight to nine months (240 – 260 days), often gives birth to twins (Fall 1972, Sheffield et al. 1983, Bagchi et al. 2008) and may have triplets (Fall 1972, Sheffield et al. 1983), even quadruplet was also reported from near Jodhpur (Rajpurohit, 1988) and quintuplets (5 babies at one times) was also observed near Jalore in Rajasthan (S. Dookia, Per. Observ.). This shows that with good habitat and nutritious food supply, their breeding biology is also altering at some places.

Breeding biology

During the breeding season, the bulls move about in search of breeding cows (female nilgai is known as cow and male as bull), and upon finding one, defend the area around her from intrusions by other males - a system described as 'roving territoriality' (Sheffield et al. 1983). Mature bulls maintain an area of dominance around themselves, whether or not cows are present. Breeding bulls respond to intrusions into these areas from other bulls by displays, threats, and chases, which either results in the intruding bulls leaving, or remaining in the area in a subordinate status. Courtship in nilgai is simple and involves a neck-stretched-forward, tail erect display by the male, showing the conspicuous white ventral side, and following the female in oestrus during a slow, sedate mating march.

Food habits

Nilgai is a browsers or mixed feeders. It can thrive upon variable proportions of grass, herbs, and browse, subject only to a minimum requirement of protein, which must not be below 8 per cent of their intake. A study of ungulate food habits in Nepal (Dinerstein 1979) indicated that sambar and nilgai feed on the same browse species. Apart from this, there is little information available on the dietary overlap between nilgai and other wild ungulates. According to Rodgers (1988), the large size of nilgai means they can exist on much poorer quality food items, making them coarser browsers. They are also fond of raiding crops and are regarded considered as pests in agriculture fields. Their ability to reach up to a great height helps in reaching and gaining accessibility to forage on lower canopy of trees. At many times, it was observed that nilgai standing on hind legs and feeding on *Zizyphus mauritiana*, *Tecomela undulata* and *Prosopis cineraria* branches, leaves and fruits (*S. Dookia pers. observ*.). It is very generalist in diet and can feed on variety of plants available round the year.

Water dependence

The availability of surface water influenced the distribution and movements of many animals including nilgai. According to Prater (1971) nilgai can go for long periods without water, and even during the hot weather, nilgai do not need to drink water regularly. Nilgai are reported to be water independent even in desert areas (Bohra et al., 1992). The water availability in western Rajasthan, after systematic planning and canal irrigation, increased many folds. This provided ample opportunity for nilgai to explore newer areas and its population increased catastrophically in irrigated areas. As per records available with Desert National Park authorities, no nilgai was reported till 2004-5. Invasion of nilgai started through Indira Gandhi Canal Project side (from Bikaner towards Jaisalmer) and now it is common in many parts of Jaisalmer district, can be seen regularly in Desert National Park too.

Material and Methods

A general survey and stakeholder discussion was conducted to understand the Nilgai encounter rate and people's perception towards its day-to-day interface with local farmers in and around Jodhpur, Nagaur and Pali district of western Rajasthan. Along with this, questionnaire survey (opportunistic) was also conducted in Haryana and other parts of Rajasthan too.

Results and Discussion

A large bodied wild antelope, nilgai is one of the common wildlife in agriculture dominating landscape of Northern India. Out of 345 respondents, 209 were from double cropping agriculture areas where as 136 was from rain fed agro-ecosystem zone (Fig. 1). This gives an interesting insight, almost 95% of farmers from double cropping system clearly said that nilgai is a serious crop pest and damages variety of crops and remains problematic year round (Fig. 2). Whereas, only 22% respondents from rain fed agro-ecosystem area classified this as a moderate to serious crop pest (Fig. 3). This give an opportunity to understand that availability of year round high nutritious food and lack of any large predator around agriculture fields gives an edge to nilgai and places them into conflict category. Though none of the respondent came forward to cull the problematic nilgai, but at the same time they spent quite a high proportion of their working hour on guarding the fields day and night. Even at some fields, farmers make a cluster of fields and hire local tribal person as a field guard and pay the charges to keep nilgai

at a bay from their fields. Some of the farmers also had local solar powered electric fence to keep their field safe from nilgai and other crop pests.

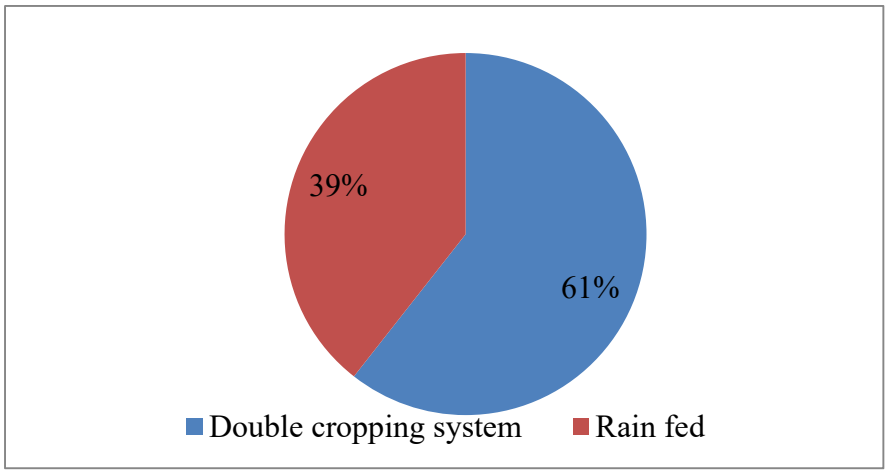

Figure 1: *Farmer's survey sharing between double cropping pattern and rain fed agriculture system in Western Rajasthan*

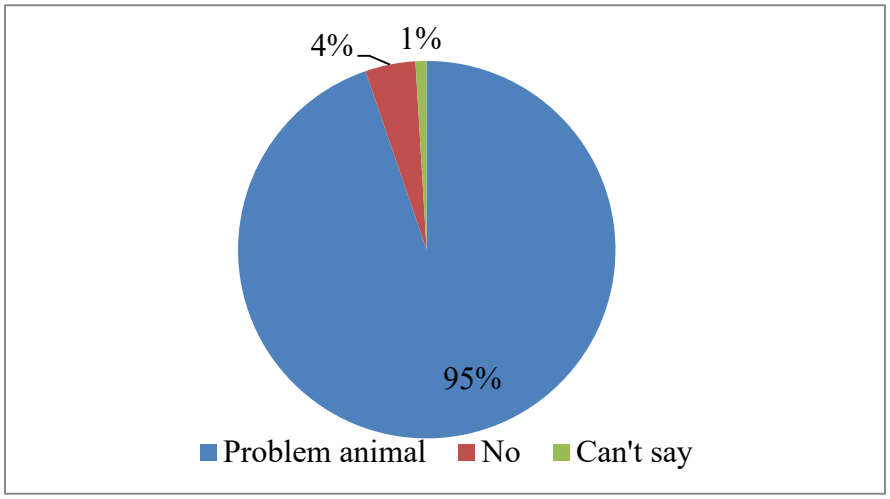

Figure 2: *Status of NIlgai as Crop pest in double cropping agro-ecosystem in Western Rajasthan*

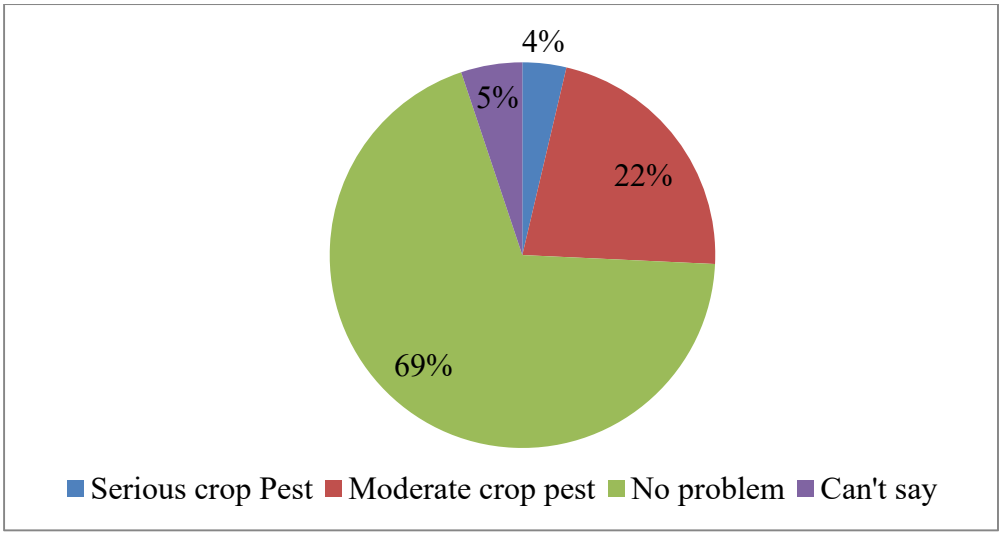

Figure 3: *Status of Nilgai as moderate to no Crop pest in rain-fed cropping agro-ecosystem in Western Rajasthan*

During survey, data on its sighting and nearby habitat was also recorded. Out of 1596 sightings in 2 years long survey, 75% direct sightings were reported from or near area of agriculture fields. Whereas 13% sightings were from plantation areas of Gram Panchayat, followed by Natural landscape or Oran/gauchar land was of 7% and 5% from wastelands (Fig. 4). This shows how the entire area converted into agriculture dominating landscape and the same is being utilized by free ranging wild antelopes as their habitat. These animals are born and brought up in this type of agro-ecosyetem where availability of food is year round and that is also helping them to reproduce for longer time in comparison to the nilgai present in any protected areas. In the study area territorial fights between adult nilgai and young ones with females were seen throughout the year, without any specific seasonal trend.

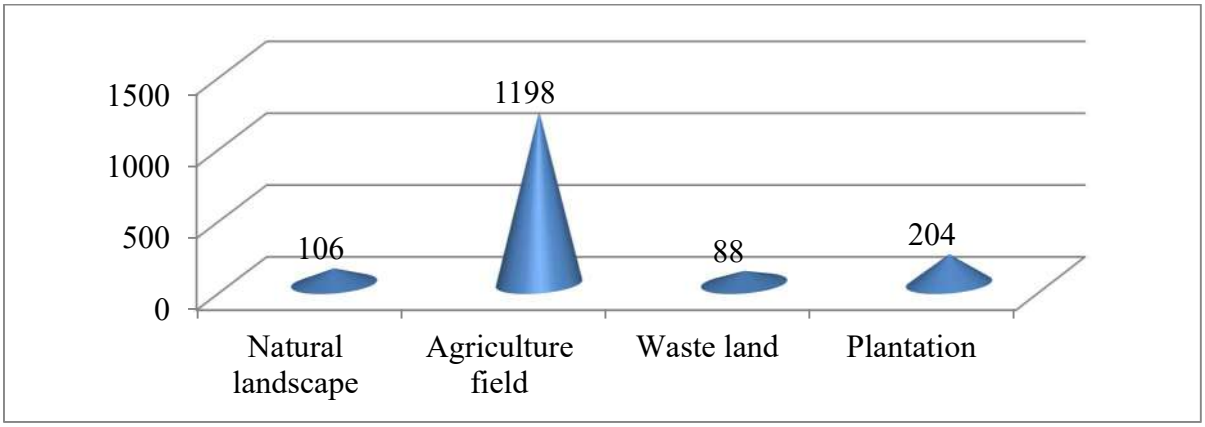

Figure 4: *Sightings of Nilgai in different available habitats*

In Conflict as Crop Pest

Because of conversion of wastelands, grassy and open plains to agricultural lands coupled with religious sentiments attached to it because of its local vernacular name, nilgai (meaning blue cow – cow being holy and sacred for Hindus), the animal has grown in numbers outside protected areas rapidly. This expansion of agriculture, and rapid growth in its population, has been cause of destruction of crops by it in most of the states of the country. Out of the 16 states where it is found, the states of Bihar, U.P., Rajasthan, Gujarat, Haryana, Punjab, Madhya Pradesh and Uttarakhand are the worst affected

Being large in body size, without natural predator in its distributional range, gives it an advantage to roam freely in the vast landscape in large herds. It prefers open grassland and savannas, is a significant agricultural pest in India and is endemic to the Indian subcontinent (Leslie 2008). Locally called *rojara,* it is infamous for destroying crops, Blue Bull menace is sometimes a topic of discussion in the corridors of power, especially in state assemblies. Lack of predators of this antelope couple with its high growth rate due to multiple births (generally one fawn but twins, triplets and quadruplets are also observed in western Rajasthan) this species has increased considerably and become locally overabundant in many states viz. Gujarat, Uttar Pradesh, Haryana, Punjab, Rajasthan, Madhya Pradesh and Delhi, thereby causing serious problems which include damage to crops leading to huge economic losses to the farmers. It causes considerable annual damage to agriculture, property, human health and safety, and natural resources. Agro-ecosystems have provided many new opportunities for vertebrates to exploit, resulting in their becoming serious "pests" with humans taking various steps to protect their agricultural resources. This conflict has intensified as the human population has increased, efforts to get more production out of traditional croplands have intensified, and marginal lands have been placed into crop production. Additionally, as the human population has increased, people have moved into lands occupied by wildlife, resulting in more human-wildlife encounters and conflicts.

Management in Agriculture Landscape

The overall population has been reduced in the overall range of nilagi, but the existing populations seem to be doing well. This is largely because of they are a protected species under the law, and more importantly the protection they acquire from considered sacred due to their resemblance to domestic cow. The constantly degradation of the natural forests, absence of large predator and the increase agricultural activities, has offered favourable habitat conditions. Invariably, this situation forced nilgai to become serious crop pests as crop raider and a major issue of human-wildlife conflict problem. One of the possible solutions is include a selective culling programme linked to licensed hunting permit under Section 62 of the Wildlife Protection Act, 1972 (WPA), to allow large-scale culling of wild animals (as recently used by State of Bihar). So far, only section 11 (b) of WPA, under which the state chief wildlife warden can permit hunting of wild animals, has been widely used by states to contain wild animals. Despite of the severity of the problem, very few come up to get license for culling.

Possible mitigation strategies to reduce crop damage include use of fear provoking stimuli, chemical repellents, fencing agricultural areas, capture and translocation, sustained harvesting, and reproductive management of nilgai populations. These management options are discussed herewith:

(i) Fear Provoking Stimuli: Fear-provoking stimuli are on-site devices by which animal's fear can be generated. These are visual (e.g. scarecrow, predator models, powerful lights) auditory (e.g. firecrackers, noise devices, siren, explodes, distress calls) and olfactory (e.g. predator odours). Most of the fear-provoking stimuli are effective for few days only as animals get quickly habituate to them. These stimuli have limited and have short term applicability. To get better effectiveness of the used stimuli, it should be altered frequently so that animal does not get habituated. Generally wild animals have a fear of loud sound. This can be used as a sudden sound burst, like fire cracker or programmed loudspeaker sound on the boundary of agriculture fields. If the same is repeated frequently and with a fixed interval in playing of such sound can lead towards learning by nilgai and it can be futile exercise in long run. Keeping this in mind, it can be used intermittently.

(ii) Chemical Repellents: All animals have likes and dislikes smell of certain chemicals. Repellents used in control of crop depredation by herbivore species are generally plant based or safe synthetic chemicals. When sprayed on the target crops it gives odd test through olfactory cues to animal for avoidance. One such chemical is known as Phorate. It is also known as Thimate and gives unpleasant smell for many days, from spraying sites. It is an organophosphate and used as insecticide and have toxicity to human too, so use of this chemical with caution. It has been reported by them that repellent effectiveness is influenced by its concentration, test duration, field size, plant palatability, availability of alternate forage, season of use and weather. Repellent use in India has limitations due to wet climate. However, it may be effective to protect high value crops during critical periods of its life cycle.

(iii) Fencing Agricultural Fields: Fencing is one of the best and non-lethal ways to keep away all unwanted animals. Since nilgai is known for jumping and crossing fences easily, height of fence should be minimum 6-7 ft. There are various ways of fencing, traditional fence, barbed wire fence, chain-link fence, green fence, etc.

a. Traditional fence: This is the most commonly used fence, where an earthen mound or 5-6 ft high and is covered with dead thorny bushes.

b. Barbed wire fence: Multiple barb wire can be used to fence the agriculture field. The distance between the wires can be reduced to make it more effective.

c. Chain-link fence: This is another wire fence where wire mesh of different sizes comes in market, and as per the requirement, it can be erected around the field. There is no barb in the wire, hence, humane way of keeping nilgai away from the field.

d. Power Pulsating fence: Keeping away ungulates through fences or netting is one of the most effective and widely used methods. However, for containing blue bulls, high fences with several strands (7-8) would be required. It is usually expensive and therefore viable only in case of high economic value crops. Another important aspect in exercising this option is regular maintenance of fence to ensure its effectiveness. We recommend a 8 strand power fencing with wires on the height of 30, 60, 90, 110, 130, 150, 180 and 225 cms from the ground level (see figure below). In drier areas, two strands may be earthed. The cost of Blue bull proof power fence will depend on type of posts (wooden/iron) and accessories

(brand) used for its construction. Average cost for an 8 strand power fence would be anywhere between around Rs. 4 to 5 lakhs per km. Cost per km would be lower as the length is increased.

e. Green fence: This is one of the best ways to keep unwanted animals away from the crop fields as well as humane approach for controlling crop pest. There are various hardy and fast growing plants with long thorns and spines. For growing these plants, earthen mound is required. Sowing the seeds or planting these plants during monsoon season can allow them to grow faster. Within 2 years, the fence of these plants can make a good green fence, which is even not allowing bird to cross. If nilgai attempt to cross, the thorns and spines will leads to severe pain and in future the same animal will not attempt to cross.

(iv) Capture and Translocation: As name suggests, all the problem animals required to be captured and translocated. Wildlife translocation is another option. This option, though useful for quick mitigation has its own limitation. One of the limitation is that the translocated animals may adversely impact other wildlife with new pathogen at new sites. Screening for disease is recommended before considering any translocation for restocking a depleted habitat. This requires a large fund, details of number of animals, technical expertise and permission from forest department, as nilgai is a wild animal and listed in Schedule III of Wildlife (Protection) Act, 1972. This work is not possible without support from concern authorities and scientific expertise. Large numbers of methods are available for physically restraining the deer and antelope species. These are: drop nets, drive nets, net gun, rocket nets and specially designed corrals. Adult Blue bull being large and strong will be difficult to handle in drop nets, drive nets, net guns and rocket net. The only suitable option available therefore is specially designed corrals to be constructed in open areas and allow blue bull to enter by providing lure food. Once confined, they can be taken out in boxes placed at mouth of the narrow tapering. Relocations of problematic animal, for the time being, seem the safest solution, but these problem animals start creating problem in the newer areas.

(v) Chemical Capture of Nilgai or Bluebull: The Blue bull are the biggest Asian antelope. They are strong and fast moving. Chemical capture of these animals is challenging and require skillful team and equipment. Widely used chemical immobilization and capture drugs for Blue bull include Etorphine hydrochloride, Xylazine hydrochloride in combination with Ketamine, and Meditomidine hydrochloride can control the adult

animals. These are all scheduled drugs and only certified veterinary practitioners should use.

(vi) Fertility control: Fertility control is a method employed to keep wildlife population under check. This is generally done by mechanical and surgical intervention, endocrine disruption or immunocontraception. Each of these methods has advantages and disadvantages in managing wildlife population. Current efforts to control free ranging deer (white tailed deer, mule deer, elk deer and fallow deer) rely on use of immuocontraception, especially PZP (Porcine Zona Pellucida). In India, we are not having any reference study on this method, which required to understand its efficacy in a control condition.

Scientific Management options for Nilgai problem in for the state of Rajasthan

Owing to religious sentiments of the society, ill-informed animal activist groups and hyperactive civil societies and complicated procedure associated to be followed upon, the authorized officers under the section 11 (2) (b) of the Wildlife (Protection) Act, 1972 remained reluctant in passing such orders of elimination of problematic nilgai. As the he socio-economic conditions are a bit different in Rajasthan as compared to Gujarat, the Gujarat model can be tried in Rajasthan before switching to declaring blue bull as vermin under section 62 of the Act. Success chances of implementing the Gujarat model in Rajasthan with respect to authorization of sarpanchs under section 11 (2) (b) of the act cannot be ruled out and depend on how we simplify the associated post elimination procedure of the problematic animals. In addition, awareness and sensitization programmes for the villagers and public sarpanchs may play a major role in dealing with the problem. As long as there is balance between the tolerance to economic loss and religious sentiments, the farmer will be reluctant to kill the so called "gai" unless until if the balance is skewed more towards economic loss. In that case he may opt for eliminating the problem animals.

Declaring the species as "vermin" and to be brought in Schedule V of the under section 62 of the Act. Section 62 of Wildlife (Protection) Act empowers the central government to declare by notification wild animals other than Schedule I and part II of Schedule II to be vermin for specified area and period. It should be viewed as short term strategy and due care has to be taken by the decision makers and wildlife managers for using this option in a particular area for a particular period of time. For the same proper monitoring of the population of the target

species has to be done by independent agency to know the status and demographic parameters. For the purpose, the status survey of the species has to be conducted using the help of scientific institutes so that the extent and magnitude of the problem can be quantified for decision making. The prevalent population estimation based on annual water hole count is unscientific, biased and always lead to unrealistic figures.

Government of Rajasthan has already exercised the legal option of allowing elimination of problem animals from agriculture landscape (i.e. areas outside notified forests), however even after these orders have been in force for many years now the problem of crop depredation by Blue bull has not been contained. Government of Rajasthan in its different orders P.11 (27) Forest/91 dated 3.3.94, P.11 (27) Forest/91 dated 19.1.96, P.11 (27) Forest/91 dated and 30.4.1997 authorized officers up to the rank of Range Officers for giving permission for the killing of blue bull under section 11 (1) (b) of Wildlife (Protection) Act, 1972. Subsequently vide its order F.11(27) Forest/91 dated 31.8.2000 Rajasthan government authorized Collector, Superintendent of Police, Sub-divisional officers, deputy superintendent of Police, assistant conservator of forests, *Tehsildar*, *Naib Tehsildar* and *thana* in-charges in all of Rajasthan for the purpose. So far none of the authorized officer has given permission for the purpose.

Conclusion

This wild antelope is well adapted in the agriculture dominating landscape of northern India, lack of any natural predator, decrease of fellow or buffer land around the villages forced nilgai to become a crop pest. Many of these suggested remedial measures are constantly being tried here and there, but the problem is also either constant or increasing. Therefore, a national level policy decision is required to understand this issue and joint efforts should be done through involvement of all stakeholders like forest department, local panchayat bodies, agriculture department as well as livestock or animal husbandry department to help the poor farming communities

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From conflict to cooperation in the Indian Sundarbans

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Abstract

The mangrove forests of the Sundarbans, spread across India and Bangladesh, are considered to be one of the world's seven most important wetlands for biological diversity. It is the only coastal wetland habitat globally with a uniquely adapted population of tigers (Panthera tigris). The tigers are excellent swimmers, adept at hunting and living within the harsh, muddy mangrove forests. From rising sea levels, erosion, and storm surges to the impacts of human-tiger conflict, tigers in the Sundarbans remain among the most threatened species in the country.

The Indian Sundarbans – home to more than 4.5 million people – comprises an ecosystem that directly supports subsistence activities such as fishing, crab hunting, and the collection of non-timber forest products. Access to such resources, except in the Protected Areas, plays a crucial role in supporting the livelihoods of the rising human population. An increasing population also means an increased risk of human-tiger interactions, resulting in loss of lives. On average, approximately five people are killed by tigers each year. Saline intrusion in agricultural fields, declining agricultural productivity, soil erosion, and extreme weather events have forced traditional farmers to take up fishing in estuaries, thus increasing negative interactions between tigers and humans.

The Forest Directorate (FD), Government of West Bengal, has initiated interventions to deter tigers from straying into the villages and measures (such as encircling the area with nylon net fences to avoid both human and tiger casualties, placing cages to trap the tiger, chemically immobilizing and relocating tigers from villages or agriculture fields to the forests) to address the situation post straying. There are 65 Joint Forest Management Committees (JFMCs) functioning in the region, and 40% of the tourism revenue flows into the JFMC account for implementing micro plans – an integrated participatory development plan. As these measures increase the trust between the FD and local community, not a single straying tiger has been killed since 2001. In collaboration with research institutes, civil societies are implementing climate adaptive agriculture and pisciculture practices in the region. Such practices withstand salinity shock while reducing associated livelihood risks. The programs empower the forest fringe communities of the Sundarbans Biosphere Reserve both socially and economically through enhanced access to livelihood assets in a changing climate.

Though the stated slew of interventions benefits the forest-dependent communities in building overall resilience, they are only temporary fixes. Current development planning processes, especially at the district level, are complex and involve multiple stakeholders with varied capacities and mandates. In the face of growing threats from climate change coupled with human-wildlife conflict, the stakeholders need to plan for transformational programs in sector

development, including agribusiness, livelihoods, entrepreneurship development, micro, small and medium enterprises, human resource development, capacity building, and institutional strengthening, among others, in coordination with line departments to increase the resilience of agricultural livelihoods and foster coexistence between humans and tiger in the Sundarbans. This would also help the stakeholders realize the global goals on Sustainable Development and policymakers the causal factors of human-wildlife conflicts.

Keywords: *H*uman-wildlife conflict, sector development, sustainable development, coexistence, and climate resilience

Introduction

The Sundarbans mangrove forests in their entirety in India and Bangladesh, based on biological diversity, are considered one of the seven most important wetlands globally (Junk et al., 2006). The entire Sundarbans landscape in both India and Bangladesh covers an area of around 10,000 sq km, while the Indian Sundarbans, in the state of West Bengal, is a cluster of low-lying islands in the Bay of Bengal, spread over an area of around 4000 sq km. Over time, the new set of conservation values from scientific forestry confronted with the desire to extract common property resources has helped the Sundarbans to work its way up the ladder of protection, first becoming Reserved, and Protected, then a Tiger Reserve, then a National Park and, finally, a World Heritage Site and a Biosphere Reserve, as well as a Ramsar Site.

The Sundarbans is a microcosm for examining global dilemmas of development, ecology, and competing values. It is the only coastal wetland habitat in the world and is home to a uniquely adapted population of tigers (*Panthera tigris*). It also contains more than 10% of India's mammal, fish and crustacean population as well as approximately 19% of its bird population (Danda et al, 2017).

The Indian Sundarbans (Map 1) is also home to 4.5 million people, with the ecosystem directly supporting subsistence activities, such as fishing, crab hunting, and the collection of non-timber forest products. Access to such resources, except in Protected Areas, plays an important role in supporting the livelihoods of the burgeoning human population. An increasing population also means an increased risk of human-tiger interactions, with people being killed by tigers when they fish and extract honey within the forests. With traditional farmers being forced to turn to fishing due to saline intrusion in their agricultural fields, declining agricultural productivity, soil erosion and extreme weather events; fishing in the estuaries leads to overfishing and several

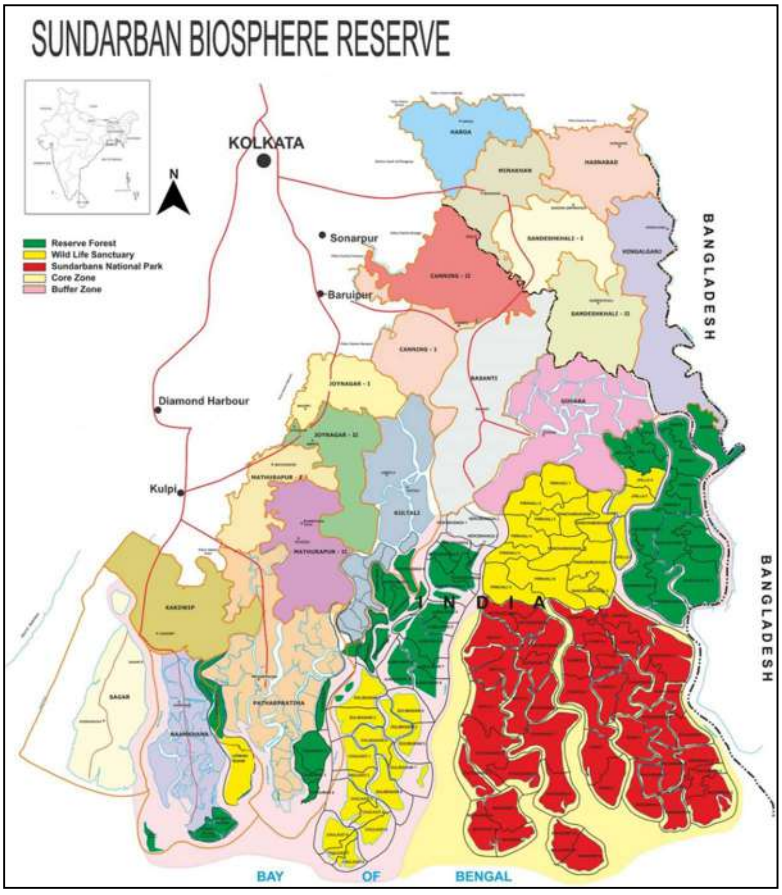
incidents of negative interactions between tigers and humans. The Intergovernmental Panel on Climate Change (IPCC), in its Fifth Assessment Report (AR5), has marked out the lower Bengal Delta for high risk of coastal flooding and wetland loss in the 21st century. Any depletion of bioresources from the Sundarbans will impact other departments, such as fisheries, agriculture and forestry, all of which are closely linked with livelihoods. Negative interactions also affect the relationship between the Forest Department and the local communities.

Post-independence, multiple agencies handle the region's administration, but the governance and management have remained fragmented. Negative interactions can have consequences that extend beyond the directly affected communities and wildlife. If not managed effectively, such interactions have the potential to negatively affect not only the concerned people and animals, but also conservation and sustainable development initiatives at scale. It can also weaken production systems and other businesses in the local economies.

The estimated cost of environmental damage associated with ecosystem degradation and biodiversity loss is about 6.7 Billion[1] per year. It accounts for about 5% of the estimated GDP of the Sundarbans in 2009. Because of the lack of relevant data, this estimate of total damage only partly captures losses due to mangrove degradation and overfishing. Among the categories of costs of environmental degradation, the cost of damages from cyclones are the highest (USD 2.9 billion), followed by losses from tiger prawn post larvae by-catch (USD 2 billion) and carbon revenue losses[2] (USD 0.8 billion). The cost of damages due to soil salinity is USD 0.6 million, biodiversity loss is USD 0.2 billion, and preventable sea level rise cost is equal to USD 0.045 billion (Danda et al., 2011).

[1] Estimated using average exchange rate in 2009 1 USD= INR 45

[2] Carbon revenue losses take the form of opportunities to obtain carbon financing that are foregone as a result of ecosystem degradation.



Map 1: *Sundarban Biosphere Reserve*

Current development planning processes, especially at the district level, are complex and involve multiple stakeholders with varied capacities and mandates. In the face of growing threats from climate change coupled with human-wildlife conflict, and issues like poverty, public health, education and food and water security need immediate attention. It is thus imperative to ensure that adequate measures are incorporated in the district plans to address these threats. Though there can be no fixed set of actions, emphasis may also be given on engaging local communities in conservation activities towards effective adaptation and resilience building.

This paper explores the climate-induced changes in the Indian Sundarbans; how these concerns can potentially result in weakening the resilience of the landscape; and why it is important to integrate them into development planning and management for the region through measured strategic responses in agriculture and enhanced cooperation between the government departments moving forward.

Ethnography of forest use and victims

Since 1893, under various working plans, the Sundarbans forests were subjected to clear-felling operations with natural regeneration, and a large workforce (staff and labour) used to be deployed for the forest felling. The tigers were always a threat to the workforce, and conflict was imminent with tigers as well as people losing their lives (Curtis, 1933). Despite best precautions, numerous accidents have taken place in which the tiger has either killed or injured the staff or labour. Since the inception of the Project Tiger in 1973, the core area of the Sundarbans Tiger Reserve has been kept free from all exploitation activities, including harvesting of timber and fuelwood. The felling of forests or coupe operations had stopped in the Sundarbans from 2001 onward.

Open access resources, except in protected areas play an important role in supporting the livelihoods of the people in the Sundarbans. Though forested areas offer varying degrees of protection, permits are available for the utilization of forest resources and fishing within the forested areas by fishermen (*jele*). Fishing is not allowed in Protected Areas. Of the total of 9630 sq. km. of the Indian Sundarbans, while a total of 78.13% of the area is open for fishing, 21.87% area remains closed. Within the forest areas, fishing is permitted in 50.31% of the area. The Sundarbans forest and nearby water resources are officially managed by the State Forest Department. The fishing permits or Boat licence certificates (BLC) are registered with the Forest Directorate on payment of usual registration fees, plus a royalty for dry firewood is to be collected and consumed in each fishing trip. Apart from fishing, wild prawn seed collection and crab collection is also an important activity.

Fishing is a major source of livelihood for the communities living in the fringe area of the Sundarbans. However, several fishing boats in the permissible areas have been regulated through the Boat Licence Certificate (BLC) by the Forest Department to lower the fishing practice in the creeks near the forest. These BLCs are issued to individual boat owners and are non-transferable. The BLCs need to be renewed on an annual basis upon payment of the registration fees based on the capacity of the fishing boat. The BLCs were first issued in the 1980s to individual boat owners. Each BLC carries the name and address of the boat owners as well as the description of the boat. At present, there are only 700 BLCs are in circulation for the extraction of fish within the designated areas of the Reserve.

There is also a group of specialists in honey-gathering, the *moulis* (perhaps from the colloquial Bengali word for 'honey,' *mou*), who carry out the honey collection (legally with permits or otherwise) during the spring and early summer months when forest flowers are in full bloom. During this time these men, track the course of bees (*Apis dorsata*) and, by measuring the velocity of the wind, calculate the exact location of the beehives. About 1500 honey collectors are given permits to collect honey for a fixed quantity. This collection is purchased at a pre-declared price in tune with the minimum support price to the Forest Department. The honey collected is processed and marketed by the West Bengal Forest Development Corporation.

Human-tiger conflict in the Sundarbans

The Sundarbans tiger is different from any other tiger in the country as well as the world because of its adaptability to the mangrove habitat. Their behaviour is largely individual-specific and cannot be generalized from the studies on other tigers of the world or the country, even so in the Sundarbans itself. The role that the tigers play as a top predator is vital to regulating and perpetuating ecological processes and systems (Sunquist et al., 1999). They are seen as an adaptable species because of their ability to tolerate a wide range of physical conditions and habitat types in the Sundarbans. The tiger conflict in the Sundarbans is either due to people entering the mangrove ecosystems with licence permits or otherwise to fish and collect non-timber forest products, such as honey, or because of tigers 'straying' into the forest fringe villages.

Forest offence for 10 years (2008-2018) shows an increasing trend in offences and indicates a high eco-resource dependence and potential exposure to the conflict situation. Of the approximately 3000 cases recorded in the 24 Parganas (South) forest division over the same period, fishing-related offences were the most prevalent (Fig 1). In the Indian Sundarbans, 789 persons have been attacked by tigers (of which 423 were fishermen) between 1986 and 2008. Between 2000 and 2015, the count was more than 450 people, where most of the victims were dependent on natural resource extraction (fishing, crab collection, tiger prawn seed collection, honey collection and fuelwood collection) (Fig 2).

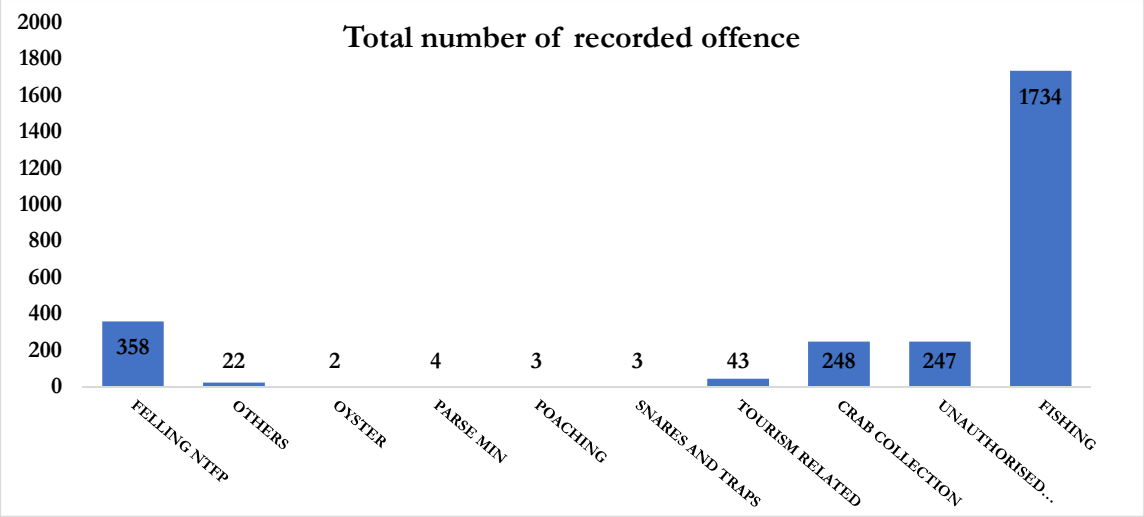


Fig 1: *All recorded offences in 24 Parganas (South) forest division, Sundarban Biosphere Reserve over a period of 10 years (2008-2018).*

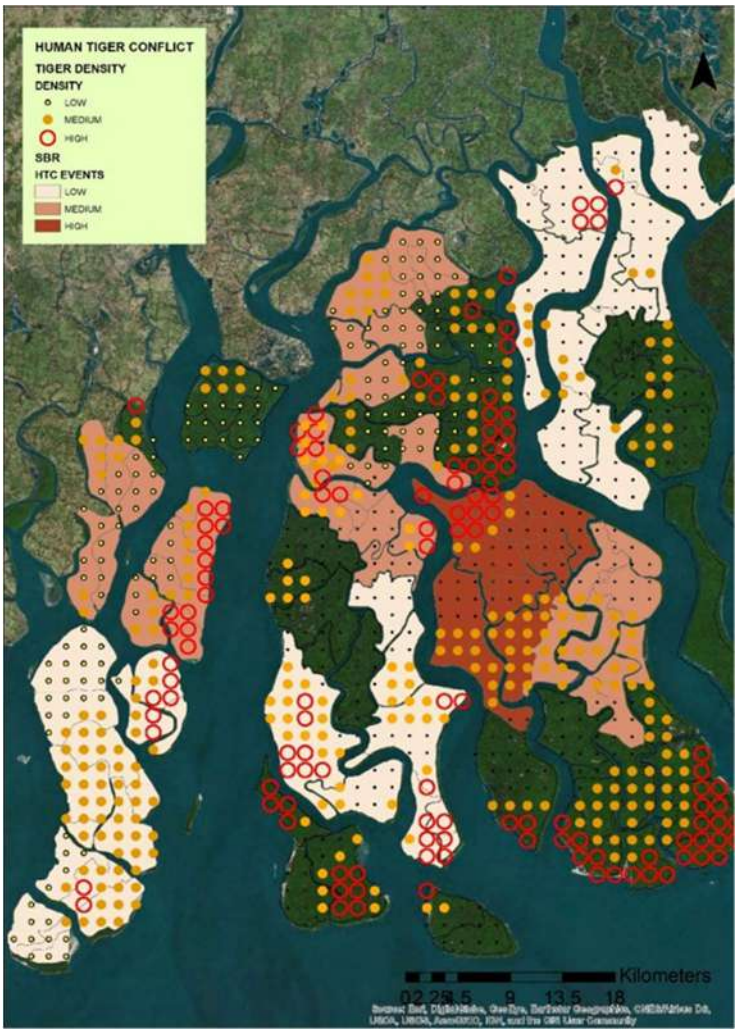


Fig 2: *Number of victims of tiger attack in SBR during 2000-15 as per the records of the Forest Directorate*

Vulnerability of Climate Change on the Sundarbans

Cyclonic activity

Cyclones are the most severe and frequent in the Sundarbans region. The Bay of Bengal has seen nine of the 14 deadliest global tropical cyclones in history, and the frequency of such cyclones is likely to remain unchanged owing to the erratic/extreme rainfall pattern (World Bank, 2014). In addition, the change in weather patterns and increased storm surges will intensify the destructive impacts of cyclones (IPCC, 2014). It will, in turn, increase the depth of inundation across larger areas . Moreover, storms that form over the Bay of Bengal are more likely to strike land in the near future owing to their semi-enclosed shape. Therefore, with the increase in cyclonic storms and landfalls, the Sundarbans will also become more prone to a deadly melange of climate change impacts (Dasgupta et al., 2014).

Sea-Level Rise

In the Sundarbans, the maximum centennial-scale Relative Sea Level Rise (RSLR) is estimated to be 0.9 ± 3.3 cm per year. The current rates of sea-level rise will bring recurrent coastal flooding and cause erosion and saltwater intrusion (Hanebuth et al., 2013). At this pace, the increase is likely to decline mangrove coverage and salt marshes unless a well-established estuary management mechanism is in place or the region has sufficient fresh sediment to keep pace. It can also increase the backwater effect in the coastal rivers and move the saline front inland, which will happen much earlier than now and remain for a more extended period of time. The phenomenon will prevent proper draining of water and result in inundation of the land. Moreover, recurrent flooding may increase the rate of sedimentation/siltation in the swamps and creeks in the area. It can trigger permanent inundation of the forest floor. Therefore, flooding from storm surges continues to be a challenge to preserving embankments, as they can completely wipe them out from the region (Townend et al., 2002).

Erosion

Mangroves protect coasts against natural hazards, such as tsunamis, storms and erosion. But sea-level variations, including tidal hydraulics, cause erosion of the estuary and coastal margins, thereby reducing the land area and raising the floor of the channel. It inundates areas for a longer period of time. As a result, the entire southern part of the Sundarbans has retreated.

The west-central section of the region, which falls between the Saptamukhi and the Gosaba estuaries, records the highest erosion rate, reaching up to 40m a year. Data suggests that the total erosion in the Indian Sundarbans in the coming 30 years can be around 162.879 sq km (Hazra et al., 2010).

Consequences to the forest ecosystem

Excess sea surface temperature and atmospheric CO_2 are getting absorbed by the ocean at the rate of 49 Gigatons/annum, affecting the carbonate system of the ocean. Altered carbonate chemistry and ocean acidification change biological food-webs of aquatic organisms (phytoplankton, zooplankton and algae, among others and organisms like bivalves that need carbonate in their development and for forming shells and skeletons. Such alteration can affect the rich fishery resources in the Sundarbans region, which are dependent on planktons and may lead to a large-scale ecological disaster in decades to follow. Subsequently, this change will directly bear the economic loss and impact 6,52,500 fishermen of the total population that inhabit the eco-region through decreased fishery and crab harvests (Mukherjee, 2004).

A rise in sea level directly impacts the habitat structure for the avifauna of the Sundarbans because they use coastal mudflat habitats. Wintering and breeding populations of these birds, namely wildfowls, waders, and passerine birds, are majorly affected. They can start breeding earlier, timings of migrations can be changed, along with changes in breeding performances (egg size and nesting success), distribution pattern, as well as selection differentials between components of the population. The influence of sea-level rise on invertebrates depends on compensation by sedimentation (Beukema, 1992).

An increasing trend in the mean maximum ambient temperature has been noted (Mishra, 2002), indicating the delayed onset of monsoons and increased concentrations of CO_2 in the atmosphere. Elevated CO_2 concentrations result in decreased nitrogen investment in leaves and a concomitant increase in the carbon: nitrogen ratio of plant tissues, which have flow-on effects to consumers (Stiling et al., 1999) and on decomposition processes; nutritious leaf material with low C: N ratios have higher decay rates (Bosire et al., 2005). Decreased precipitation results in a decrease in mangrove productivity, growth and seedling survival and may change species composition, favouring more salt-tolerant species and loss of the landward zone to un-vegetated hyper-saline flats (Snedaker, 1995) and resulting in a net loss and disruption in the stability of the ecosystem (Shaver et al. 2000).

Consequences to coastal agriculture

Natural as well as climate-induced hazards, such as sedimentation, embankment erosion, salinity incursion, storm surges and recurrent flooding, impact the productivity and production trend of agriculture in the region. These hazards are bound to influence the lives and livelihoods of the local communities as they identify agriculture as an important occupation even though it doesn't bring notable/visible economic prosperity in the region, given the existing infrastructure and opportunities. Data shows that the average monthly income of the agrarian community from cultivation and rearing of livestock is about 16% lower than the all-India figure (136%) because of the average cropping intensity in the Sundarbans subdistricts. These changes disturb the socio-economic foundation of these local communities, leading to poverty, hunger and out-migration from the region.

A study by DECCMA on Climate Change, Adaptation and Migration in the Indian Bengal Delta cites that of the total households surveyed, 18% of them recorded out-migration. Around three per cent of the people had migrated to other regions due to direct, prolonged environmental stress. The study further found that 23% of the current non-migrant households will possibly migrate in the future because of multiple impoverishment risks (DECCMA, 2019). However, these concerns are often missing in development planning strategies for the region.

A maze of government agencies

As discussed above, the administration of the region has been handled by multiple agencies since independence. Despite having the Sundarban Development Board (SDB) since 1973, the Sundarbans Biosphere Reserve since 1989, and subsequently the Sundarban Affairs Department (SAD) since 1994, the region lacks a specific development plan or strategy. Only in the last couple of years have there been talks of setting up Sundarbans District in India and was likely to be formed by October 2016.

Administratively, the region comprises 19 blocks that fall within two separate districts: North 24 Parganas and 24 Parganas (South). At the state level, the administration of different areas of governance is overseen by the departments assigned sectoral responsibilities. The two departments that have the broadest administrative influence over the Indian side of the Sundarbans Delta are the SAD and the Forest Department. There was a move in the 1970s

favouring the creation of dedicated agencies for geographical areas that were viewed as socioeconomically backward (Danda, 2007). The SDB was initially created in 1973 in response to this. In 1994, the SAD was developed as a dedicated department under which the SDB was subsumed. The SAD was conceived originally as a coordinating body, primarily to oversee the integration of activities by other agencies but carries out activities similar to the mandates of other agencies, such as the forests, fisheries and agriculture departments (Living with Climate Change, Centre for Science and Environment, 2012).

The state's departments in charge of fisheries, forests, agriculture, irrigation, panchayats and rural development, disaster management and power are working at cross-purposes in the Sundarbans region, further confusing responsibilities and duplicating execution (Fig 3). For example, the Forest Department controls forest resources, including the collection of non-timber forest produce (NTFP), prawn seedlings and timber. It undertakes a wide variety of development works independently, but its decisions and prohibitory orders can have an immediate impact on what is perceived as the domain of other departments, such as fisheries and irrigation, which builds embankments. Similarly, the agriculture department distributes seeds, fertilizers and pesticides, but does not have a say in the construction of embankments or management of the freshwater aquifers that make cultivation possible. So, development in the region is very slow because of the lack of coordination between multiple agencies working there.

Management of all conservation areas falls under the Forest Department, with the Chief Conservator and Director of the Biosphere Reserve bearing ultimate responsibility at the state level. Under this level, a Joint Director oversees the management of two Deputy Forest Officers who are respectively responsible for areas of the SBR that fall under (i) 24 Parganas (South) and (ii) the North 24 Parganas divisional blocks in West Bengal, India. A separate Field Director for the Tiger reserve operates at the same level as the Joint Director and is responsible for a staff body of Deputy Field Directors and Rangers. The department has implemented a slew of measures to gain community trust and ownership in tiger conservation in the past two decades. Activities include generating alternative livelihoods, controlling straying of animals by using Nylon Net fencing along the forest boundary, using 'Tiger Guards' as a protection measure, reducing "Reaction Time" through improved communication measures, deploying speed boats, allowing traditional honey collectors to place boxes inside the camps and their subsequent branding, building the capacity of the staff to capture tigers by automated trap cages

and raising awareness among the locals. These have collectively resulted in the reduction of human-wildlife conflicts in the region. Currently, 65 Joint Forest Management Committees are working, and 40% of the tourism revenue flows into the JFMC account towards building constituencies for tigers.

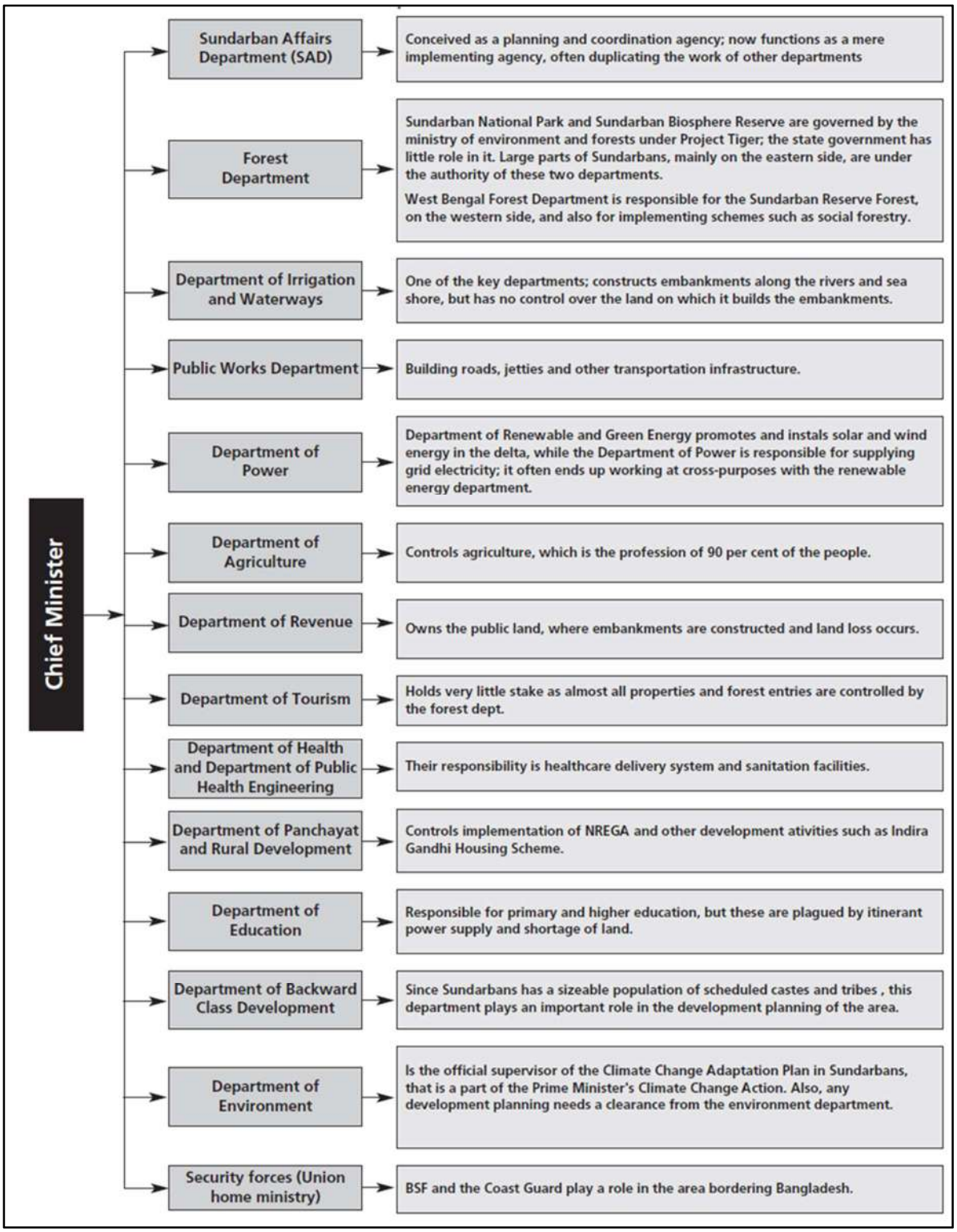


Figure 3: *Multiple Agencies working in the Indian side of the Sundarban Delta*

There is a broad suite of sectoral departments operating in the Sundarbans, ranging from energy provision to agriculture to education. Each department is generally working towards fulfilling policy goals that include targets and priorities that feed down to the district and sub-district levels. In the Indian side of the Sundarbans Delta, the development deficit has often been attributed to the fact that the administration is handled by multiple agencies, which tend to work at cross-purposes as said above or duplicate work in the absence of a specific development plan or strategy.

Emerging trends and local communities

The five trends in Fig 4 represent human and environmental processes that are exceptionally large in geographical extent and magnitude and are difficult to reverse. These trends are driven by a complex set of factors that are external to rural communities. These factors include biophysical processes shaping environmental dynamics (for example, forest mega disturbances), as well as political and economic processes driven by private and public elites (for example, large-scale infrastructure development). Their effects result from the interactions between these external forces and local dynamics and responses. The five trends constitute new challenges to our understanding of forests and livelihood links and are likely to influence forests and livelihoods through a series of mechanisms.

These emphasize the importance of novel actors (middle-income group), new technologies (ICTs and digital monitoring platforms), increasing mobility patterns (changing gender relations and circular knowledge exchanges) and changing dynamics (forest mega disturbances and rapid infrastructure development). They also highlight key mechanisms through which these trends are likely to affect forests and forest livelihoods, including new conservation priorities, shifting agricultural and extractive frontiers, land abandonment and changing agricultural practices, and monitoring and evaluation tools (Oldekop et al., 2020). Current development planning processes in the Sundarbans, especially at the district level, are complex and involve multiple stakeholders with varied capacities and mandates.

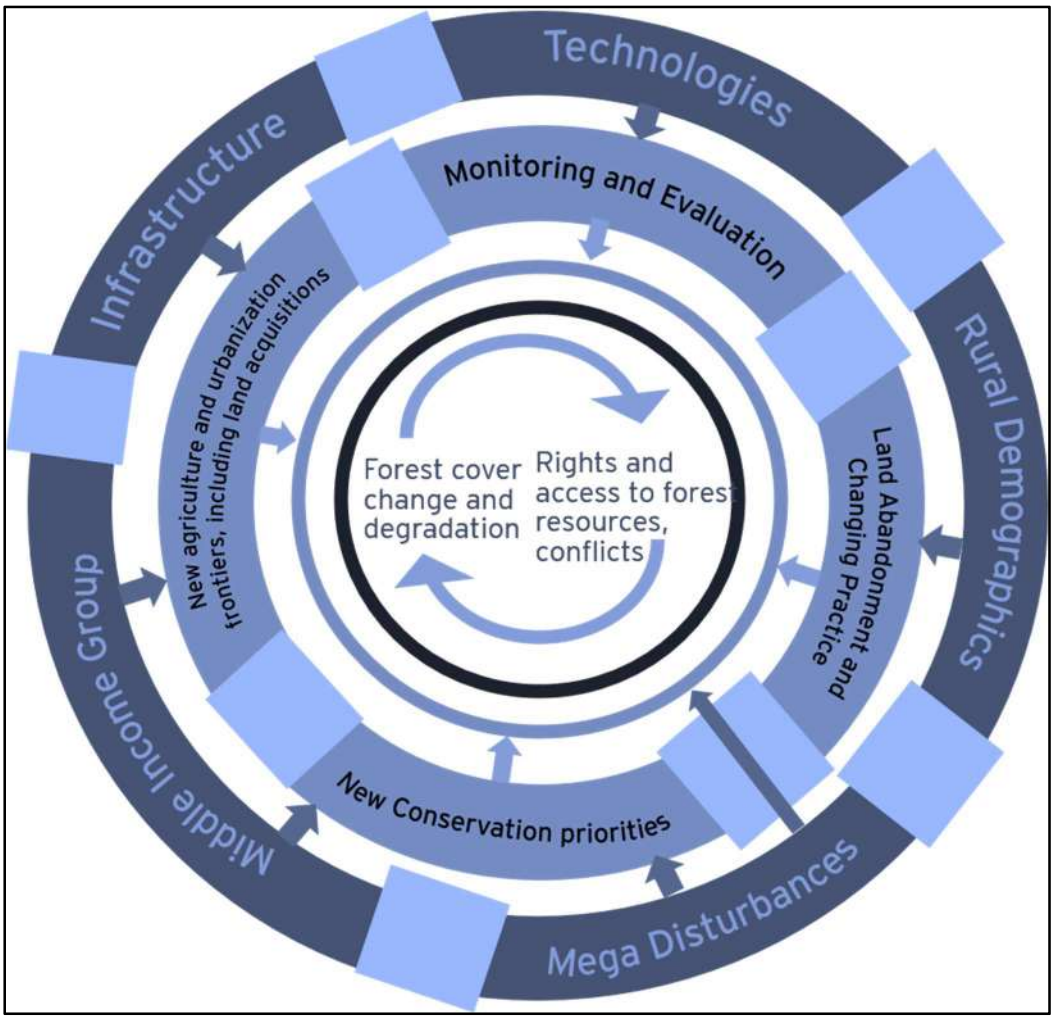


Figure 4: *Conservation priorities and linkages*

Hence, it is required to design a robust knowledge management framework for the landscape and habitat management and for agricultural resilience of the Sundarbans, which will look into ways of adaptation, enhancing yield from the existing agricultural assets and managing crop risk. A resilient farming system will ensure the provision of the system functions in the face of increasingly complex and accumulating economic, social, environmental, and institutional shocks and stresses through capacities of robustness, adaptability and transformability. The issues of resilience need to be addressed with a focus on the Sundarbans context in which farming systems operate because farms, farmers' organizations, service suppliers and supply chain actors are embedded in local environments and functions of agriculture. A more dynamic and inclusive agricultural sector can dramatically reduce rural poverty, helping countries meet the Sustainable Development Goals.

Communities of Practice

Applied ecology lies at the intersection of human societies and natural systems. Consequently, stakeholders are constantly challenged when it comes to using knowledge to influence the management of any ecosystem. An informed stakeholder analysis is required to be carried out to develop a state-wide knowledge platform, which will consolidate the experiences and key insights of the stakeholders into institutional, technical and participatory aspects of collective natural resource management interventions and their effects. The analysis will identify key institutional actors at the central and state levels responsible for policy regulation and public investments in nature conservation and management. Subsequently, these institutional actors must be facilitated to create and sustain Communities of Practice in a manner that fosters cooperation and collaboration to drive on-the-ground development impact. The key issues in the inter-organizational process also need to be identified to develop a stepwise approach to get a grip on critical knowledge gaps and implementation barriers using the Knowledge Framework (Dalkir, 2005).

The Knowledge Framework (Fig. 5) comprises four segments: knowledge development, knowledge sharing & transfer, knowledge harmonization, organization & storage and knowledge application. The four segments are part of a cyclic process to enhance the development of the stakeholders towards the implementation of set program goals. It is envisaged that the barriers will be related to environmental data, networks, capacity building and policy.

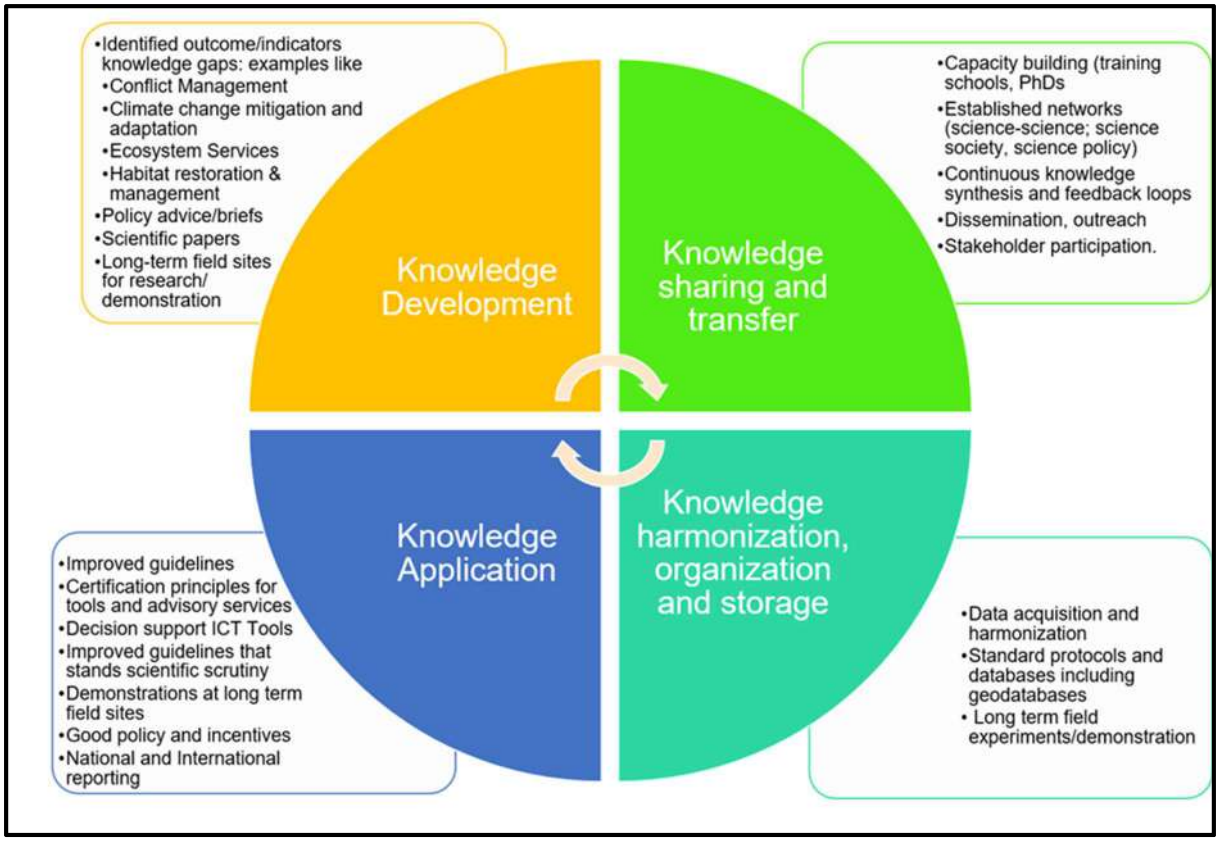


Figure 5: *Representative analysis of the gaps using Knowledge framework*

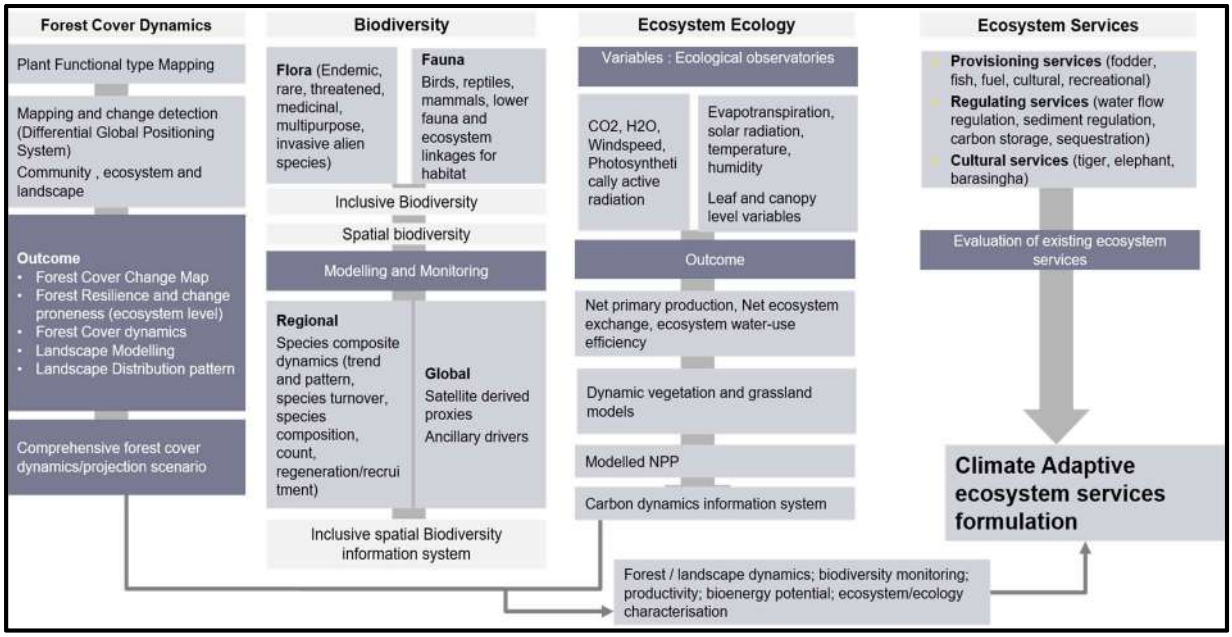


Figure 6: *Knowledge management framework for landscape and habitat management*

Knowledge management framework for landscape and habitat management

Environmental management has often been carried out based on partial information and local expertise, with practitioners relying on intuition, past experiences and anecdotal evidence in their decision making (Sutherland et al., 2004). It has led scientists and environmental managers to call for better integration of science and management practice to promote a shift towards evidence-based decision-making in conservation. There is a growing necessity to better understand the nature of the relationships between environmental attributes and estuarine species/communities to enable meaningful action against the impacts of environmental change in river ecosystems. The framework in Fig 6 aims to investigate causal relationships rather than the study of statistical correlations or the use of expert opinion, as is generally the case.

Growth Nucleus Micro-Production Arrangement

A holistic inclusion of the small and marginal farmer is possible through a farm-based business. The following table (Table 1) depicts the current process that is generally followed across agrarian society across Sundarbans:

Following outcomes are envisaged:

1. Form a Farmers' Collective (farm-sector specific) and promote it as a business entity for micro-production arrangement (MPA) and subsequently develop a Micro-Economic Zone. There will be more than one farmer's collective based on the nature and intensity of the sectors present in a situation, e.g., Agri-Horticulture Collective, Goat Rearer's Collective, Fish Producers Collectives, Poultry Producers collective and NTFP collective.
2. Consider rural entrepreneurs as a one-stop solution for all needs of small and marginal farmers
3. Develop farmer service centres to avail and access advanced knowledge and information for small and marginal farmers and rural entrepreneurs
4. Community-owned seed banks, Agri-Horti processing, Farm Produce Aggregation units, and Marine Aquaponics units

Table 1: *Barriers in Rural Agri Ecosystem in Sundarban*

Sl. No	Process	Concerns/Barriers
1	A developmental action plan is prepared in Gram Panchayat with the village-level participation	Development constraints and vulnerability context are not considered in planning Household-level farm produce mapping is missing or not documented
2	Developmental schemes are accessed by individuals and through the convergence of schemes	Convergence of schemes and their implementation is a tedious task and is only successful when officials from the block and district levels take a personal interest in their implementation
3	Small and marginal farmers will often package their commodities and sell them to an aggregator	Capital and credit linkages Modern agriculture inputs Irrigation and land development avenues Soil mapping and convergence with a soil health card Skills to deal with environmental and weather shock Weak market linkages Weak transport facilities

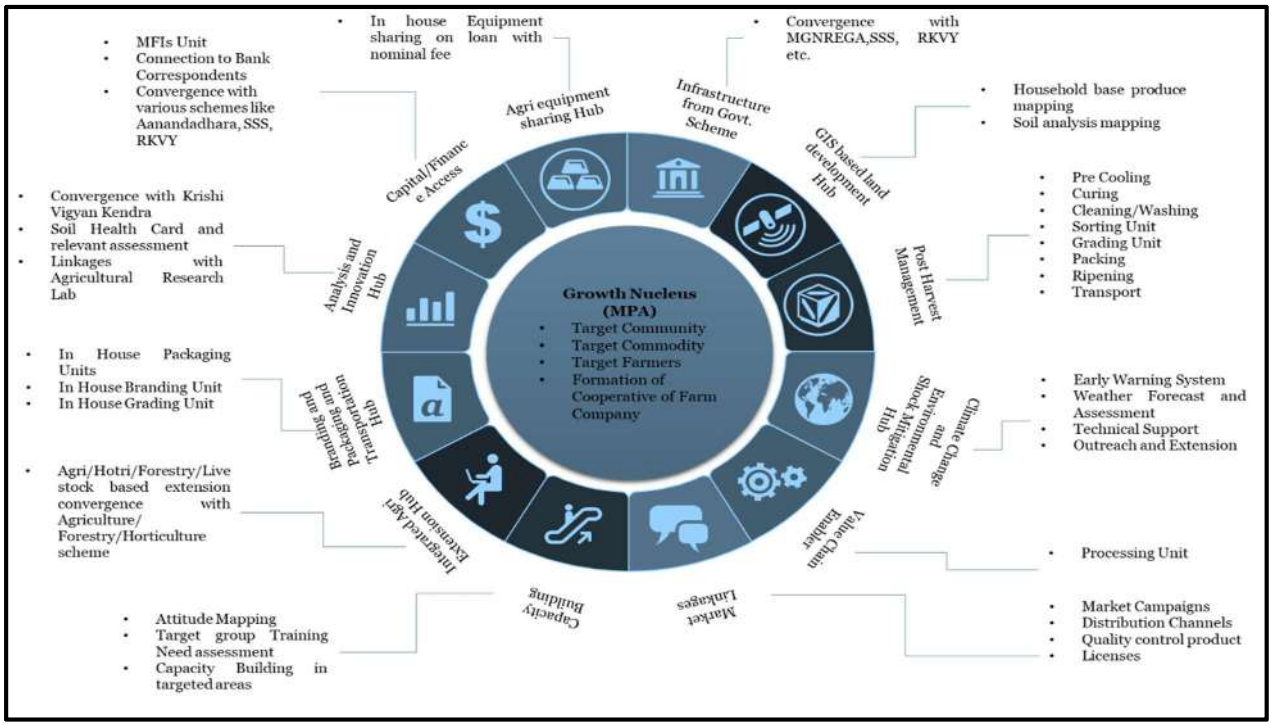


Figure 7: *Growth Nucleus Micro Production Arrangement Ecosystem*

The first step is to initiate a 'Growth Nucleus' (MPA) Creation (Fig 7) comprising villages with around 200-250 households. To ensure that small and marginal farmers are included in the high-value farm-based business transaction, a localized farmer collective needs to be established, too.

Conclusion

Ecological stability in the region is generated more by the diversity of its functional groups than by species richness. Knowledge of these factors and functional groups are important in predicting ecosystem resilience and stability. However, an understanding of the factors that maintain ecosystem integrity in the Sundarbans remains incomplete mainly because of the complexity of its natural systems and functional groups. There is relatively little knowledge on the status of the Sundarbans ecosystem resilience and biodiversity groups contributing to it. The loss of ecosystem values will weaken the ability of the system to adapt to catastrophic changes on longer time scales, given the climate change stressors in the Sundarbans. It is thus important for the government entities or agencies to come together on a single platform and share their best practices to remove the existing challenges.

Besides, understanding associated climate risks in the region and having a value chain approach will help analyze the climate risks at all stages beyond production to make the value chains more sustainable. As adaptation occurs in response to multiple stresses, it highlights the need to connect adaptation with development strategies and plans and disaster risk management. Therefore, developing adaptation plans involving development needs and challenges becomes key in view of addressing the climate vulnerabilities of the region. However, the effectiveness of the adaptation measures (included in the plans) can reach its limit with greater magnitudes and rates of climate change. In this hour, a long-term planning perspective will increase the likelihood of immediate adaptation measures enhancing future options and preparedness; where all levels of government need to work together in addressing the drivers of climate change as well as plan and integrate actions at multiple levels.

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People, Wildlife and Weeds: Understanding Changing Ecosystem and Sociological Dynamics in Response to Invasion

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Abstract

Invasive species have been recognised as drivers of socio-economic change. Their varied roles as predators, facilitators, vectors, competitors etc. have been extensively studied and identified. Human dimension of invasion has recently gained momentum wherein the role of invaders is being understood in human-dominated ecosystems or anthromes. One such species, Lantana camara, which has emerged as a noxious weed in the global perspective, has been rendering multi-trophic cascading effects. In this study a primary assessment is done to understand the effects of Lantana on agriculturalist society in the vicinity of tiger reserves of central India and Western Ghats landscape. An attempt is undertaken for the first time to explore the probability of weed as a facilitator for human-wildlife conflict. The gregariously spreading and dense thickets of weeds have been providing alternative cover value to conflict-ridden wild animals, which is supported by empirical evidence through this study. The perception of farmers in identifying Lantana as damaging to the crops, both directly and indirectly has been established. Furthermore, the baseline study provides evidence that due to the encroachment of unpalatable weeds into wildlife habitats, the forage value retrogrades, forcing ungulates to move towards edges and human habitations and in turn attracting predators. This study proffers the theory of increased human-animal interface issues, a research question which needs to be investigated extensively.

Keywords: Human-wildlife conflict, social perception, weed, Lantana camara

Introduction

Invasive alien species (IAS) have been recognized as drivers of socio-ecological changes (Shackleton et al., 2018). Their negative impacts can be identified under their roles as predators, competitors, alien-native hybridisation facilitators, vectors, or ecosystem engineers (Goodenough, 2010; Doherty et al., 2016; Fei et al., 2014; Duenas et al., 2018). However, the varied and well-studied negative implications of invaders have a skewed report for native vegetation (Raizada et al., 2008; Babu et al., 2009; Prasad, 2009; Kohli et al., 2012; Simba et al, 2013, Mandal & Joshi, 2015; Hiremath, 2018; Ahmad et al., 2019;), while minimal representation for their effects on wild animals (Kohli et al., 2006; Sampson et al., 2018; Solanki and Gopal, 2020) or in the sociological context.

In the recent years, Human Adaptations to Invasive Species (HAIS) has emerged as a ripe subject for study across human-dominated ecosystems or anthromes (Howard, 2019). According to Rejmanek (1995), the inter-related and inter-changeably used terms 'weeds', 'colonizers' and 'invaders', can reflect different viewpoints as being: 'anthropocentric' (growing at undesirable places and interfering with people's needs), 'ecological' (appearing early in successional series), or 'biogeographical' (spreading into non-native ranges). In the social or anthropocentric context, any plant species is conferred the status of a weed depending on how it interferes with the everyday activities of the society (Binggeli, 2001). As summarised by Shrestha et al. (2019) four broad categories of their negative impacts on local communities can be quantified in terms of their impacts on agricultural production; livestock poisoning; reduced forage; and biodiversity loss. Weeds represent one of the oldest and serious problems in agriculture and natural resource management where their perceived role as a pest is known to render pronounced effects on society and livelihoods (Gaddeyya & Kumar, 2014; Bajwa et al., 2019). It is stated that 'weeds are as old as agriculture', yet the social dimension to invasion ecology has started gaining momentum only recently (Yaduraju et al., 2015; Shrestha et al., 2019). Most widespread invasive species are agricultural weeds (Binggeli, 2001) which are known to reduce crop yield or hamper their produce and disrupt fuel or fodder provisioning (Khadka, 2017; Pradhan et al., 2019), and continue to be one of the major threats to cropped and non-cropped Indian lands (Yaduraju et al., 2015). At the national level, weeds have been estimated to cause an annual loss of over 11 billion USD to the agricultural sector alone (Gharde et al., 2018).

It has been noted that people's perception and responses to invasion are variable and often influenced by their interests and knowledge about the local environment, their community or context and/or by their dependency on the invaded system (Binggeli, 2001; Khadka, 2017; Head 2017). Their impressions about IAS are dubious and complex for areas where human livelihoods are directly dependent on biological resources (Howard, 2019). According to a recent study by Reynolds et al. (2020), it was indicated that landscapes with poorer households and those which rely on provisional ecosystem services were at more likely to be affected by invasive species. With majority of its Protected Areas having their long histories of forest management and traditional use of resources by local forest communities for fuelwood & NTFP collection, grazing etc. (Hiremath & Sundaram, 2013), it is evident that the risk will be more pronounced for Indian forest dwellers and other dependent communities. The impacts of such plants on economies and subsistence communities (Rotherham, 2005) due to declining forage

availability leads to important repercussions on the productivity, use cost and security attributes of their cattle and livestock (Kent & Dorward, 2015). Apart from that, the range of the recognised social impacts usually come at the cost of increased livelihood vulnerability due to loss of livelihood assets or outcomes (Shackleton et al., 2019). Depending on these perceived interests, local land managers are known to either voluntarily curtail their spread or promote the same via active or passive means (Hall, 2009).

Weeds and invasive plants are also known to affect wildlife either by altering resource availability, influencing habitat suitability or biotic interactions (Aravind et al., 2010; Grice et al., 2013). They reduce availability and access to forest resources like firewood, medicinal plants etc., and have negative impacts on crop production and livestock carrying capacities (Shackleton et al., 2007). They can also modify herbivore feeding behaviour by limiting food resources and rendering forage areas unsuitable (Choudhury et al., 2017; Murphy et al., 2013; Wilson et al., 2014). Weeds can act as temporary feeding or roosting sites (Zandstra & Motooka, 1978) and have also been known to provide shelter to small carnivores (Blaum et al., 2007). These altered ecosystem patterns can lead to novel interactions having multi-trophic and multi-faceted consequences on both people and wildlife. In that view, the present study, which is first of its kind, professes the concept and role of weeds in facilitating human-wildlife interface issues. We limit our study to the infamous weed of pan-tropical origin, *Lantana camara* (hereafter Lantana). A weed of national as well as global significance, Lantana has emerged as a grave threat in our country (Kent & Dorward, 2015). It is known to negatively affect grazing, cropping and NTFP outputs in India (Kent & Dorward, 2015; Howard, 2019), while also being attributed to reducing the productivity of forest grasses (Kent & Dorward, 2015) and forage availability for animals (Shrestha et al., 2019), leading to financial losses and restricted human mobility or access to land (Shackleton et al., 2019). Impaired agricultural productivity and decline in agrarian livelihoods due to its extensive spread has been reported by several studies (Mandal & Joshi, 2015; Terefe, 2015; Shackleton et al., 2017). It also hinders animal movement and narrows the size of available farmlands creating difficulties in crop cultivation (Alemu & Assefa, 2015).

Though deemed unsuitable and unpalatable for most ungulates, gregariously spreading weeds like Lantana provide alternate cover value to conflict-ridden animals, an aspect which has not been explored yet. Lantana is reported to provide food and cover/shelter to several wild animals including large carnivores like the tigers & leopards while also to certain ungulate species

(Johnsingh & Negi, 2003; Bhagwat et al., 2012). Wild boars, one of our primary crop raiders and conflict species are also known to take refuge in the dense Lantana bushes (Rai et al., 2019; Negi et al., 2019). The presence of such weeds in the agrarian systems can not only catalyse conflicts but also lead to building up of negative perception of people towards wildlife when the rural and peri-urban livelihoods are threatened by their presence. Thus, it is important to understand the potential functional role of weeds for effective management and conservation policy implementation.

Through this exploratory study our major objective was to understand the knowledge and impacts of weeds, especially *Lantana camara,* through villager's perception, while also trying to assess the differences in perception of the local communities with respect to weeds. Our null hypothesis that there was no significant difference in perception of the impacts of weeds across the study areas was tested against various impact parameters taken into consideration. We also hypothesised that weeds like Lantana provide suitable habitat or alternative cover values (for resting or roosting purposes) to wild animals which come in regular conflict with the local communities, hence acting as drivers to human-wildlife conflicts.

Methodology

The survey design and sampling were based on primary and secondary data collected through published literature and in consultation with the forest department. Villages in the peripheral/buffer areas of the tiger reserve were selected based on the intensity of human-wildlife conflict. A definite sample (5%) of households per village were surveyed via semi-structured questionnaires. Local perception regarding weeds and wildlife was assessed along with information regarding their primary occupation, knowledge/awareness about weeds, livestock owned, crops grown & effects of weeds on crop productivity, source of fodder & effects of weeds on fodder, cost & methods of weed eradication as well as monetary losses incurred due to weeds, major conflict animals in the study area and their reported likelihood of using weeds as a refuge.

Study area(s)

The study was undertaken in two Protected Areas, namely, Kanha Tiger Reserve (KTR) and Bandipur Tiger Reserve (BTR) (Fig.1), situated across the biogeographic zones of Deccan plateau and the Western Ghats respectively. Covering approximately 2051 km^2 and 914 km^2 of

areas (inclusive of core critical and multi-use buffer), both Protected Areas have been recognised as major reservoirs of biological and cultural diversity, inclusive of long history of wildlife conservation as well various ethnic communities residing there. The river catchments of Narmada for Kanha and Cauvery for Bandipur have been very productive for agricultural purposes, hence many settlements around the park are ancestrally old and flourished in agriculture dominantly. Kanha is surrounded by 181 villages (161 in the peripheral buffer zone and 20 in the core area), comprising of both tribal and non-tribal communities (Sinha et al., 2012), with Baigas and Gonds constituting the major tribes (Hopker et al., 2018), while Bandipur has approximately 200 settlements near the northern park boundary (Lingaraju & Venkataramana, 2016) with various ethnic tribes and communities such as the Betta Kurubas, Karu Kururbas, Jenu Kurubass, Yeravas and the Soligas, inhabiting the area.

The rich floral biodiversity mainly consisting of Moist Sal Forest, and Miscellaneous forests in Kanha and Tropical Dry to Moist Mixed Deciduous forests, Semi- Evergreen Forest and Scrub Forest of Bandipur (Champion & Seth, 1968) have been identified to be threatened by various invasive alien species (IAS). Kanha is invaded by *Lantana camara*, *Cassia tora*, *Parthenium hysterophorus*, *Ageratum conyzoides* majorly (Bhargava, 2010, TCP Kanha Tiger Reserve) and Bandipur infested by *Lantana camara* and *Chromolaena odorata* dominantly (Hiremath & Sundaram, 2013).

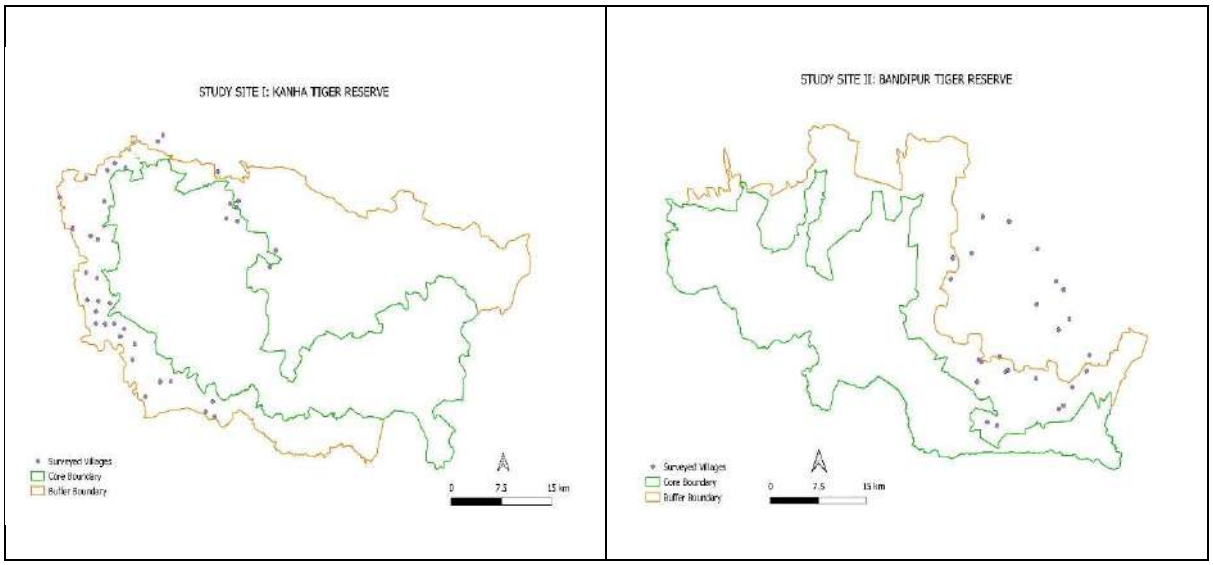

Figure 1: *Study area and sampling intensity. Surveys were conducted across the high human-wildlife conflict ridden villages situated in the buffer areas of both Tiger Reserves.*

Result

A total of 166 households from 40 villages of KTR and 100 households from 25 villages of BTR were interviewed during the surveys conducted in the months of November 2020 and March 2021 respectively. Local people's perception of weeds was analysed using descriptive & statistical analysis (Chi square, T-test) and graphics. The results are summarised under the following parameters assessed:

a) Agrobiodiversity and livelihood profile:

Agriculture was identified as the prevalent primary occupation amongst the respondents interviewed across both the sites (Fig.2). This clearly depicts the agrarian nature of the local communities, which is also corroborated by the fact that the districts under consideration (namely, Mandla, Balaghat, Mysuru and Chamarajanagar) hold a sizeable share of their GDP under agricultural cropping and production (Department of Planning & Statistics, Govt. of India).

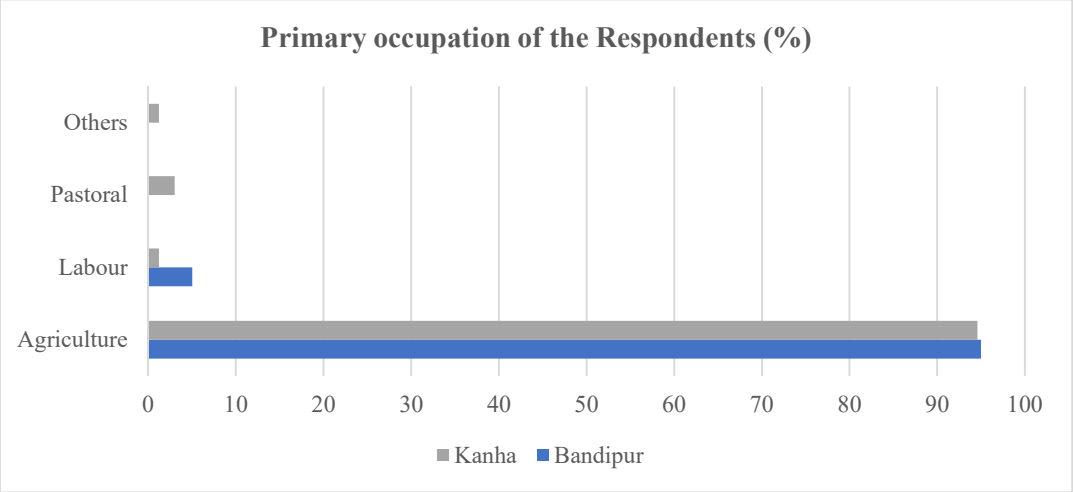

Figure 2: *Primary occupation of local communities across the study sites*

Although both regions have highly productive river catchments, their soil types differ, and hence crop suitability patterns are also different. As evident from the above results, there is prevalence of horticultural and cash crop cultivation in southern India more than it is in the central India landscape. The soil of Bandipur region is more suitable for cash crops like cotton (Mysuru is one of the highest producers of cotton). As per the State Agriculture Contingency Plans (district-wise summarised below under Table 1), major crops grown across these districts has been enlisted, which also corroborates with our study. Paddy, maize (corn) and mustard are

the dominant crops grown by the local communities of KTR and Wheat, vegetables, horticultural and cash crops like sunflower, turmeric are predominantly grown around BTR (Fig.3).

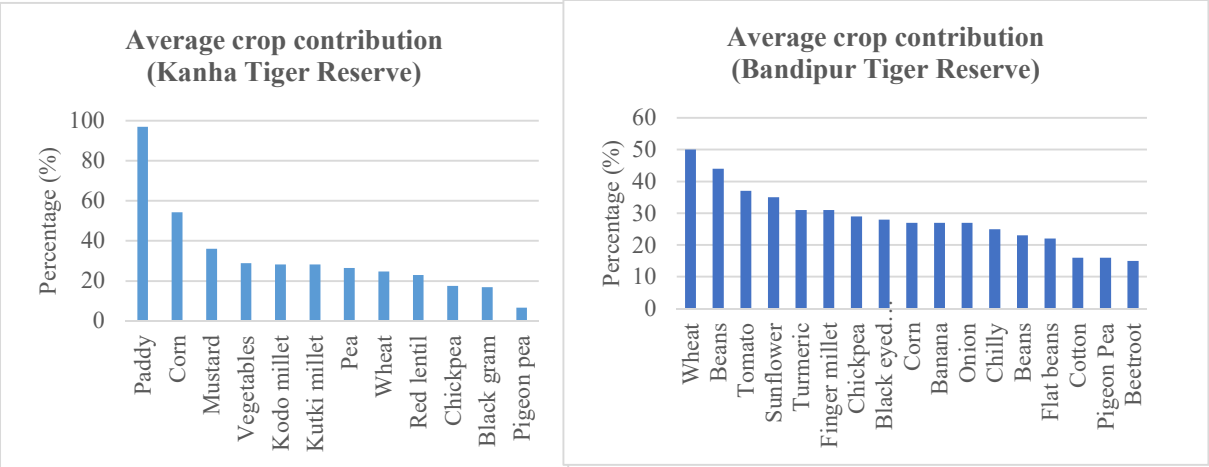

Figure 3: *Diversity of crops grown across the study sites*

Table 1: *List of crops grown across the study area districts*

State	District	Major crops grown
Madhya Pradesh	Mandla	Paddy, Pigeon Pea, Wheat, Peas, Mustard, Soybean, Maize, Lentils, Kodo-kutki millets
Madhya Pradesh	Balaghat	Paddy, Wheat, Sugarcane, Maize, Jowar, Pulses, Oil seeds
Karnataka	Chamarajanagar	Ragi, Paddy, Maize, Pulses, Oil Seeds, Horticultural crops (Coconut, Turmeric), Cash crops (Sunflower, Sugarcane, cotton)
Karnataka	Mysore	Paddy, Jowar, Ragi, Mulberry, Groundnut, Pulses, Cereals, Commercial crops (cotton, sugarcane, tobacco), Sesamum

(Source: State Agriculture Contingency Plans for Districts (http://www.nicra-icar.in))

b) Weeds and their impacts on local livelihoods:

The following major themes were identified in order to understand the local perception towards Lantana and other weeds:

i) Effect on crops and agricultural productivity: Approximately 96% of the respondents from both the sites reported that weeds led to decrease in their crop

productivity. However, the other responses varied across both the sites ($p < 0.05$). While a minority (3.5 %) of the respondents in KTR indicated that there were no effects of weeds on their crops, 5% of the respondents in BTR failed to recognise any such impacts (Fig.4). A probable justification for this could be based on the type of crops grown by the respondents and the soil productivity, which is also known to be hampered by certain weeds such as Lantana (Wang et al., 2015).

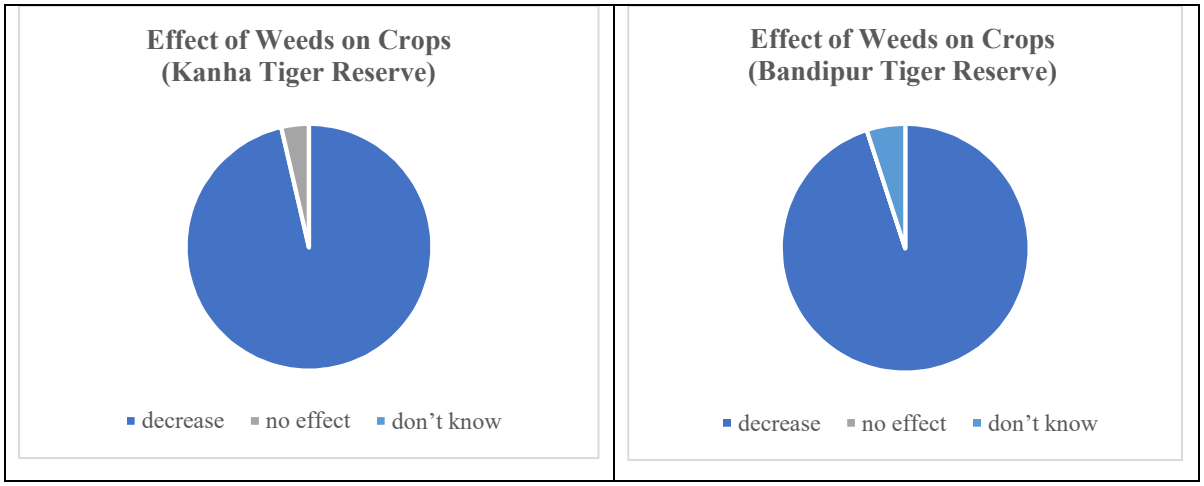

Figure 4: *Perceived effects of weeds on crops and productivity across the study sites*

ii) Effect on Fodder for animals: Majority of the respondents were either collecting fodder from their own agricultural land (61% for Bandipur, 27% for Kanha) or were dependent on forest lands for the same (25% for Bandipur, 67% for Kanha) (Fig.5).

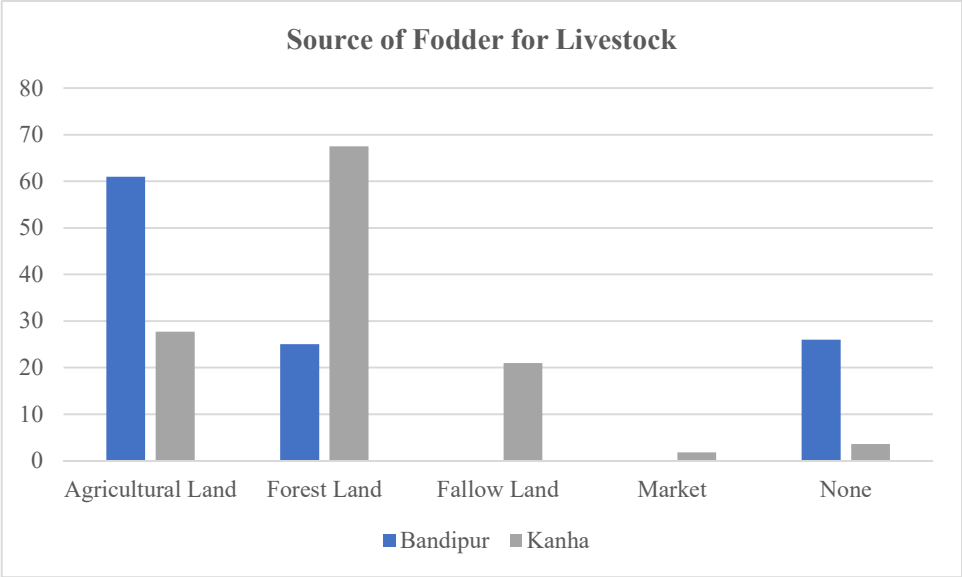

Figure 5: *Sources of fodder collection by the local communities*

Our results revealed that weeds were negatively affecting fodder resources, but the perceived responses were significantly different across both the sites ($p < 0.05$). While the declining effects were well perceived for both areas (79% for Kanha; 73% for Bandipur), approximately 10% respondents in Kanha perceived that weed were increasing forage cover (Fig.6). This could be attributed to the palatability of some weeds by their livestock, or due to the lack of awareness about their harmful impacts, but this presumption is subject to further investigation.

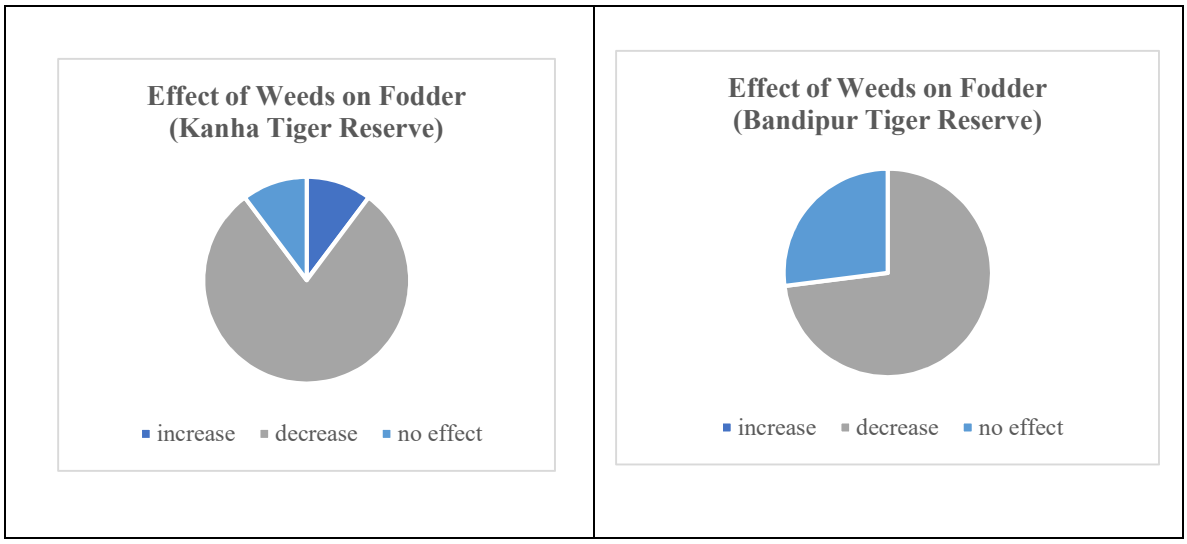

Figure 6: *Perceived effects of weeds on fodder for livestock across the study sites*

iii) Feasibility of weed eradication & monetary losses incurred: Weed management and their eradication was perceived to be a difficult and time-consuming operation as most respondents reported using manual methods for their control (Fig.7). The process was reportedly labour intensive and required sufficient monetary investments for the same.

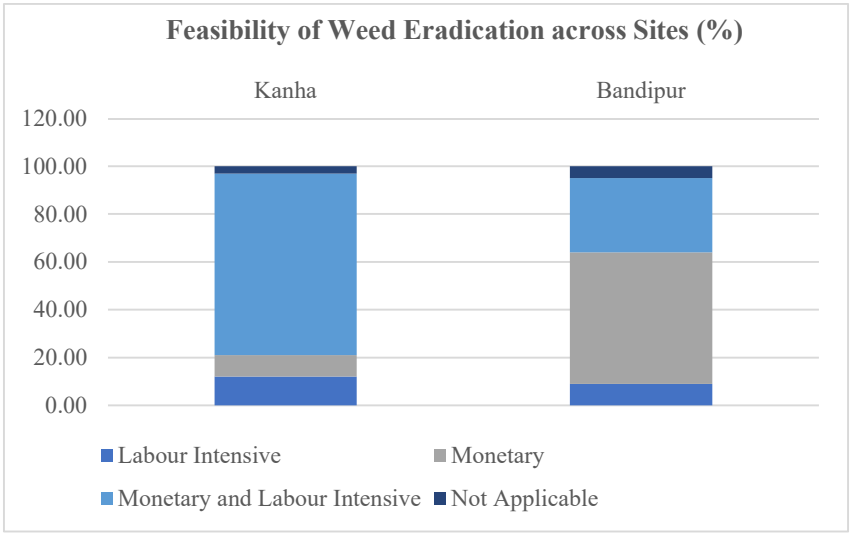

Figure 7: *Feasibility of weed eradication across the study sites*

Financial losses incurred due to the direct and indirect effects of weeds owing to the hampered crop productivity, reduction in fodder and available grazing land, or additional expenditure spent in their control differed significantly across the two sites ($p<0.05$). The average estimated loss was low at an average of Rs.10,160 per household for Kanha, while almost four times high for Bandipur at approximately Rs.38,347 per household. This can be explained by the fact that monetary losses due to encroachment of land competing with cash crop is relatively higher than for other crops. Also, per day labour charges are higher (Rs.350 for unskilled labourers) for Bandipur as compared to Kanha (Rs.250). From the agro-economic perspective, the effects of invasive plants or weeds in general will be more pronounced across these landscapes where perceived risks are more. Hence, agricultural crops at risk (cash & horticultural crops for BTR, cereals for pulses for KTR) and the monetary losses by weeds as perceived by the respondents in our survey coincides with the above causes.

iv) Local use of weeds (*Lantana camara*): All the respondents identified Lantana as a major weed in their agricultural systems, despite that, the intentional/unintentional use of the plant was recorded for both the sites (Fig. 8) which was in accord with the most common form of Lantana utilization i.e., for fencing or hedging purposes around villages or farmlands (also noted by Alemu & Assefa, 2015) and innovatively utilising the weed towards economic gains was observed in BTR. 'Invasive use', or the use of invasive species for goods and raw materials such as income, subsistence etc., has been considered as a control option in cases when other methods of population check fail (Howard, 2019). Many local NGOs are encouraging the use of Lantana in craft and furniture making as an alternative source of income for severely infested areas (Kent & Dorward, 2015). Ethnic communities in southern India, like the Soligas, have been trained and using Lantana for livelihood activities such as making baskets or even furniture.

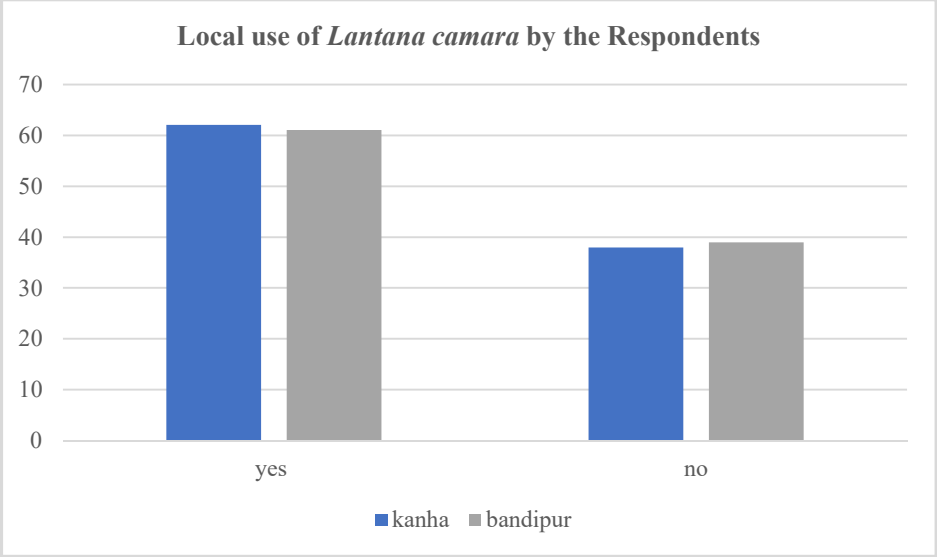

Figure 8: *Local use of Lantana camara by the respondents*

Another indirect use of Lantana that has come out of this study is from the wildlife perspective. Its thickets are reportedly being used by wild animals, mainly for refuge provisioning purposes. The role of Lantana in providing cover to carnivore and game species has been highlighted by some authors (Kannan et al., 2013; Malviya & Ramesh, 2015; Negi et al., 2019). A majority of our respondents also agreed to observing wild animals utilising Lantana as a cover, predominantly being used by animals frequently involved in human-interface cases (eg. wild boar, spotted deer, tiger, leopard) such as crop raiding, livestock depredation. Thus, anecdotal evidences, coupled with findings from our study ascertains the theory of alternate habitat provisioning by weeds and is indicative of the fact that changing interactions might foster conflict interface issues, however it also warrants extensive studies towards the same to understand the ability of weeds on affecting and modifying rural livelihoods and economies.

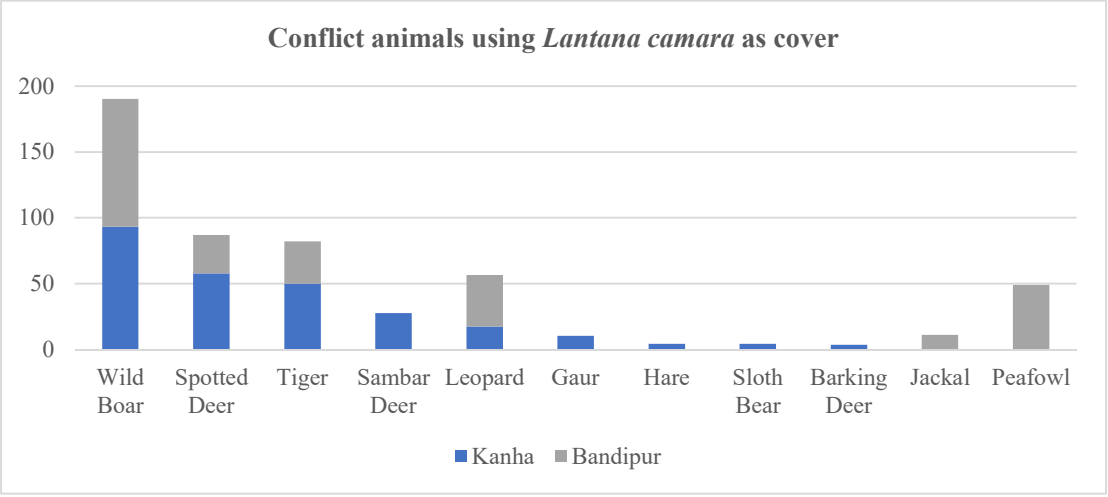

Figure 9: *Utilisation of Lantana camara as an alternative habitat by conflict-ridden animals*

Discussion and conclusion

An integration of policy and practices for management of multiple land-uses is a necessity to ensure sustainable use of "landscape". Such holistic management approach benefit in the economy, natural resource conservation as well as adaptation for climate change in long run. Forest health is a requirement for wellbeing of ecosystem, inclusive of indigenous communities in the vicinity of the forests as well as other stakeholders having direct and indirect benefit from the forests. Kanha and Bandipur Tiger Reserves, that come under Mandla-Balaghat and Chamarajanagar-Mysuru districts respectively, are important not only from the ecological but also cultural and economic perspective. The areas being home to several ethnic-indigenous tribes and communities harbour some endangered and ecologically important biodiversity and hold considerable GDP shares in agriculture. The reliance of local communities on agriculture-forests landscape for subsistence, livestock rearing or cash income is prevalent across both the study areas. The landscapes have also been identified as potential hotspots of biological invasion by several alien species (Adhikari et al., 2015, Padalia & Bahuguna, 2017), with the plant invasions across these mosaic landscapes not being limited to human dominated areas exclusively.

Weeds, especially of invasive nature, are dominating across different classes of landcover with the conglomerate of forest and agriculture patches being highly threatened. The park managers regularly invest in keeping a check on weeds inside the park boundary. However, in the periphery of the park, no such government department is functional uniformly. Hence, weed identification, awareness and removal depends largely on individual agriculturalists. The investment of weed removal is both, financially constraining and time-consuming, resulting in the development of weed buffers in and around the fields. The situation is furthermore aggravated by the fact that gregariously spreading and dense thickets of such weeds are providing alternative cover value to conflict-ridden wild animals, which can now be supported by empirical evidence. With the encroachment of these unpalatable weeds into wildlife habitats, sometime ungulate species are forced to move out in search of suitable forage, which eventually attracts predators towards the forest edges and human habitations. This leads to increased incidents of crop raiding and human-wildlife conflicts, posing another challenge of concern.

The management of IAS not only requires a multi-stakeholder approach (Shrestha et al., 2019) but also amalgamation of scientific inputs with traditional knowledge of rural communities which can unfold 'diverse contexts relevant to invasiveness' (Head, 2017). Community perceptions and attitudes can widely influence management of invasive species, especially in the agricultural or horticultural systems (Oxley et al., 2016). Differential patterns of resource usage and perceptions of ecological change leads to varying levels of management interventions (Hall, 2009). In this regard, the recognition and contribution of agrarian and forest-dependent local communities involved in invasive species management as primary stakeholder groups in rural and peri-urban regions should not be overlooked (Shrestha et al., 2019). It is thus of prime importance to address all the ecological, agricultural and social impacts of such plants before developing effective management portfolios (Bajwa, 2019).

Hence, as a summary, our study demonstrates how weeds also affect and modify rural livelihoods and economies apart from devastating forest communities and resources. In the wake of global environmental change and anthropogenic modifications, it is very likely that the transformation of these 'naturalising aliens' into stabilised 'honorary natives' (Rotherham, 2005) would lead to formation of 'novel ecosystems' (Dar et al., 2019) with altered states. Identifying and understanding the costs and benefits of invasive species on human livelihoods and well-being is thus important for guiding policy formulation (Shackleton et al., 2019).

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Human-Wildlife Conflict Management Practices and Approaches

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Abstract

Human Wildlife Conflict (HWC) is a growing concern that affects the lives and livelihoods of people across large tracts of the developing world. We in India are no exception to it, rather, our Laws and Acts forbid even chasing away of wild animals inimical to people. Their lives and livelihoods are thus imperiled. Hence, it is imperative that a closer, more realistic management approach be taken in addressing the issues of HWC. HWC has several components that the Acts and Laws we have cannot cope with today. In a changing scenario, where human populations and also wild animal populations are rising, it needs careful handling so that lives and livelihoods are secured, while the wild animals and their habitats are also protected and maintained. The one globally accepted norm is the SU of natural renewable resources. The HWC should address human and wild animal distress and find ways to mitigate them making it a win-win situation for all. It should look at addressing SU meaningfully so that wild animals now considered valueless will be valued and treated as assets. The redress of HWC should build trust, opportunities and develop skill sets for the local communities, while developing toolkits to address the conflict and resolve them, reducing risks and vulnerability.

Keywords: Sustainable Use (SU), Human Wildlife Conflict (HWC), Local Communities, Wild Animals, Herbivores, Carnivores.

Introduction

Human Wildlife Conflict is complex and, as old as humanity itself. Since the early humans started living semi-nomadic lives and early pastorals and agriculturalists evolved out of hunter-gatherers, having tamed wild animals, used them for draught, skin and meat, the wild carnivores were drawn to herds of animals in captivity. Primitive fields of ancient crops meanwhile drew herbivore depredators. From prehistoric times there have been conflicts; humans being at one time were prey for a wide variety of predators, from eagles to crocodiles to carnivores. The

crops were devoured by wild herbivores. The semi-domesticated wild animals in kraals and ancient humans themselves became prey to a variety of carnivorous animals. Thus, the seeds of tussle and conflicts were sown. The Inuit people of Iceland are an ancient tribe of hunters and follow the reindeer migration and use them for transport, meat and skin even today; a throwback to ancient times.

Today, we are the most dominant, most abundant and most widespread species in the world. That being said, we still are at war with our ancient foes. Yet it devolves on us to protect biological diversity and that includes wild animals that are to a lesser or a greater extent inimical to us; because we are all part of the same ecological web. We, therefore, need to change tack and tackle the issue with modern day management practices and approaches.

This paper therefore looks at how this complex issue can be addressed positively to make it a win-win situation for the wild animals and the people dependent on agriculture, dairy, livestock and poultry, forestry, agro-forestry etc. for livelihoods; in fact those that service the underbelly of conservation and face Human Wildlife Conflicts (HWC) routinely.

To summarize and put it succinctly: "*The conflict about wild life is between people with historical wounds, cultural misunderstandings, socio-economic needs, as well as gaps in trust and communication over how to conserve wild life and ensure the well being of people at the same time.*" (Francine Madden)

Human Wildlife Conflict

Human Wildlife Conflict (HWC) can be described as *the competition for the same declining resources by the growing human and wild animal populations.*

"*Human–wildlife conflict (HWC) refers to the negative interactions between human and wild animals, with undesirable consequences for both people and their resources and wildlife and their habitats* (IUCN 2020)." The loss of habitat for wild animals due to the conversion of forests, wetlands, grasslands, steppes and savannahs for the production of food, infrastructure, energy, water and raw materials have brought them into conflict with humans and is exacerbated because of climate change, and the stopping of harvesting of wild animals that was an age old custom and practice that reduced the number of animals and that had kept populations at sub-optimal to optimal levels, but never over, thus having a positive effect on

the reduction of HWC. That was done away by the myopic laws. The indigenous people meshed into the ecosystems were made outlaws and that is one of the causes and a key factor leading to an increase in HWC.

Wild animals were used in many ways. *The elephants were caught and trained and used for war, work; royal and* religious processions. Wild animals were hunted for sport, protection and food. Skins of thick-skinned animals like rhinoceros, blue bull and wild water buffalo were in great demand for body armour and shields. The hair of many animals was used in making brushes – wild boar bristles and mongoose hair for example used to make paint brushes. Egret feathers were used in fashionable hats for women. Ivory used in making figurines, trinkets and billiard balls. Leopard and snow leopard pelts as well as pelts of other spotted cats were in high demand in the fashion industry. Fur from many animals was and still used as fashion adjuncts. Civet, extracted from civet cats and musk from musk deer is still used in perfumes of very high value.

All this now banned in India with the advent of the Wild Life (Protection) Act 1972. India increased its wild animal population through a preservationist model of wild life protection and very little management, while southern Africa, Europe and the U.S. went in for improving their wild life through the conservation and sustainable use models.

When faced with the HWC, India has neither the tools; the laws nor the wherewithal to address this complex problem. The laws that governed hunting, use of wild life and even protection of crops have been severely truncated, nullified or withdrawn. While in Southern Africa (SADC countries), Europe and the U.S. there are systems and SOP in place to address the HWC practically.

HWC has conservation consequences that need to be addressed. Many mega fauna (especially large carnivore) populations are in decline, while they manifest themselves inimically with the local communities because of their propensity to take livestock and humans.

The earlier deference and reverence towards wild life declines as human populations shift away from traditional and cultural ties with the wild animals and the wild habitats. This has a huge negative impact on those wild populations that are already struggling. Poisoning, trapping and other methods of eliminating the wild animals have reduced their ranges and in many cases, caused local extinctions. This has had a positive effect on some of the opportunistic commensal herbivore and omnivore populations. The skewed populations of blue bull, blackbuck and wild boar that live almost exclusively in human dominated landscapes with hardly any wild predator of note indicates a very imbalanced ecosystem.

We must acknowledge the collective trans-generational knowledge and wisdom of the local communities when dealing with HWC. They have a very deep understanding of the locally seen wild animals and their behaviour which has been handed down over millennia as oral traditions, especially among the tribes and communities that are still traditional hunters. These tribal groups were meshed into the ecology of the area; an off-take by them of wild animals was the norm, until the laws simply outlawed customs and cultures that developed over millennia. They developed skills, which was refined over time into an art; that which can be harnessed today in addressing HWC.

When the traditional systems are tied with modern scientific learning; practical skills and toolsets can be developed to better cope with HWC. Habitat preferences along with seasonality of conflicts should be harnessed to provide toolkits for effective engagement which can, over time, contribute to changed behaviour, improved livelihoods, SU, reduced risks and vulnerability.

Conflict resolutions can be preventive and mitigative. Ideally, preventive measures are better, but lethal prevention is generally held in abeyance and is then applied as a mitigative measure – example – capture or killing of man-eating carnivores.

Unimaginatively, even herbivore depredations of crops happen to be mitigative rather than preventive in treatment. Preventive interventions are cheaper, less laborious and have positive effects on the populace, while dispersing and scattering the raids by wild herbivores, causing far less damage on the whole.

The conflict with wild life can be classified loosely into four threats:

Graminivorous birds do some amount of damage to crops that is usually overlooked. These birds eat a lot of grain. Another very unlikely destroyer of crops is the cattle egret that fly up peck at insects, thus dropping almost ready to harvest grain from their sheaves.
Kingfishers dive into and take a certain number of released fingerlings in aquaculture ponds.
Sunbirds peck into grapes and for the farmer destroys a small percentage of produce.
However these are minor and the loss is manageable and tolerable.

Minor threats: Graminivorous birds like munias, weaver birds and frugivorous birds like parakeets, bulbuls, starlings and myna, small rodents like mice and squirrels which affect farmers growing grain and millets and fruit orchards, and kingfishers in aquaculture only at the early stages. Damage generally is manageable.

Moderate threats: Large birds in flocks like duck, geese and peafowl, large flocks of parakeets and starlings; monkeys and large rodents like porcupines and other herbivores. These affect all types of crops and plantations including agro-forestry. Picivorous birds like cormorants, storks, herons and egrets consuming high value fish and shellfish in open pond aquaculture.

Major threats: Herbivore and carnivore depredations – deer, antelope, wild boar and monkeys, and livestock predation by carnivores taking poultry (commercial and barnyard) and livestock, and cormorants and otters preying on high value fish and shellfish in open pond aquaculture systems.

Existential threats: Marginal and small farmers losing crops and predation of domestic use livestock and poultry, large-scale killing of livestock by large carnivores and predation of poultry by civets, mongooses etc. and severe damage by elephants. People, especially the breadwinners who get killed by large herbivores including wild boar, blue bull, elephant, gaur etc. and by large carnivores; some of which turn inveterate man-eaters, pushing people into penury and causing distress.

In the case of leopards, since they readily raid human habitations, garbage should be reduced and cleared regularly to avoid the stray dog population from growing which fuels their population by being an easily available and favoured food source. To address the growing menace of feral dogs, some lethal as well as other methods of control of their population is urgent. The collapse of the vulture population has had an impact on feral dog population. The rotting carcasses of cattle and piles of domestic organic garbage are being devoured by dogs. They are not efficient consumers of dead carrion, and the availability of food is increasing feral dog populations; that in turn is fueling the leopard population. The several footages on social media of dogs being lifted from homes (pet and guard dogs) as well as stray and feral dogs, points to the fact that leopards are increasingly preferring dogs which is bringing them into close contact with people as dogs are seen in human habitations. This is leading to severe conflicts in pockets where some animals are turning man-eaters, thereby needing them to be eliminated.

The Laws of the Land

There are three Acts that come into play when dealing with the biological diversity, wild life and people, especially those living in close proximity to forests and wild animals. The two Acts that directly affect wild animals and people living in close proximity to them; both are in conflict with each other, there being no synergy between them. These two Acts are The Wild Life (Protection) Act (WL(P)A) of 1972 and The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 or otherwise known as the Forest Rights Act (FRA). The third one is the Biological Diversity Act (BD Act) of 2006.

The WL(P)A clearly states under Chapter III Hunting of Wild Animals: 9 Prohibition of Hunting – It goes on to read in section 11 (3) Any animal killed or wounded in defence of any person shall be Government property.

It implies that it cannot be used sustainably – the carcases of the animals have to be destroyed – providing no local benefit whatsoever. Since the carcases are burnt or buried, there is no use whatsoever even in the ecosystem – food for carrion eaters and scavengers. However, the Government can give away its property to anybody through an order by a competent authority. – Pers. Comm. Dr. H.S. Pabla

The FRA, Rule12. Process of verifying claims by Forest Rights Committee.

(1) The Forest Rights Committee shall, after due intimation to the concerned claimant and the Forest Department:-

g) prepare a community forest resource map with recognizable land marks and through substantial evidence as enumerated in sub-rule (2) of rule 13 and thereafter, such community forest resource claim shall be approved by a resolution of the Gram Sabha passed by a simple majority.

Explanation: The delineation of community forest resource may include existing legal boundaries such as reserve forest, protected forest, National Parks and Sanctuaries and such delineation shall formalize and recognize the powers of the community in access, conservation and Sustainable Use (SU) of such community forest resources."[18]

This means the control over these lands and appurtenant resources, including wild animals, gets transferred to the concerned community. However, the WLPA recognises no control over wild animals and PA lands by any entity other than the government.

[18]Inserted by Rule 10 of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Amendment Rules, 2012 (vide Notification No G.S.R. No. 669 (E). dated 6th September, 2012)

Though the FRA is immediately not relevant in managing wild life and the HWC; both the laws affect people living in a landscape that is forested and have wild animals in them. It is evident that laws are divergent while addressing the same resources, making it abundantly clear that the laws are not going to help.

The Law governing wildlife is a central Act and the states have very little, if any, role to play in it. This makes it very difficult for managers of wild animals to take any decision without first bringing it up for the centre to take cognizance of the issues they face. The delay translates into problems for people and wild life. The Wild Life Act that especially deals with wild animals should be a state subject and be deregulated so that personnel on the ground can take prompt and immediate corrective measures and actions.

States however, with prior consent from the central government, can amend central laws to suit local conditions. Assam, for example has done it and increased penalties. The major problem is that none want to think outside the box, stereotypes being the norm, originality and innovation being the exception. – *Pers. comm.* Dr. H.S. Pabla

Global HWC Management Practices

There are several management practices being applied globally to address HWC. From the culling of specific number of animals to maintain sub optimal to optimal populations of carnivores and herbivores, to repellents, scent barriers, sound barriers, intercropping, fencing and other methods with varying degrees of success.

Adaptive management of the targeted species is taken up almost exclusively, wherein the management of desired species is given utmost priority to the exclusion and possible removal (lethally if need be) of other non-desirous species.

Water and terrain are used as limiting factors in segregating the two. Pers. Comm. Bugs Van Heerden. Selective planting of herbage should address the wild animals ecologically; this will be an advantage in keeping them close to the selected areas and possibly within proximity – though they will range further afield in search of territory and breeding potential – of such areas that have their fodder or prey.

The Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) started in 1989 in Zimbabwe and Community Based Natural Resources Management (CBNRM) of Namibia which started during the 1990s allows indigenous and local communities and individuals to earn livelihoods from the SU of nature and natural resources including the consumptive use of wild life. These initiatives are excellent tools in managing HWC while providing meaningful, gainful employment and skill development, protecting traditions and cultures that especially use wild animals.

Under the CAMPFIRE initiative, the thirty-seven communities that participated in it received twenty million U.S. dollars from 1989 to 2001. Eighty-nine percent (89%) of that income came from trophy and sport hunting (Frost, 2007). It was similar in many ways to Payment for Environmental Services (PES). Animals to be hunted are not randomly selected, but those that are past their prime. Management and meat hunting essentially removes weak and non-typical

animals, improving the general stock. The removal of such animals through harvests helps in bringing in new and improved blood into the wild animal populations. Since such removal opens space for younger animals, the animals are maintained at optimal levels and are known to reduce HWC.

HWC Management Approach for India

Many states across the country have tried to address the HWC through orders within the framework of the WL(P)A without much success. The Act itself is so deficient and left to interpretation that it can never be used to its full potential. States like Maharashtra and Uttarakhand give out orders as and when required to shoot and kill man-eating large carnivores.

The most persistent and chronic of conflicts is from the herbivores – especially wild boar and blue bull (neel gai). Lately, the name has been changed to Van Roz by the government to allow for its killing where it destroys crops.

Telangana State has allowed the shooting of wild boar and is presently held jointly with the Panchayat Raj ministry; the Sarpanches can give orders for the killing of wild boar as the Forest Department has made the Sarpanches Honorary Wildlife Wardens. The order is on an annual and renewable basis, but does not allow the consumption of meat of such killed animals which have to be buried or burnt.

Kerala is issuing orders for killing of wild boar and is paying a fixed sum for every wild boar shot and killed. The meat however cannot be consumed and the carcase of the animal must be burnt or buried.

The states have used the provisions in the WL(P)A especially Section 11 – 1 (b). The states have used this provision, and since wild animals are government property, the forest department does not allow its use or consumption and is either burnt or buried. All these orders are given out for the protection of crops on a case to case basis only. Bihar and Uttarakhand, through the Government of India (GoI) got wild boar (and blue bull in the case of Bihar) declared as vermin whereby the meat can be consumed, but did not renew the orders subsequently. Such short term knee jerk actions served no purpose whatsoever. The highly truncated WL(P)A is not able to address the issue satisfactorily.

However, Punjab is the only state so far that has got the closest to SU with the provisions of the WL(P)A. Punjab allows for the consumption of the animals harvested, but since the use of skin and other parts are not allowed to be used according to the WL(P)A, it must be destroyed. The Government allows for the consumption of the meat but not trade of such harvested animals; since the government can give away its property to whomsoever it deems fit. They have also quantified how many animals can be harvested per person who applies for a permit to shoot, and the weapons to be used are clearly prescribed.

The order is perpetual; and since farming is all year round and perpetual. With all the constraints, the Punjab model is still the best option there is.

(https://www.pbforests.gov.in/Pdfs/nofication/WLS/Permission%20of%20Hunting.pdf)

Overhaul of the Wild Life (Protection) Act

The Wildlife (Protection) Act itself needs a complete overhaul and may be the word "Protection" dropped and in its place, "Sustainable Use (SU)" or better still, the word "Conservation" be incorporated as it will address both preservation of the animals as well as sustainable use.

The rewriting of the Wild Life Act should be done in consultation with local, informed stake holders, including those that have sound knowledge about SU and the scientific community represented by social scientists, behavioral scientists, conservation biologists and experts in the field.

It should lay emphasis on SU of renewable resources that will help both wild animals and local communities.

The schedules (Annexes) in the Act should be reduced to just Three (3) at most:

Annex – I for highly vulnerable species Example: (Great Indian Rhinoceros; Wild Water Buffalo; Clouded Leopard; Thamin; Dugong; Bustards and Floricans).

Annex – II for species that have economic value, high value poaching and trafficking Example: (Tiger; Lion; Leopard; Snow Leopard; Elephant; Pangolin).

Annex – III for species that can be harvested and used as a sustainable, renewable resource Example: (all Deer; Antelope; Mountain Goats and Sheep; Gaur; Tiger[1]; Leopard[2]; Lion[3] in certain cases: ([1,2,3] especially in conflicts of human and livestock depredations)).

Rats, mice and such agricultural pests should be delisted from the Wild Life Act and shifted to the agriculture department as it is there that these do the most damage.

The Act, Rules and Laws to protect wild life should be reviewed every three years and the animals in Annexes reviewed and any changes made should be transparent and the local communities should be consulted.

Community involvement in the management process

Conflict resolution should be community based in approach. The stakeholders selected for such consultations should have thorough understanding of the problems and be able to communicate very freely with the local affected people (who are the larger affected stakeholders) and the wild life managers. The approach should be location and species specific. A-biotic barriers, acoustic and scent repellents, culling and community based SU management approach should be applied.

Zimbabwe is a country that uses hunting as a means of livelihoods and sustainably uses its renewable wild life resources. The country has, as on 24th of May 2021 seen twenty-seven deaths due to wild animals while in India eighty-two people lost their lives; thirty-five to tigers (42.68%), twenty-nine to elephants (35.37%) and twelve to leopards (14.63%), others included wild boar, sloth bear, rhesus monkeys and mugger crocodile accounted for six deaths (7.32%). Fifty-five people were injured due to wild animal attacks of which twenty-four by leopards (45.45%), twenty-two by tigers (40%), five by wild boar (9.1%) and Himalayan black bear one, and sloth bear two totaling to three (5.45%) for the same given period of time (1st of January to 24th of May 2021). Zimbabwe has over one hundred thousand elephants (which accounted for 14 deaths) while India has thirty-five odd thousand of them; yet we have a greater incidence of human deaths (29 deaths) due to elephants. It can therefore be argued that hunting is a necessary tool in controlling HWC. (This is from my records; it is definitely far lesser than what is actually happening.)

Management approaches should not be biased and based on perceptions, especially that of wild life managers, but appropriate to what needs be done. Single, one size fits all will not help; it will develop into mistrust and ill-will that will be detrimental to the wild animals. This is crucial when dealing with wild animals especially those that are endangered, yet sporadically come into existential conflict with the local people who share the landscape with them.

Community based consumptive tourism is one of the approaches that is being widely discussed as well as being implemented worldwide, especially in southern Africa with great success. CAMPFIRE, CBNRM and like initiatives give the right to manage the wild renewable

resources to local people and stakeholders, which addresses local concerns, governance and management of natural resources.

In a country where, between seventy-one and seventy-five percent of the population is protein deficient, the meat from culled, harvested and hunted animals can be used to address the issue.

It also provides employment and innovative livelihoods and skill development. The money earned from consumptive and non-consumptive tourism will drive local economy.

In many agrarian landscapes (agro-forests, fruit orchards and groves, and farms and fields) that are not aesthetically appealing for photo tourism and eco-tourism; consumptive tourism will aid in bringing in much needed finances, employment and also protection against marauding wild herbivores. Hunters are interested in bagging trophies, or hunting for meat (biltong hunting), and the landscape matters little to them. This will put aesthetically poor areas on the consumptive tourism circuit map. Since hunters typically pay more than eco-tourists and photo-tourists, the lesser footfall is also beneficial to standing crops; it being economically viable while generating newer avenues for livelihoods.

Questions that must be discussed:

1. Is coexistence possible between wild animals and human populations & by what degree, and who decides?
2. Do the rural people have to pay for conservation successes?
3. What are the social, economic and livelihood benefits they derive for sharing the landscape with wild animals, some of which are extremely dangerous?
4. How are the tangible and intangible benefits accrued from protection of wild animals translated positively to the local communities living and sharing the landscape with wild and often dangerous animals?
5. Are there mechanisms to address specific issues including HWC and livelihoods?
6. What role do the local communities of the affected areas have to play in the process of conservation interests?
7. What is the value of conservation for local communities in terms of income, skill development, employment and livelihood generation?
8. In species recovery and reintroduction, what is the cost to the local communities affected, and how are they addressed and mitigated?

9. How can voices of local communities, indigenous peoples, conservation biologists and scientists, and experts be heard by policy makers and decision makers so that wild animals become assets rather than liabilities?
10. Will donor agencies come forward to fund conservation of endangered species, especially if the local community or communities cannot use that resource sustainably, while being deprived of livelihoods because of depredation by wild animals and by law?
11. Why should not the local communities benefit from SU of wild renewable resources?
12. Should not the present day appeal towards coexistence be reworked towards symbiotic coexistence?

Results and Outcomes

To effectively manage wild animal populations, initiatives like CAMPFIRE and CBNRM need to be adapted to our local needs. Wild life needs to be managed scientifically with a certain off-take in the form of harvests that should benefit the local people.

Mechanisms and policies need to be reviewed periodically with experts in the field and the stakeholders who have much to gain or lose depending on what decisions are made in their behalf.

1. Local communities, especially those living in areas of wild animal depredations of their livelihoods, lives and properties must be allowed to hunt, consume, sell or otherwise sustainably use those animals that share the landscape with them.
2. SU of wild biological resources – including consumptive and non-consumptive use – and the development of livelihood skill sets will help alleviate poverty, create jobs, develop local skills, and increase aesthetic, cultural and intangible benefits and access to game meat and strengthen social capital.
3. Wild animals should be managed so that local people derive the maximum benefit.
4. The reduction of HWC should logically lead to symbiotic and mutual coexistence through SU.
5. Management of wild animals should underpin what suits the local people and communities living close to wild animals including off-takes and address HWC.

6. There should be absolute trust between local communities, stake holders and wild life managers to bring about and insure sustainable coexistence, SU and live in harmony with nature, its vagaries and its resources.

Way Forward and Recommendations

"*A useful response to critiques of the rational decision-making model is to introduce a standard for good decision making: a set of steps that, if followed, provide a defensible basis for making good decisions.*" (Riley)

Coexistence is defined as "*the state of being together in the same place at the same time*". Symbiosis is defined as "*a close ecological relationship between the individuals of two (or more) different species*." Symbiotic coexistence therefore is "*a close ecological relationship between individuals of two or more species in the same place and at the same time*". It is the way forward since we too share the same space and are dependent on all the ecosystem goods and services and also interact with all living organisms positively and negatively while we also alter the landscapes, therefore the ecosystems.

"As Divisional Forest Officer of the Melghat, I took the collection of dropped horns out of the contractor's hands, partly to increase revenue and partly to try and control poaching; allowing for a fair number of skulls with horns attached as a result of jungle casualties, any increase over this number could be ascribed to the poacher, and a man who habitually brought in the horns which had not been dropped had to explain himself. In two years approximately four tons of dropped horns were collected." – Wild Animals in Central India – A.A. Dunbar Brander – Edward Arnold & Co. London 1927

The country itself is not level in addressing issues. We are two nations in one: the rich, small in number, erudite urbanites; and the large in number, largely poor, usually unsophisticated rural and tribal people. The policies and decisions affecting the largely rural and tribal populace are made by the educated, urban populace who do not understand the intricacies of the lives lived by the rural and tribal communities and their interdependence with wild animals, trees and other natural resources. It therefore devolves on the influencers, policy makers and law makers to formulate Acts and Laws that will be in tandem with the lives of the largely rural and tribal sections of society and address their concerns while also addressing the needs of the wild animals and their habitats. There should be synergy between the two if HWC must see a definite reduction, rural people allowed to use wild animals, plants etc. sustainably as they have been doing for centuries. The tribal and indigenous people – Indigenous People and Local Communities – (IPLC) used wild animals

sustainably long before they were outlawed by myopic Acts, Rules and Laws, first brought in by the colonists to rule and subjugate people for their larger interests.

With shared governance, communities will be less resentful and more tolerant to the damage by wild animals. They should be involved with the planning and management and address the cost of living with wild animals which should be offset through benefits of SU. They must be involved in the development of wild life management plans.

HWC needs to be managed and it should be flexible and adaptable to local conditions, it should be approached with a standpoint that addresses food security, livelihoods and lives, social, economic and political implications.

Prey base of carnivores should be increased and water provided at safe places within the forests. SU will improve tolerance towards wild animals, improve biodiversity conservation, and address HWC more meaningfully which addresses living with nature in harmony through symbiotic and mutual coexistence.

Conclusion

"*Wildlife management is the guidance of decision making processes and the implementation of practices to purposefully influence interactions among and between people, wildlife, and habitats to achieve impacts valued by stakeholders*." – Human-Wildlife Conflict Management by Daniel J. Decker, T. Bruce Lauber and William F. Siemer

With the current trends in human population growth, there will be an increase in demand for natural resources and land. Natural resources and land are both finite and the pressure by both wild animals and humans will only escalate the problem. The management of conflicts is to learn how to reduce conflicts while in the long-term; coexistence coupled with mutual and symbiotic synergies should be the goal.

It must be understood that wild life is managed to achieve outcomes that people desire (Daniel J. Decker *et al* 2002), paramount being the continued persistence of wild animals with opportunities to use them sustainably.

It must be a continual learning and teaching process, adapting to the needs of both local communities and the wild animals that share that landscape. There is no single one-size-fits-

all approach to managing wild life conflicts, hence established options and new tools must be innovated to address and reduce HWC which must involve stakeholders and local communities. It will fail miserably if the local communities are excluded from decision making mechanisms. Conflict management is an ongoing work in progress of adaptive management which has to be cost effective, mutually beneficial, and should address the affected local communities, while helping local biodiversity, including wild life to flourish and not skewed as we see them today.

A combination of various tried and tested solutions should be applied, while looking for other innovative methods that will alleviate the burden on rural and tribal communities and wild life.

"*Treat HWC as a human rights issue that particularly affects the human right to a safe and healthy environment and adopt rights-based approaches to its management*." – The need for Human – Wildlife Coexistence – WWF – The Netherlands 2021.

Scientific names

No.	Common English Name	*Scientific Nomenclature*
1.	Blackbuck	*Antelope cervicapra*
2.	Blue Bull (Neel Gai, Van Roz)	*Boselapus tragocamelus*
3.	Bulbuls	*Pycnonotus sps.*
4.	Civet cats	*Paradoxurus hermaphrodites and Viverricula indica*
5.	Clouded Leopard	*Neofelis nebulosa*
6.	Cormorants	*Phalacrocorax sps.*
7.	Ducks	*Anas sps.*
8.	Egrets, Herons and Storks	*Egretta sps., Ardea sps., & Family Ciconiidae*
9.	Elephant	*Elephas maximus*
10.	Gaur	*Bos gaurus*
11.	Geese	*Anser sps.*
12.	Great Indian Rhinoceros	*Rhinoceros unicornis*
13.	Hare	*Lepus nigricollis*
14.	Kingfishers	*Family Alcedinidae*
15.	Leopard	*Panthera pardus*
16.	Mongoose	*Herpestes sps.*
17.	Monkeys	*Macaca sps.* and *Presbytes sps.*

No.	Common English Name	*Scientific Nomenclature*
18.	Otters	*Lutra sps.*
19.	Pangolin – Indian and Chinese	*Manis sps.*
20.	Peafowl	*Pavo cristatus*
21.	Porcupine	*Hystrix indica*
22.	Reindeer	*Rangifer tarandus*
23.	Sambar	*Rusa unicolor*
24.	Snow Leopard	*Panthera uncia*
25.	Spotted Deer/Cheetal	*Axis axis* also *Cervus axis*
26.	Squirrel	*Funambulus sps.*
27.	Rodents (Rats and Mice)	*Rodentia – family Muridae*
28.	Thamin or Eld's Deer	*Cervus eldi*
29.	Tiger	*Panthera tigris*
30.	Wild Goats	*Capra sps., Hermitragus sps., Nemorhaedus sps.,*
31.	Wild Sheep	*Ovis sps., Psudovis nayaur*
32.	Wild Boar	*Sus scrofa*
33.	Wild Water Buffalo	*Bubalus arnee*

Glossary

1.	BDA	Biological Diversity Act
2.	CAMPFIRE	Communal Areas Management Programme for Indigenous Resources
3.	CBNRM	Community Based Natural Resources Management
4.	FRA	The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 – otherwise known as the Forest Rights Act
5.	HWC	Human Wildlife Conflict
6.	IPLC	Indigenous People and Local Communities
7.	NTFP	Non-Timber Forest Produce
8.	SADC	Southern African Development Community
9.	SOP	Standard Operating Procedure/s
10.	SU	Sustainable Use
11.	WL(P)A	Wild Life (Protection) Act

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Human–Animal conflict and the role of Governmental and Non-Governmental Organizations in its Mitigation: A case study from South India

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Abstract

Human-Animal conflict is an issue of serious concern world-wide, which most certainly occurs as a result of competition for limited natural resources between Humans and wild Animals, which subtlety means favoring one over the other leaves the latter at the receiving end. Hence it is of utmost importance to satiate both the Humans and wild Animals not only for survival, but also for existence. The study was carried out based on an assumption that the Governmental and Non-Governmental Organizations must be working and playing a big role in mitigation of the wicked problem of Human-Animal conflict. In order to check the hypothesis, a survey using structured and semi structured interviews was carried out with the farmers (respondents) affected by the Human-Animal conflict in order to analyze the effectiveness of the governmental and non-governmental organizations role in mitigation of this conflict. The study found that the governmental organizations were the only one to take measures and working to mitigate the conflict and there is no direct measureable role of non-governmental organization in mitigation of the conflict in the study area. Even though the government is trying to mitigate the problem of Human-Animal conflict the respondents were not very satisfied with the governmental policies and respective measures to mitigate the Human–Animal conflict.

Keywords: Human- wildlife conflict, Mitigation, policies, effectiveness, stakeholders, plantations, respondents

Introduction and General overview of Human-Animal conflict in India and study area

India hosts a wide variety and great booty of biological diversity, with 2.4% of the world's area, which is over 8% of the world's total biodiversity, making it one of the 12 mega diverse countries in the world (MoEF, 2004). India is also the second most populated country in the world with population exceeding 1.2 billion, creating heavy competition between Humans and Animals for limited natural resources, thereby giving rise to a complex and evil problem of Human-Animal conflict.

"Human-wildlife conflict occurs when the needs and behavior of wildlife impact negatively on the goals of humans or when the goals of humans negatively impact the needs of wildlife. These conflicts may result when wildlife damage crops, injure or kill domestic animals, threaten or kill people" (Madden 2004. Pg. 248).

This issue of Human-Animal conflict today is a major problem for policy makers and forest managers in general because of its complexity and scale, posing a serious threat to the survival of both Humans and Animals worldwide both in developing and developed countries and these conflicts are site specific and according to my understanding cannot be generalized.

According to Pawan, et al., 2016 the main causes or reasons for these Human-Animal conflicts in India are forest degradation, fragmentation, habitat loss, species invasion or succession resulting in loss of grass lands for herbivores, insufficient prey for carnivores, depletion of water bodies in the forests, agricultural expansion and increased livestock farming resulting in over grazing, competition between domestic and wild animals and developmental activities. In a nut shell all these are primarily due to rise in Human population- resulting in competition for limited natural resources. In many countries around the world, the Human- Animal conflict is dealt with pro-Human measures like control of problematic animals, the animal involved in conflicts with Humans especially crop depredating animals are dealt with measures like translocation of the problem animals, capturing of problem animals like elephants and taming them, in severe cases of conflicts poisoning, hunting, shooting and electrocution of the problem animals is widely practiced. But fortunately or unfortunately these above mentioned methods or measures cannot be practiced in Indian scenario, because of the existing policy and legislation. Most of the Problem animals involved in the conflict are endangered and are protected under “the Wildlife Protection Act of 1972”. Which limits measures to be initiated in an event of Human-Animal conflict, because of the endangered status of the problem animals. This issue makes the Human-Animal conflict in Indian context more and more complex.

In such a complex situation, it would be of great interest to scientists and to policymakers to know and analyze how effective is the Government, its policies and the role of Non-Governmental Organizations in mitigation of the Human-Animal conflict and prospective scope for improvement in order to satiate both the Humans and Animals.

Organizational structure of the forest administration, Policy and Law in India

The whole of the forest organizational structure, management, administration, framing of policy and law are chiefly governed by the central ministry of environment, forests and climate change. The ministry is further divided its organizational structure into two different wings namely the Environment wing and the forest and the wildlife wing. And the forest and wildlife

wing is directly monitored by secretariat of the ministry followed by the director general of forest (DGF) and is again divided into two and an additional two with minor roles namely the forest conservation department (FC), National Tiger Conservation Authority (NTCA), the wildlife department (WL) and Joint secretary of Forests for Forest Establishment (FE) which are again monitored by the respective additional director general of forests (ADDL. DG) under the supervision of the DGF. Under the supervision of ADDL.DG The forest conservation division is divided into 5 branches for effective administration under the following authorities namely, Director, Regional Office Head Quarters (ROHQ), Inspector general of Forests for Forest Conservation (IGF, FC), Inspector General of Forests for Externally Aided Projects (IGF, EAP), Deputy Inspector General of Forests for Research and Training (DIG, RT), Inspector General of Forests for National Afforestation and Eco- Development board (IGF, NAEB). The Wildlife division is divided into three branches for effective administration under the following authorities namely, Inspector General of Forests for Wildlife (IGF, WL), Inspector General of Forests and Director for Project Elephant (IGF & Dir, PE), Additional Director for Wildlife Crime Control Bureau (WCCB).

The forest conservation (FC) division is responsible for matters relating to the Indian Forest Conservation Act, monitoring of Forest Protection Division (FPD), Forest Survey and Utilization Division (SU), Forest policy (FP), Forest Research and Training (RT) and monitoring and implementation of National Afforestation and Eco development program (NAEP). The Wildlife division is responsible for monitoring of Zoo's by forming a chief body called the Central Zoo Authority of India (CZA) and protection of wild animals from poaching, implementation animal protective programs like Project Elephant (PE) and all the crimes related to or with the wild animals by establishment of a bureau called Wildlife Crime Control Bureau (WCCB).

This organizational setup at the central or national level is vested with the responsibility of framing of policies and law to the whole country and the respective states or state governed forest departments are responsible for implementing, monitoring and functioning of the centrally or nationally framed forest policies and law.

The process of public policy formulation and implementation in India

The process of policy formulation and implementation in India is as depicted in the figure above. Generally, when there is an issue or problem faced by the public or any stakeholder,

they approach to their elected representatives called legislatures and explain the problems and demand for a satisfactory solution. The legislature, then discusses the issue with the executives of the respective department and order them to develop a path/plan/policy for the solution of the public problem. The executives then discuss and formulate a policy and hand it over to the legislature for his perusal. Then the legislature adopts the policy suggested and prepared by the executives and takes the policy to the cabinet for discussion and general approval of all the legislatures of the cabinet, then if all the legislatures agree on the policy, the policy is then approved. Then the cabinet or the government orders the respective executives to implement the policy and then the legislatures and the comptroller and auditor general (CAG) and the media and others make sure the policy is effective and the bureaucracy is functioning efficiently. But unfortunately and practically these legislature or politicians are allured by the strong stakeholders and the weak stakeholders are suppressed and unheard of their problems or issues and eventually land up into problems, like Human-Animal conflict, etc. (Figure 1).

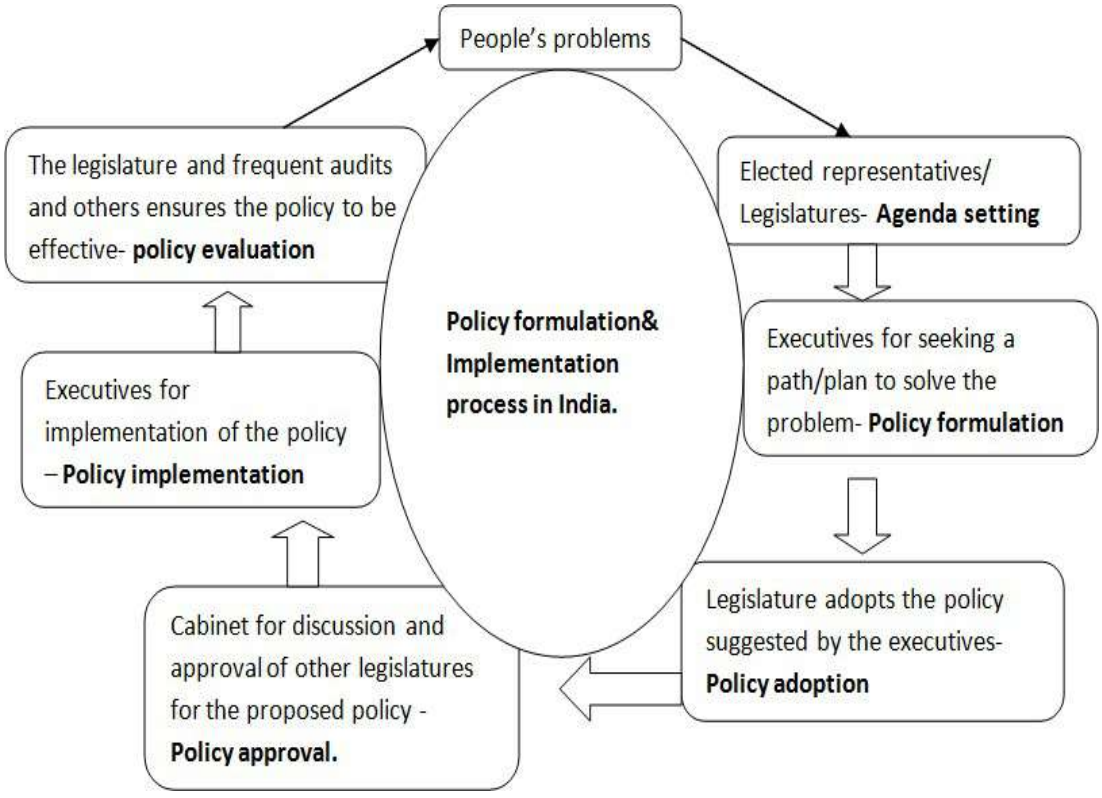


Figure 1: *The process of public policy formulation and implementation in India*

Policy and law pertaining to Human-Animal conflict.

There is no direct policy and law pertaining specifically on the problem of Human-Animal conflict mitigation. As discussed earlier most the animals involved in this wicked problem of conflict with Humans are rare, endemic or endangered and are protected by a strict policy and law called the Wildlife Protection Act passed by the Indian government in 1972. But after the implementation of the Act the Government soon realized the immediate need for stringent conservation programs to conserve the critically endangered wild animals and the government started with the conservation of national wild animal the Tiger, because of its dwindling population and launched a scheme or program called "Project Tiger" in 1973 and the Indian government also launched another program called the "Project Elephant" in 1992 in order to conserve the elephants. Under these two projects the issue of Human- Animal conflict is indirectly addressed. Generally, a protocol is followed in case of Human-Animal conflict under the preview of the two schemes namely…

Project Tiger

After this program was launched and implemented, Tiger reserves were established in many parts of the country based on a strategy of establishing core zone and buffer zone, the core zone is strictly monitored and any kind of anthropogenic activity is banned and the human settlements were evacuated and the buffer zones were solely meant for conservation purposes (Kothari, et al.,1989). The main thrusts or objectives of the "Project Tiger" are:

1. Protection and surveillance of the tiger reserves.
2. Voluntary relocation of forest dwellers from critical Tiger habitat.
3. Habitat management.
4. Addressing the issues of Human- Animal conflicts
5. Monitoring the movement of Tigers and rescuing them when they venture into human settlements.
6. Addressing the issues of reliance of local communities on the forest resources through sustainable livelihood options.
7. Creating of awareness for public support.
8. Supporting research (MoEF 2016, NTCA 2017).

Project Elephant

This program or scheme was launched by the Central Government of India. In order to provide and extend financial and technical support to all the State Governments for the management and conservation and protection of wild viable populations of Elephant, their habitat and Elephant corridors which are used by the elephants for migration (Aqeel Farooqi,2007). The main objectives of the "Project Elephant" are:

1. To protect elephants from illegal hunting and poaching, to protect their habitat from encroachment & clear the elephant corridors from all disturbances.
2. To address the issues of Human-Animal conflict.
3. To ensure the wellbeing of all the captive elephants across India (MoEFCC, 2014).

As a result of these two schemes or programs launched by the Government of India, the population of both the tigers and elephants increased considerably, especially the tigers, the number of tigers increased from 268 in 1973 to 2,226 in 2014(NTW, 2014,Wikipedia, 2016) and according to Macura et al., 2016 the population of the tigers has to some extent increased because of the stringent conservation programs, but with increasing tiger population the problem of Human-Animal conflict only increases, were as because of the project elephant the number of elephants increased from 26,413 in 2002 to 27,669- 27,719 in 2007 (GOI 2013). The Government of India is being very successful in conserving these wild animals but has not being very effective in addressing the issue of Human- Animal conflict. This increase in the number of wild animals with the constant forest resource has resulted in competition which has led to more issues of Human- Animal conflict. In the North-East India alone 1,150 human were killed by the tigers in a period between 1980- 2003 (Choudhury, 2004). Similarly every year approximately 300 humans are killed due to elephant attacks or because of Human- elephant conflict (WWF 2017).

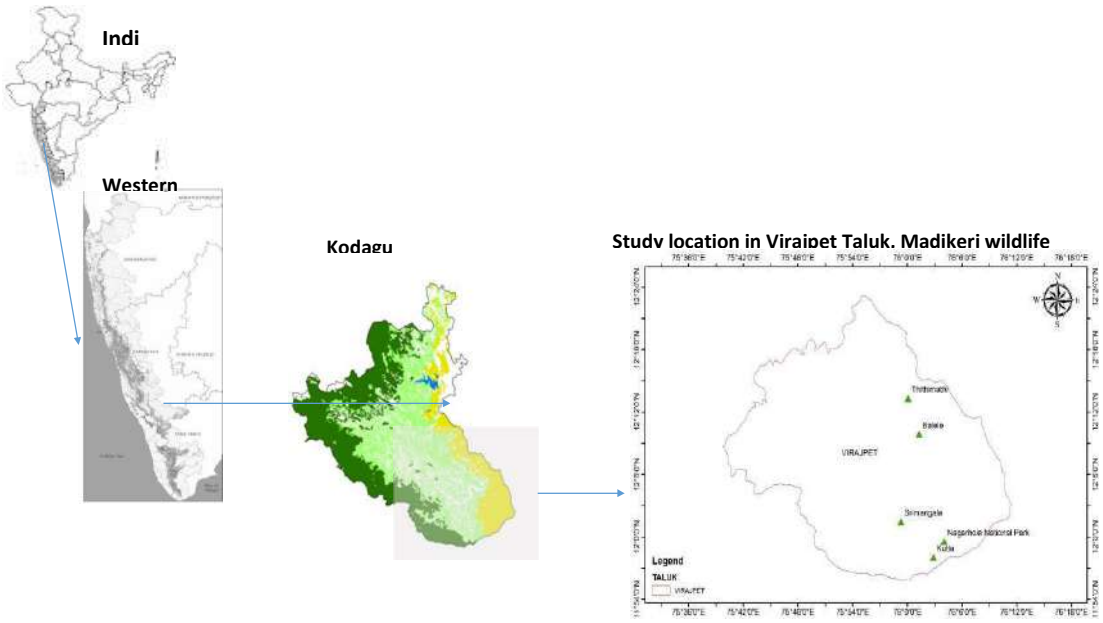
A case study of Human-Animal conflict from Karnataka, India

Karnataka jointly with other adjoining states hosts one of the rare environs of the earth called the Western Ghats. These Ghats host various different and unique forest types from wet evergreen forests to moist deciduous forest and swamp forests. These forests host some of the most rare, endangered and endemic species of flora and fauna. These Ghats with rich floral diversity also act as very valuable source of gene pool for development of agriculture by

harboring wild and natural species of Mango, Jackfruit, Pepper, Cinnamon, Cloves, Cardamom etc,. These forests are very rich in rare faunal diversity of species like Tigers, Elephants, Gaurs, leopards, lion tailed macaque, Nilgiri langur etc, (Martin, 1999). According to status of tigers in India report 2014 and estimated populations of elephants in India 2012, Karnataka state because of its stringent conservation measures and practices takes the credit of hosting highest number of Tigers and Elephants in the entire country. The most crop raiding, cattle lifting and human attacking animals of Karnataka are Elephants, Leopards, tigers and wild boars. The increase in number of wild animals with limited resource can also be termed as one of the major causes of Human-Animal conflict in the state.

Study location map

Geographic mapping of study area helps in locating the plots and finding the distribution spatially. Arc map 9.1 software of ESRI was used to perform the mapping work. The geographic location of the study area was collected using GPS. GPS provides latitude, longitude and Elevation of the particular point. The location points were extracted from the GPS and were loaded to the Arc map software using XY data algorithm. The loaded points were projected on Geographic Latitude and Longitude with WGS 1984 datum. The points were then overlaid on administrative boundaries. The map was then exported in Arc map 9.1 (Figure 2).



(Source: Sathish B N, (2010), Elouard, C., (2000) and own elaboration)

Figure: 2: *Study location map of Virajpet Taluk, Madikeri Wildlife Division.*

Methodology

Primary Data was collected through interviews conducted based on the forest range wise records obtained from the state forest department and also easy accessibility from the hosting organization was considered and the interviews were conducted based on structured and semi-structured questionnaires with the affected village communities mainly farmers and the interviews were mainly conducted with head of the households, but sometimes in the absence of household heads the interviews were conducted with their wife or any family member available and interview were also conducted informally with the field level forest officials. And a total of 123 interviews were conducted, and only 108 were considered, because of poor response from the respondents and the respondent were in the age group of 35-84 years of age and the results obtained from the interviews were analyzed in percentage using the formula (%=F/N x 100) Percentage (%) = Frequency of the answers of the respondents/total number of respondents interviewed X 100. The results of the analysis were interpreted in the form of Pie charts for better understanding.

The questionnaires were designed to extract the objective motivated information both structured and semi-structured questionnaires were designed for the affected village communities mainly farmers and informally with the field level forest officials in order to avoid any biases.

Secondary Data is based on literature review and based on the original records and not reviews of the reports meant for internal communication, from the state forest department which is a Governmental organization. All the records obtained from the State forest department were in the official language Kannada and were translated to English. The records were obtained for the last five to six years 2011-12 to 2016-2017 to check for the intensity and scale of the conflict and the results are depicted in the form of bar graphs.

Results and Discussion

Even after implementation of all these strategies to mitigate Human- Animal conflict their still exist conflict which result in crop damage, Human injuries, Human deaths, cattle deaths, property loss (Figure 3).

Figure 3: *Evidence of Human wildlife conflict in study area*

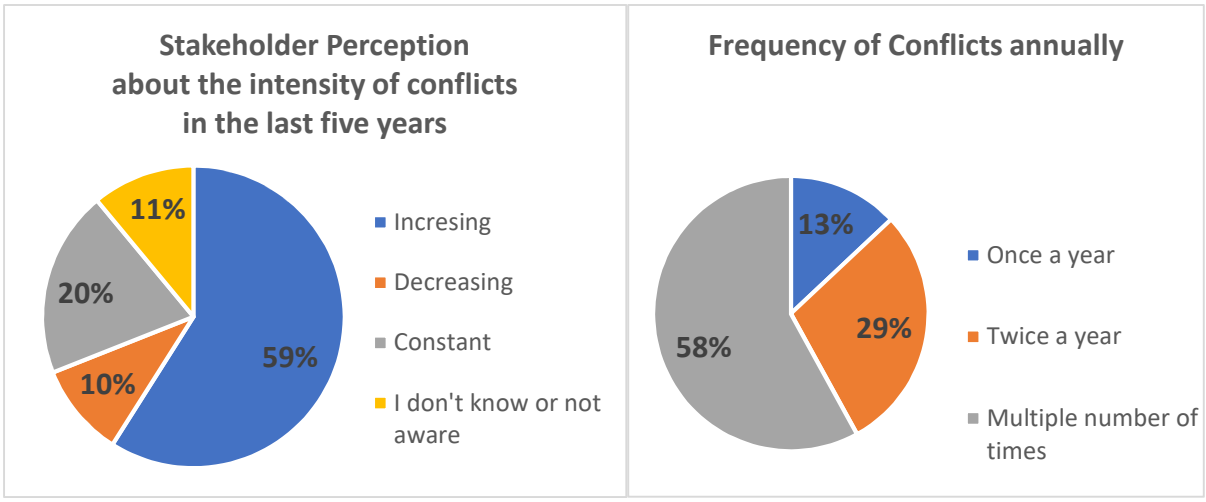


Figure 4: *Stakeholder perception about the intensity in recent years and frequency annually, of Human-Animal conflict*

59% of the respondents opined that the conflicts have been increasing, because they believe that off late the frequency of conflicts annually have increased from once or twice a year to multiple number of times. 20% of the respondents opined that the conflicts have been constant, because they stated that the frequency of conflict is twice annually in two seasons i.e., Jackfruit ripening season and in peak summers for water. 10% of the respondent opined that the conflicts have been decreasing, because they stated that the frequency of conflict annually is reducing from multiple numbers of times to once or twice annually, because of adjacent large private plantation owners taking up of safety measures (Figure 4).

Recorded cases of Human- Animal conflict in the study area (Virajpet Taluk, Madikeri wildlife division) are shown in Table 1.

Table 1: *Recorded cases of* ***Human-Animal Conflict***

Sl. No.	Year	Crop Damage		Human Injuries		Human Death		Cattle Damage		Property Loss		Total
		Cases	Amount	Cases	Amount	Cases	Amount	Cases	Amount	Cases	Amount	
1	2011-12	612	2300375.00	8	67625.00	1	200000.00	10	32000.00	-	0	2600000.00
2	2012-13	535	1953900.00	4	30767.00	3	1500000.00	5	15000.00	-	0	3499667.00
3	2013-14	601	1924932.00	4	68539.00	3	1500000.00	2	6000.00	-	0	3499471.00
4	2014-15	1719	6409750.00	3	50250.00	2	1000000.00	11	40000.00	-	0	7500000.00
5	2015-16	1212	5267463.00	2	25537.00	3	1500000.00	10	100000.00	1	7000.00	6893000.00
6	2016-17	1374	6154566.00	2	75126.00	6	2833334.00	10	126000.00	-	0	9189026.00
Total		**6053**	**24010986.00**	**23**	**317844.00**	**18**	**8533334.00**	**48**	**319000.00**	**1**	**7000.00**	**33181164.00**

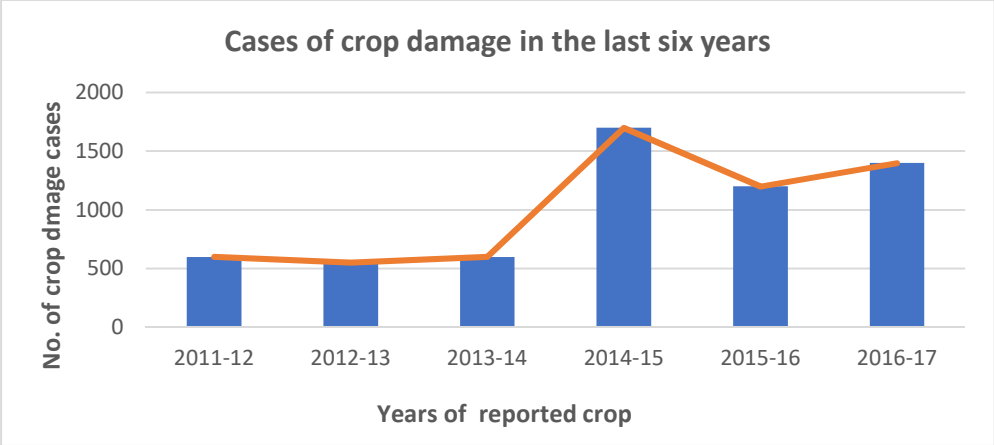


Figure 5: *Number of Crop damage cases reported between 2011-12 to 2016-17*

It appears to be because of the stringent measures of the forest department the incidences of crop damage have be reduced in 2016-17 as compared to the 2014-15, but has considerably increased from 2015-16. Technically the reasons are non-functionality and ill maintenance of the physical barriers and mitigation measures installed for stopping the Animals access to the Orchards and Agricultural fields (Figure 5).

Figure 6: *Human injury cases from 2011-12 to 2016-17*

The cases of Human injuries have reduced over the years according to the official records. But according to the respondents may incidents go unreported and suppressed (Figure 6).

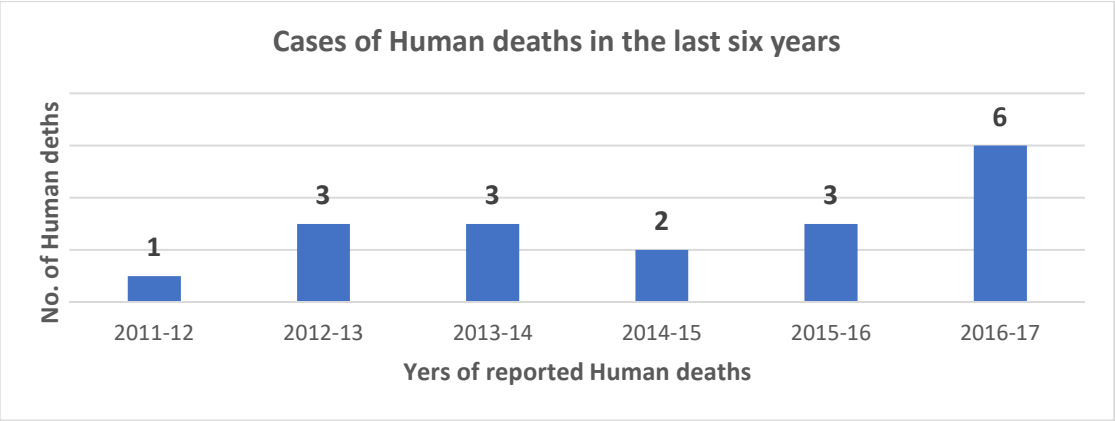


Figure 7: *Human Mortality reported between 2011-12 to 2016-17*

The cases of Human deaths have increased as per the records (Figure 7). However, practically on the field and according to the respondents there have been more deaths than reported. Because of many underlying issues of the bureaucracy and politics.

Results pertaining to each of the study objective

To analyze the existing Governmental policy related to Human-Animal conflict with respect to awareness and participation of stakeholders (affected village communities) in policy formulation and implementation.

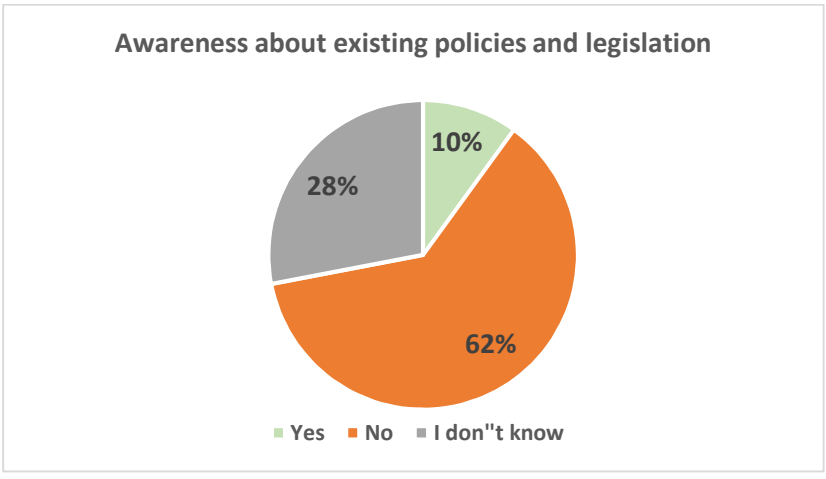


Figure 8: *Awareness of the respondents about the existing policies and legislation.*

62% of the respondents clearly stated that they are not aware of any policies and legislation in with respect to Human-Animal conflict. 28% of the respondents stated that they do know that there are policies and legislations with respect to Human-Animal conflict, when ask to justify their answer, the respondents provided justification like the government provides compensation and chases the intruding wild animals back into the forest. 10% of the respondents stated that there might be or there are policies and legislation existing on Human-Animal conflict, but they don't know anything about them. 28% of the respondents, who claimed they know something about the policies and legislation, actually were unaware of the compensation assessment process and procedure. When the standard procedure of the crop damage assessment for the release of the compensation was shown to the respondents none of them knew about it. This clearly states that, there is no awareness among the stakeholders about the existing policies and legislation (Figure 8).

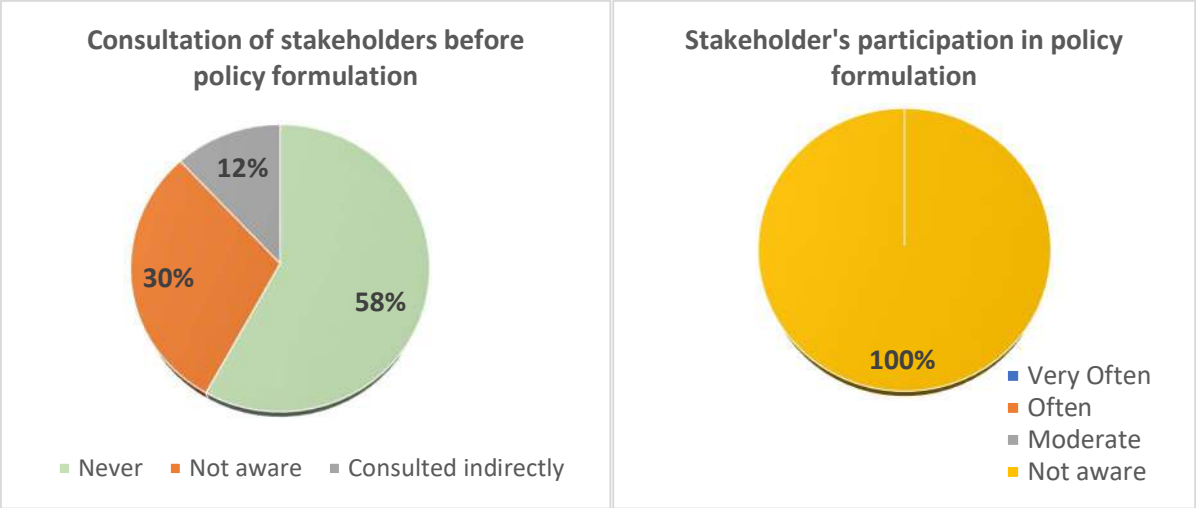


Figure 9: *Consultation of the stakeholders (respondents) and participation of stakeholders (respondents) in the policy formulation and implementation phases.*

58% of the respondents stated that they have never been consulted with regard to policy formulation or implementation. 30% of the respondents stated that they are not aware, if some consultation was in practice or not, because they never participated in any such activity or were never invited for it. 12% of the respondents opined that before policy formulation the political representatives might have been consulted, but not very sure. 100% of the respondents are not aware of any kind of a survey or a program or discussions pertaining to policies and legislation. This clearly states that there is almost zero participation of the stakeholders in the policy formulation or implementation (Figure 9).

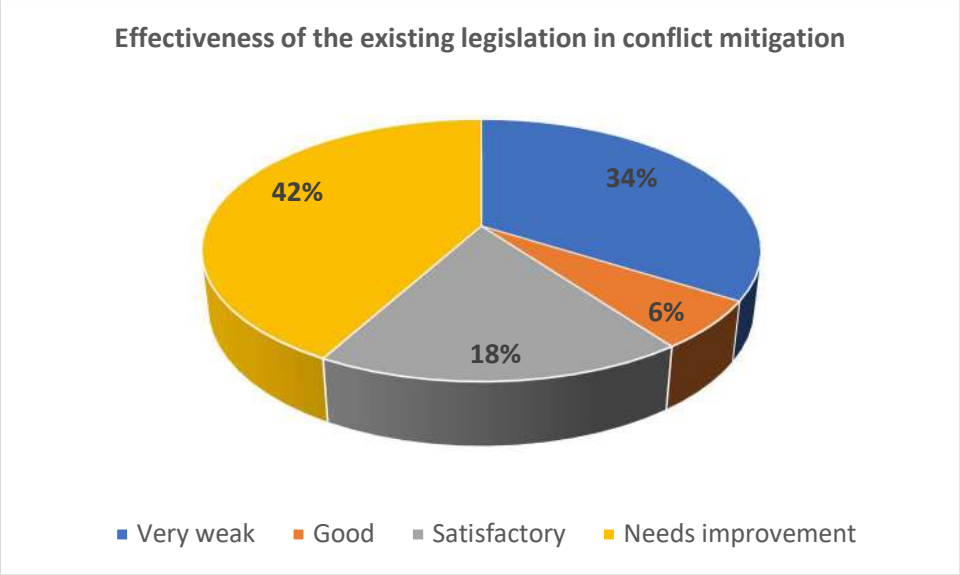


Figure 10: *The stakeholders (respondents) opinion about the effectiveness of the existing legislation in Conflict mitigation.*

42% of the respondents opined that the legislation needs improvement, because the crop damage assessment procedure is not satisfactory, unrealistic and time consuming. 34% of the respondents stated that the legislation is very weak, because many times the forest department doesn't follow the protocol and is unresponsive when approached. 18% of the respondents stated that the legislation is satisfactory, because they opine, even though the forest department is unresponsive, with frequent complaints they become receptive in following the protocol. 6% of the respondents stated that the legislation is good, because the forest department is very responsive and receptive in following the protocol in managing the Human-Animal conflict (Figure 10).

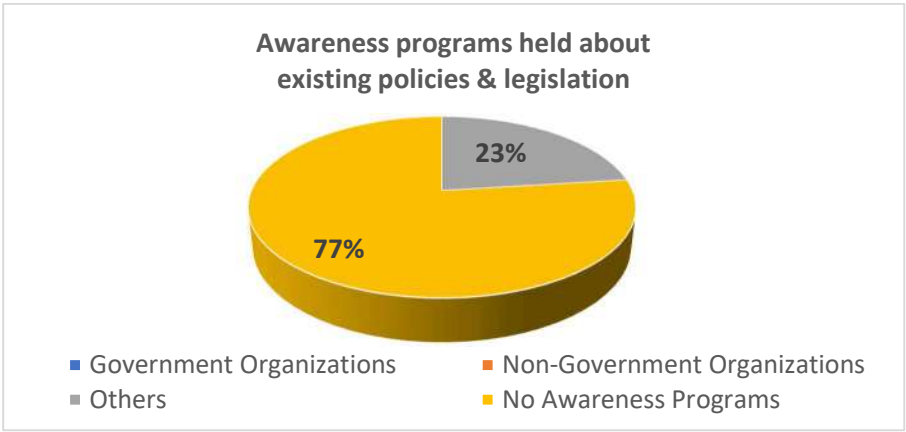


Figure 11: *The stakeholder's response on awareness programs held at the time of new policy formulation or implementation or new amendments of the existing policies and legislation in the last five years.*

When we tried to know if there was any awareness program being held to create awareness among the stakeholders about the existing policies and legislation, we found that 77% of the respondents stated there was no awareness programs held by neither Governmental Organization nor Non-Governmental organizations. 23% of the respondents opined that they were able to gain some knowledge from the media, but were not able to understand and stated they just got a hint or idea from the media about the existing or amending policies and legislation (Figure 11).

To assess the effectiveness of the measures undertaken by both Governmental and Non-Governmental organizations in mitigation of the Human-Animal conflict

Measures taken by the Governmental organizations to Mitigate Human-Animal conflict in the study area.

In order to combat the problem of Human-Animal conflict and as part of objectives of the project Tiger and project Elephant the Indian Government along with respective state governments has taken up various measures to mitigate Human-Animal conflict. Some measures taken up by Government of Karnataka, India through the Department of Environment and Forests to mitigate Human-Animal conflict are:

1) The forest Department has identified the forest dependent communities in and around the forests, and victims of Human-Animal conflicts.

2) The forest Department has taken up protective measures like regular patrolling of the Human- Animal conflict prone areas.

3) The forest department has also taken up preventive measures like Digging of elephant proof trenches, Solar fencing of the forest boundaries and possible entry points of wild animals into the human settlements. The forest department is also providing 75% subsidies to the rural farming communities to solar fence their farmland.

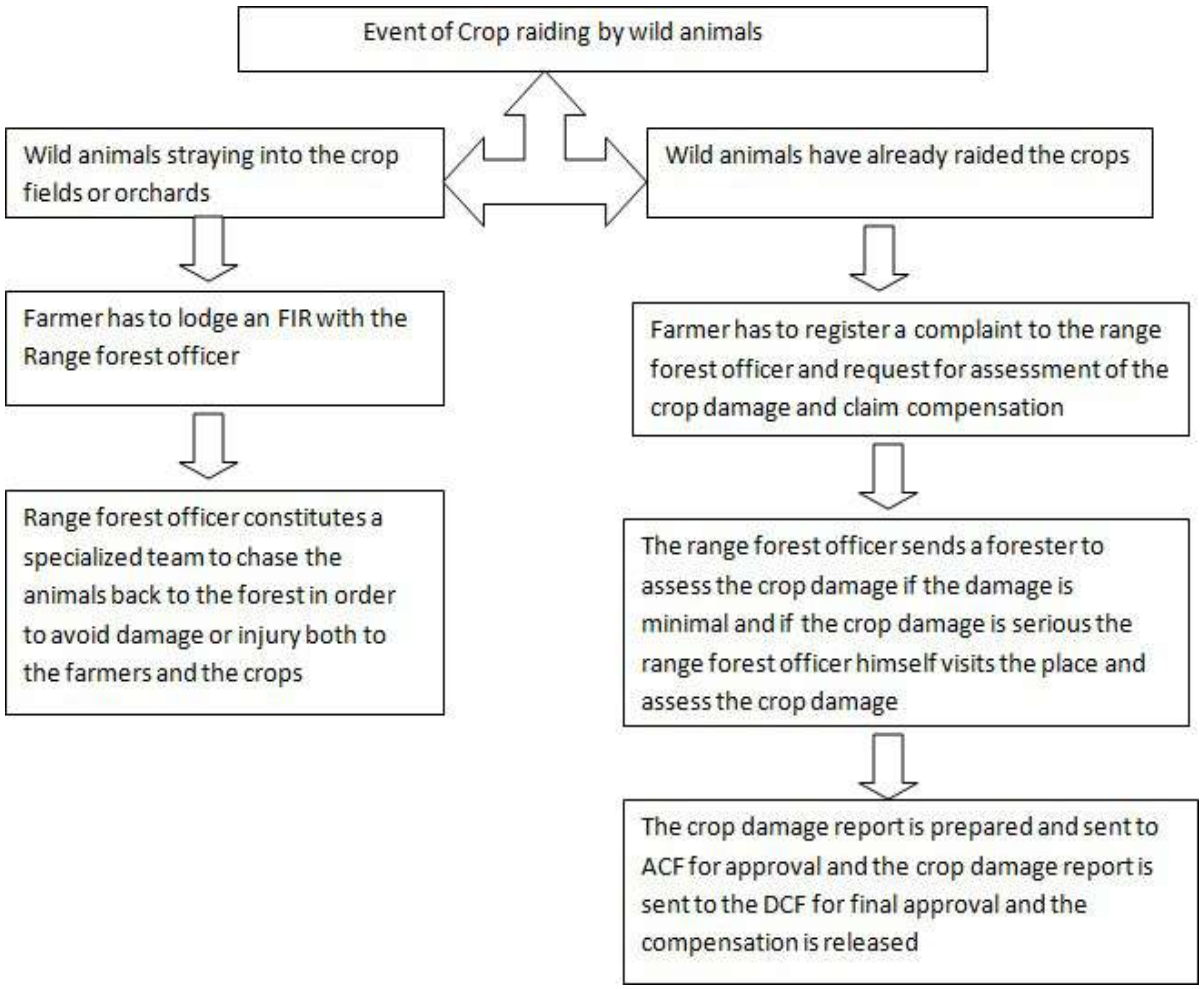
4) The forest department has also taken up measures to reduce the dependency of the rural communities on forests by providing them with forest product substitutes like distribution of Honey bee boxes for rearing honey bees for honey, LPG cylinders for reducing the

usage of firewood, energy efficient cooking stoves, solar lamps etc.

Protocols followed by the State forest department of Karnataka in the study area, in the event of Human- Animal conflict.

The protocol followed in the event of crop raiding.

The process and procedure of crop damage assessment in an event of crop raiding by the Wild Animals and the list base price or minimum support price for various kinds of crops grown in the study area, set by State Government of Karnataka is elaborated in Figure 12.



Source: Own elaboration

Figure 12: *The protocol followed in the event of crop raiding*

The assessment baseline price for the crop damage caused by wild animals, set by the governmental organizations i.e., Forest department is done according to criterions mentioned below based on the Government order number: A.p.ji- 130 FWL- 2016. Compensation fund fixed by the Government of Karnataka to the crops which have been damaged by the wild animals on date 19-9-2016 (Table 2):

Table 2: *Compensation fund fixed by the Government of Karnataka to the crops which have been damaged by the wild animals on date 19-9-2016*

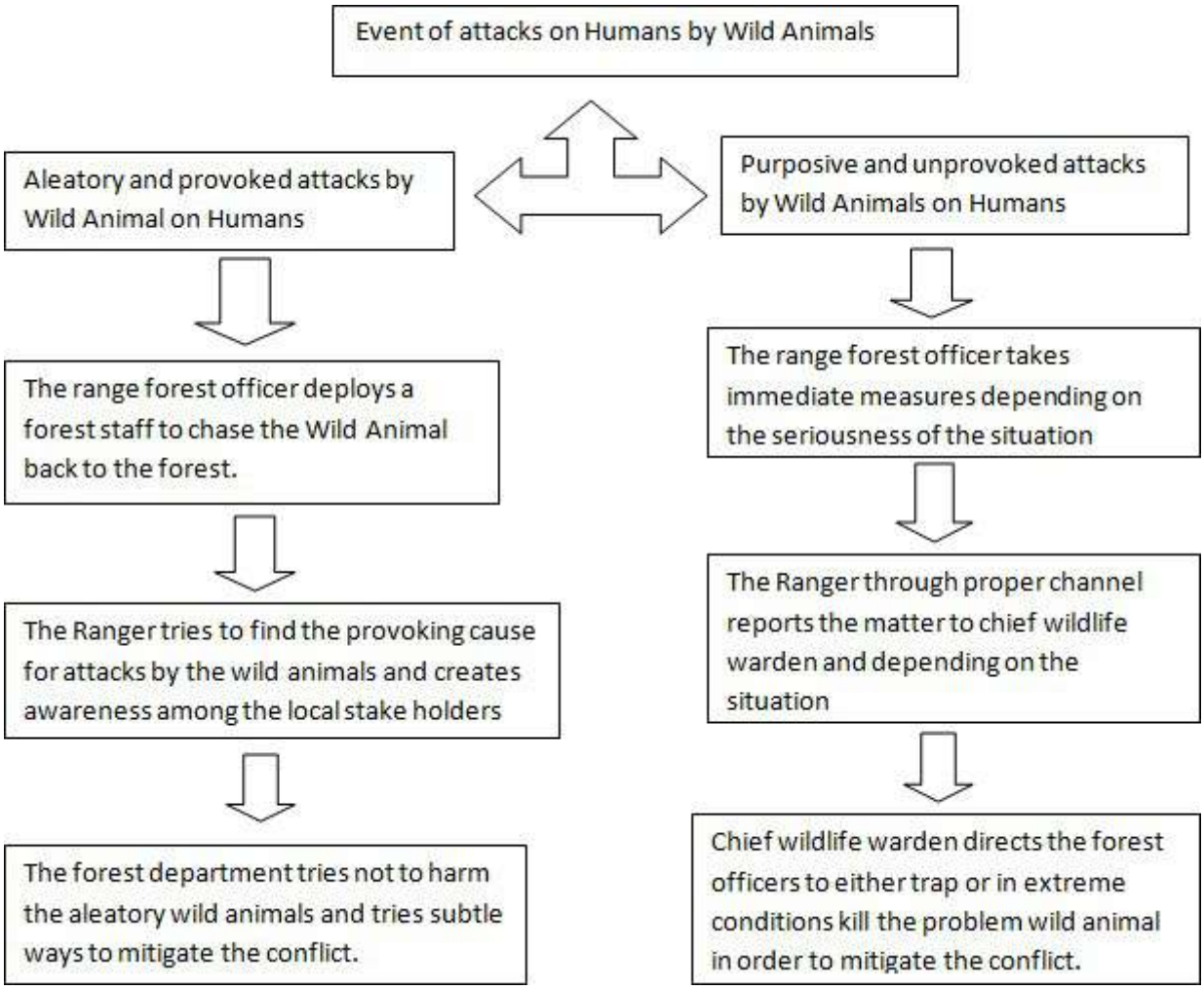
Sl. No	Details of crops	Compensation prize in rupees
1	Paddy	1, 320/- per quintal
2	Ginger	3, 870/- per quintal
3	Coffee	200/- for one plant
4	Cardamom	800/- per Kg
5	Pepper	180/- per kg
6	Banana	160/- per kg
7	Lemon	10/- per plant
8	Grape fruit	24/- per plant
9	Citrus 1. (Less than 5 years) 2. (More than 5years)	200/- one plant 320/-for one plant
10	Arecanut/ Coconut 1. Less than 5 years 2. 7 to 9 years 3. More than 10	400/- for one plant 800/- for one plant 2,000/- per plant
11	Property loss	10,000/-

Government order number: A.p.ji. 109. F.A.P 2014, Bangalore, Compensation fixed by the Government of Karnataka to Cow, Bull, Buffalos, killed cases by the wild animals on Date- 13-08-2014. (Table 3).

Table 3: *Government order number: A.p.ji. 109. F.A.P 2014, Bangalore, Compensation fixed by the Government of Karnataka to Cow, Bull, Buffalos, killed cases by the wild animals on Date- 13-08- 2014*

Sl. No	Details	Amount (in Rupees)
1	Cow, Bull, Buffalo	10,000/-
2	Goat, Ship	5,000/-

The protocol followed by the by the government of Karnataka in the event of attacks on humans by Wild Animals:



Source: Own elaboration

Figure 13: *The protocol followed by the by the government of Karnataka in the event of attacks on humans by Wild Animals*

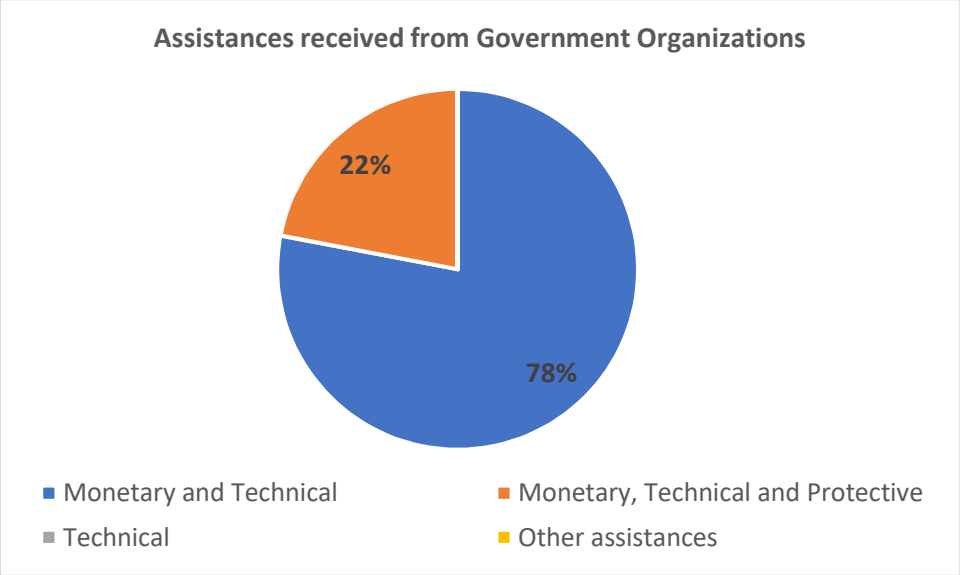


Figure 14: *Stakeholders response on kinds of assistance received from the Governmental organizations in an event of Human-Animal conflict.*

78% of the respondents stated that they only receive monetary and protective assistances, monetary assistance in the form of crop damage compensation and protective assistances in the form of creation of elephant proof trenches, installations of solar fences, deployment of additional staff in an event of conflicts. 22% of the respondents stated that they receive monetary, protective and technical assistances; technical assistances were received from in particular by the range forest officers without any scientific reasoning, but opined the technical assistance to be working sometimes (Figure 14).

100% respondents stated that they absolutely have no contact with any Non-Governmental Organizations at present or in the past working on mitigation of Human-Animal conflict. And they also stated that this is the first time that someone is asking them about these issues.

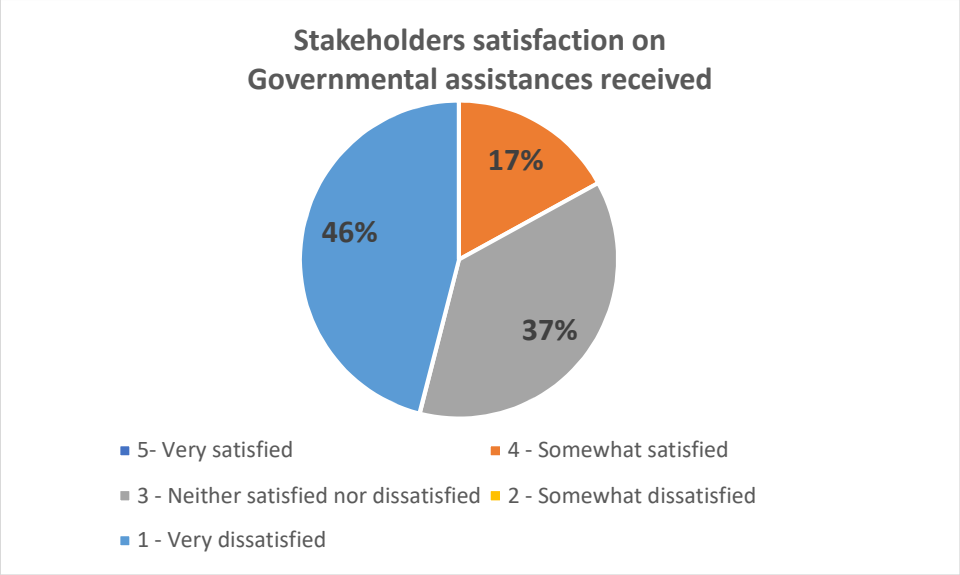


Figure 15: *The stakeholders' satisfaction on the assistances they receive from the Governmental organizations in an event of Human-Animal conflict.*

46% of the respondents stated that, they were very dissatisfied with the governmental assistances received, because they opined that the procedure of receiving the assistances is very time consuming and involved malpractices. 37% of the respondents stated that, they were neither satisfied nor dissatisfied with the Governmental assistances received, because they believe that receiving something for the losses is better than not receiving anything, even though there are a lot of constraints in receiving the assistances. 17% of the respondents stated that, they were somewhat satisfied with the Governmental assistances received, because they have had a fair rapport with the forest department and the department has been responsive for their complaints and have assisted them. Even though there are constraints in receiving the Governmental assistances (Figure 15).

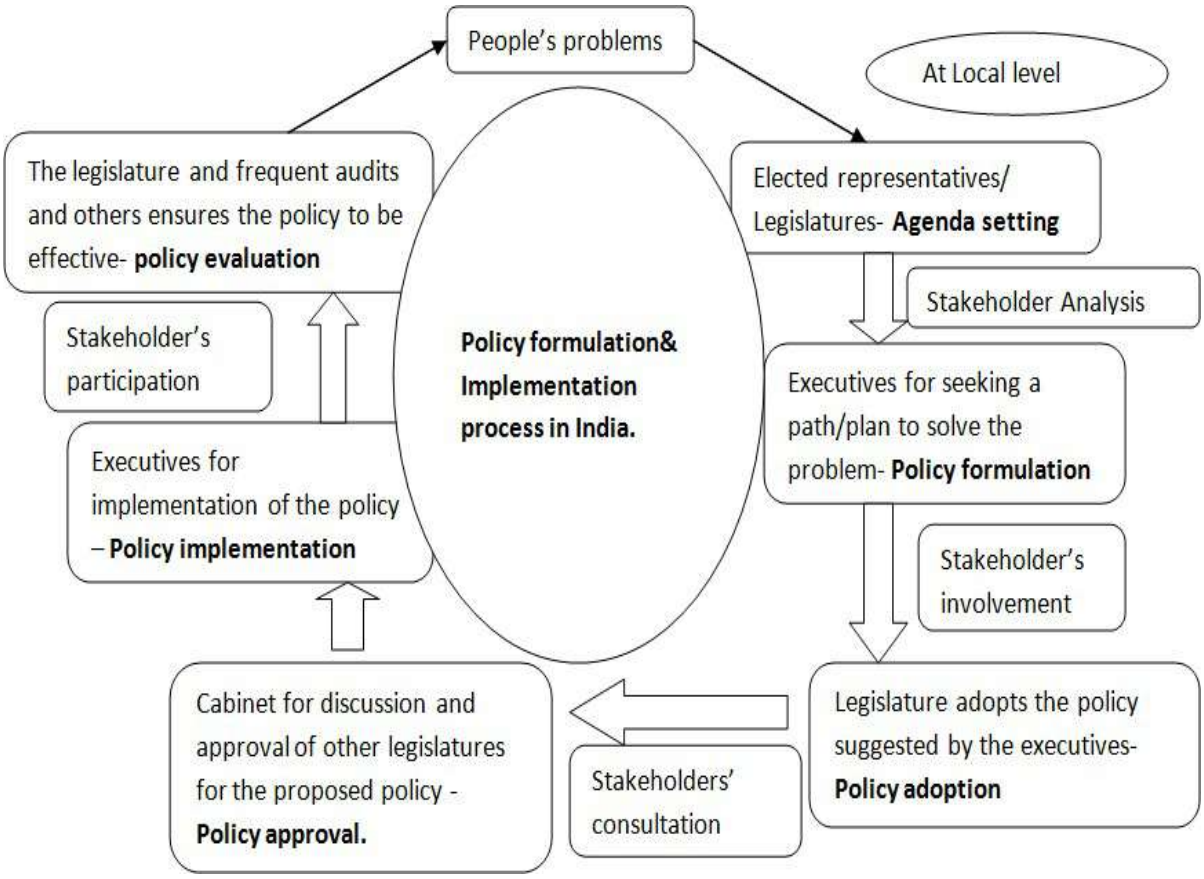
Recommendations and Conclusions

The policy to be more effective it is recommended that the honorable Government has to seriously consider and take steps for stakeholders' participation, especially weaker and underrepresented stakeholders in both formulation and implementation phases. As soon as the agenda is set by the legislatures, before the policy formulation the executives could try to perform a complete stakeholder analysis in order to avoid neglecting of the - -Weaker stakeholders and involve them or consider them in the policy formulation process for the policy

to be coherent and after the policy is formulated and final draft is developed, the stakeholders should be consulted for their consent and the policy should be tabled before the cabinet and after the approval and in the implementation phases of the policy, the policy should be continuously evaluated with the involvement of the stakeholders for the policy to be effective and gain permanence.

The Governmental organizations could also try to create awareness among the stakeholders about the existing policies and legislation pertaining to Human-Animal conflict through the local Grampanchayat. The honorable Government could also encourage the Non-Governmental organizations of state and local level to take part in the mitigation of Human-Animal conflict in this particular study area. The Governmental organizations measures and strategies need to be scrutinized and the crop damage assessment need to be performed in a scientific manner and the crop damage assessment procedure could be performed by a local agriculture or horticultural officer in order to reduce the biasness or inappropriate crop damage assessment.

The process of release of crop damage compensation after the crop damage assessment could be hastened up to satiate the grieving stakeholders suffering from Human-Animal conflict. The forest department should try to bring transparency in the crop damage assessment system. The whole process of Human-Animal conflict mitigation is solely projected as the responsibility of the forest department alone, while the forest department lacks staff and work force for it. The responsibility of Human-Animal conflict mitigation could be shared with the other Governmental organizations such as the Revenue department, the Agricultural department, the Horticulture department for the better and effective management of the problem of Human-Animal conflict.



Source: Own elaboration

Figure 16. *Proposed process of public policy formulation and implementation*

After analyzing the research data, it is quite evident from the results that there is almost no participation of the stakeholders in either policy formulation or implementation and the stakeholders are not even aware of any policy related issues pertaining to Human-Animal conflict. Hence are unaware of the processes and procedures listed in the policy and legislation. The stakeholders believe that the policies are weak and require scrutiny in every sense. The stakeholders opined that the policies are only pro- conservation and only for wild animals and not pro-Humans. The Governmental Organization is alone trying to mitigate the problem of Human-Animal conflict by adopting various measures and strategies. There is no direct participation of Non-Governmental organizations in mitigation of Human-Animal conflict. From the results of the analysis we also know that the stakeholders are not very satisfied by the Governmental Organizations measures and strategies adopted for the mitigation of Human-Animal Conflict.

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Technology to Address Different Aspects of Human-Elephant-Conflict

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Abstract

In recent times, the Human-Elephant-Conflict (HEC) has emerged as a severe socio-economic issue in several parts of India. It's not only causing financial losses frequent death on both sides has become quite frequent. The HEC issue needs to be addressed simultaneously from an administrative, societal, ecological, and technological perspective. From the technological point of view, the development of systems for successful early elephant intrusion detection and contactless & safe elephant drive away will be able to bring down the intensity of the conflict significantly. Considering these, over the years, under national and internationally funded R&D and consultancy projects we have developed technological solutions to address those two key components. The systems are verified through field implementation, feedback data collection, and subsequent data analysis over a certain duration of time. A brief overview of the technical specifications, functionality, and effectiveness of those systems are presented in this paper. The information presented in this present paper is expected to be highly useful for the ecologists, park administrators, and conservationists to replicate the same solution at other conflict hotspots.

Keywords: Elephant, Conflict, Sensor System, Warning System, Safety System

Introduction

It's well understood that by proving 'Safety of Life' and by minimizing 'Crop Raiding' to reduce tension and anger among the farmers, the Human-Elephant-Conflict can be mitigated considerably [1-4]. According to the Indian Environmental Ministry report, due to the conflict, every year on average, total 391 people and 39 elephant deaths are getting recorded across India [5-7]. The government is paying yearly Rs.34.52 crores as damage compensation [8-9]. If proper initiatives are not taken on the ground this picture is going to be severe in the future.

To counter this, as one of the leading research groups in India, over the years, through a number of national and international projects, we have developed various indigenous systems and implemented those in different parts of India as well as abroad [10]. Our technology development initiatives are framed to address two prime aspects of HEC; first, the design of

the Elephant Early Warning System (EEWS), and second, contactless and safe elephant drive-away devices [11]. On the line of EEWS development, under the first initiative, with the funding support from the forest department, IEF (USA), Rufford Organization (UK), and other NGOs, we have developed and installed 46 units of truly indigenous long-range LASER fence based Elephant Early Warning System (EEWS) [12]. Under a parallel R&D with the same objective, with the funding of WWF and DST Govt. of India, we have developed a ground vibration detection system to identify elephant footsteps and provide early warning. As the first group in India, we have successfully installed 14 such ground vibration-based elephant early warning system units at Sathyamangalam Tiger Reserve and Silent Valley National Park under government and NGO projects [13].

All our elephant early warning systems are working well, but through our fieldwork experience, we have realized that early elephant intrusion information can't make much difference unless it's supported with an effective 'elephant drive away' device. Hence subsequently, we shifted our interest for the second objective and have developed a large number of elephant drive-away devices. Under this elephant drive away device category we have indigenously developed acoustic, high-frequency, optical, vibration, and cracker-based real-time contactless pocket-friendly conflict management devices [14]. Those inventions are not only having the capability of reducing animal crop-raiding, they are having the potential of saving priceless life on both sides which are the prime target components in human-wildlife-conflict management.

Under this present paper, the technical specifications and operational details of those devices are presented as an overview. Different technical and non-technical features of different early warning systems and elephant drive-way devices which are presented as an overview will be a valuable reference for selecting precise conflict type-specific solutions for other conflict hotspots in the future.

Technology for human-elephant-conflict management

The HEC can be effectively mitigated by addressing two prime conflict components technically; first by generation reliable early elephant intrusion warning and second by executing contactless safe drive away of crop-raiding elephants. Over the years, through the numbers of nationally and internationally funded projects we have, we have successfully developed and field-tested several systems and devices to address those two components effectively and an overview of those is presented in the following sections.

Systems for early elephant warning generation

Under the elephant early warning generation part we are having two main systems; the first one is a long-range LASER fence and the second one is a ground vibration fence. The long-range LASER fence technology is developed with the funding of Rufford and IEF whereas the ground vibration fencing system is developed with the financial support of WWF and DST SERB.

Long Range LASER Fence for Elephant Early Warning

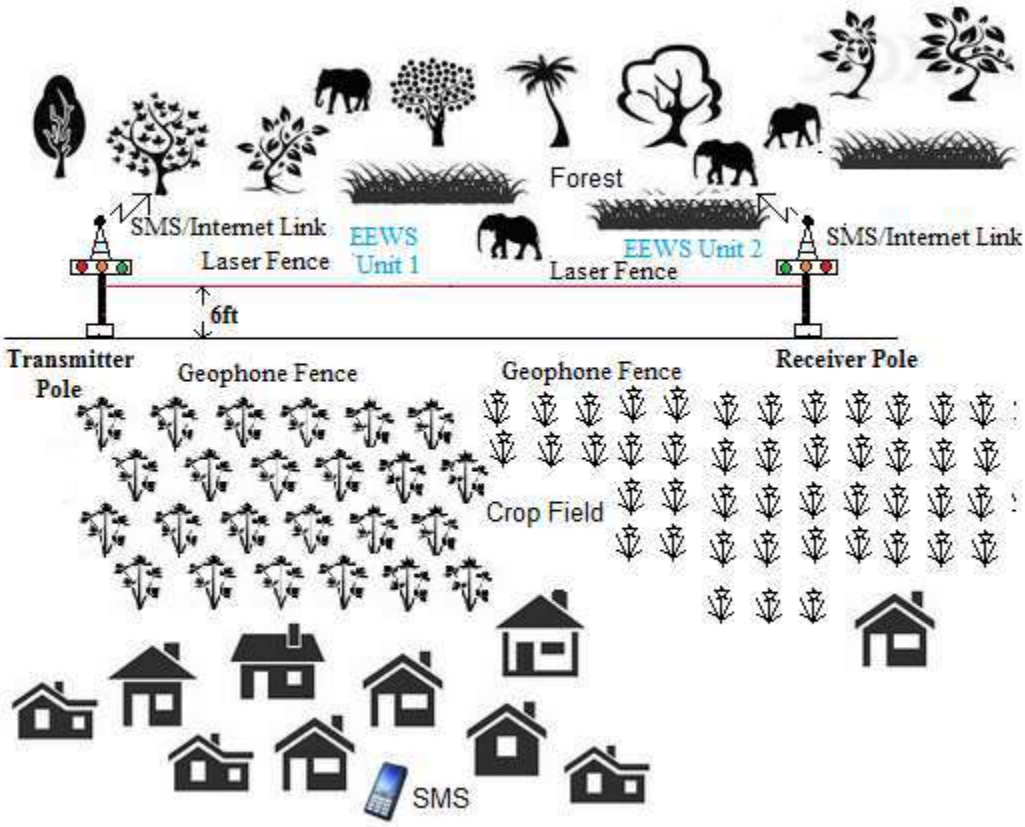

Fig. 1: *EEWS field implementation architecture*

Technical specifications

The long-range LASER fence is having the following specifications; Range: 200m+ (from Transmitter to Receiver), LASER Type: 680nm 5mw class-1 red LASER, harmless to animals, Detection type: Mainly elephant but can detect smaller animals when added a lower second line, Mode: It's a night mode device with automated on-off switching, Structure: Mounted on iron poles with solar panel battery and circuits (Fig. 1).

Working of long-range LASER fence

Elephant movement is tracked down when it crosses the fence. The fence doesn't create any obstruction to elephant movement only detects its movement. The elephant identification is done based on two parameters 'Elephant Height' and 'Activation Time'. LASER light is fixed at 1.8m (average height of an Elephant) and added with a contentious line blockage time of 5sec (activation time which elephant takes to cross the line and it's experimentally verified) and thus elephant is identified when both conditions are valid.

Early Warning

Once elephant crossing is detected and identified the system provides SMS alerts and also switches on local or remote flashlights & buzzers for the forest officials and local framers. With an updated variant of the system, a Mobile Application (App) is added which will show the unit-wise detection status on a real-time map. The system can be easily configured from elephant early warning to elephant repellent mode by integrating a high-volume hooter.

Total units installed and underactive use

As of date, 46 units of long-range LASER based early warning system units are installed in Sathyamangalam Tiger Reserve (Tamil Nadu), BRT Tiger Reserve (Karnataka), Puruliya State Forest (West Bengal) and Parsa Wildlife Centaury (Nepal), and other locations, in collaboration with Forest Department and local NGOs.

Ground Vibration Fence for Elephant Early Warning System

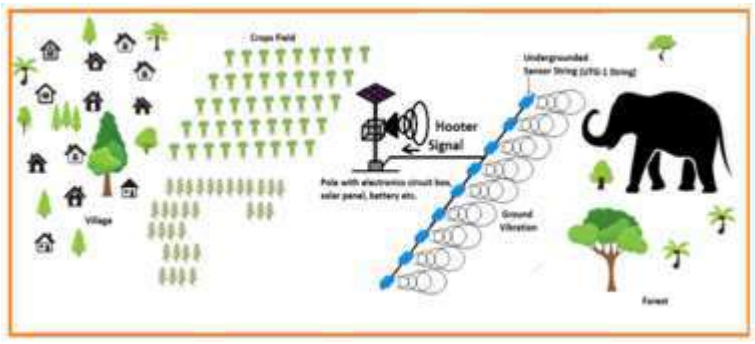

Fig. 2: *An implementation architecture of ground vibration fence*

Technical Specifications

The Ground Vibration Fence system is having the following specifications; Sensors: Fully undergrounded sensors connected in a long chain configuration, Sensitivity: It can be varied from small house cat to elephant, Segregation: It can segregate elephant and other animals with 75% accuracy, Maintenance & Life: It's a robust system and can run for years with minimum maintenance, Structure: Mounted on iron pole with solar panel, battery and circuit box (Fig. 2).

Working of the system

The Ground Vibration-Based Animal Detection System is an out-and-out indigenous system that detects and identifies an animal by extracting three signal parameters (amplitude, frequency, and volume of vibration) from the footstep vibrations. It uses an especial common vibration rejection technique to avoid any manmade or natural noise vibrations.

Early Warning

Like the LASER fence system, it's also having SMS alerts and local or remote flashlights & buzzer alerts. Presently it's also coming with a real-time detection map which is accessible with a mobile App. It can be configured into crop defending mode by adding high-volume local hooters.

Units under active use

As of date, 14 units are functioning at Silent valley national park (Kerala) and Sathyamangalam Tiger Reserve (Tamil Nadu), and those are installed under government and NGO projects.

Devices for contactless safe elephant drive away

System	Specifications
 Fig. 3	*Personal Safety Acoustic Device* Sound volume: 110 dB (single barrel) 220db (double barrel), Mode: Seven sound modes, Variants: Handheld manual operated and remote RF switch operated, Utility: Crop protection & animal drive, Units under active use: 25 (by the forest department, several NGOs and individual farmers)

 Fig. 4	*Personal Safety Sparking Device* Effective range: 20m, Variants: Two variants available with three and five sparking outlets, Utility: Crop protection & animal drive, Units under active use: 5 (by the forest department, several NGOs, and individual farmers)
 Fig. 5	*Vibration Triggered Acoustic Alarm* Detection range: 100m, Mounting: On the metal fence, Sound volume: 110dB hooter, Variants: Solar panel mounted type and manual charging type, Utility: Crop protection, Units under active use: 4 (by individual farmers)
 Fig. 6	*Motion Triggered Acoustic Safety Device* Detection range: 10m (night time), Sound volume: 110dB, Varients: Ambulance sound type and leady cry sound type, Utility: Personal safety form wild animals, Units under active use: Technology demonstration
 Fig. 7	*Crop Safety Flash Light* Light range: 50m, Mode: Connected with light sensor module to be operated during the night only, Power: 12V battery or 220V ac supply, Utility: Crop protection, Units under active use: 3 (by individual farmers)
 Fig. 8	*High-Frequency Acoustic Safety Device* Effective range: 20m, Power: 12V battery, Frequency: 9KHz to 22KHz (user adjustable), Utility: Personal safety from wild animals, Units under active use: 2 (by NGOs)
 Fig. 9	*Artificial Beehive Crop Safety System* Mini honey bee replica with bee sound and a flashlight, Utility: Crop protection, Units under active use: 1 (designed for technology demonstration)
 Fig. 10	*High-Frequency Crop Safety Device* Effective range: 40m, Power: Integrated battery solar panel, Frequency: 6KHz to 15KHz (user adjustable), Utility: Crop protection, Units under active use: 8 (by the forest department and individual farmers)

 Fig. 11	*Long Range Remote Cracker Shots Launcher* Cracker launching range: 30-40m, Remote switch range: 40m, Cracker type: Deewali crackers, Firing Rounds: Seven successive shots, Utility: Crop protection & animal drive, Units under active use: 3 (by the forest department and farmer groups)
 Fig. 12	*Multi Barrel Cracker Shots Launcher* Effective range: 30-40m, Cracker type: Local crackers, Firing Rounds: six shots with individual selection capability, Utility: Crop protection & animal drive, Units under active use: 4 (by farmer groups)
 Fig. 13	*Hand-Held Cracker Shots Launcher* Cracker launching range: 30-40m, Cracker type: Dewali crackers, Firing rounds: Four successive shots, Utility: Crop protection & animal drive, Units under active use: 4 (by the forest department and farmer groups)
 Fig. 14	*Automated Electric Sparking Device* Operation power: 220V supply or 12V battery, Sparking duration: Programmable, Mode: Night mode, Utility: Crop protection, Units under active use: 2 (by individual farmers)
 Fig. 15	*Remote Crop Safety Acoustic Device* Remote switch range: 40m, Sound volume: 110db two parallel hooters, Modes: Seven sound modes, Utility: Crop protection & animal drive, Units under active use:2 (by forest department)
 Fig. 16	*Long Range Night Camera Trap* Interface: All types of sensors, Capture range: 30m (night mode), Power sustainability: 7 days in standby mode with a single charge, Utility: Visual authentication, Units under active use: 1 (designed for technology demonstration)

Conclusion

The present paper provides the technological and operational overview of several indigenous elephant early warning systems and elephant drive-away devices which are developed by our team over the years. Under the elephant, early warning system category, long-range LASER based fence system, and footstep vibration detecting undergrounded fence system are described in terms of their technical specifications, operation, and effectiveness. On the other hand, under elephant drive-away device category, Personal Safety Acoustic Device, Personal Safety Sparking Device, Vibration Triggered Acoustic Alarm, Crop Safety Flash Light, Motion Triggered Acoustic Safety Device, High-Frequency Acoustic Safety Device, Artificial Beehive Crop Safety System, High-Frequency Crop Safety Device, Long Range Remote Cracker Shots Launcher, Multi Barrel Cracker Shots Launcher, Hand Held Cracker Shots Launcher,

Automated Electric Sparking Device, Remote Crop Safety Acoustic Device, Long Range Night Camera Trap, etc. All those systems are either manual or automated and they don't pose any threat to wild animals as well as humans since those are designed to be operated from a distance. Although they are designed to keep a wild elephant in mind, they are equally good with other herbivorous also. Most of the systems, presented here are presently under active use by the forest department, farmers groups, and several NGOs across the country and they are ensuring the minimization of conflict, successfully.

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Factors affecting attitudes of farmers towards wildlife conservation in human-wildlife conflict-prone landscape

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Abstract

Ramnagar Forest Division, Uttarakhand (RFD) is a landscape with villages and agricultural fields interspersed within the forest. Crop-raiding by wild herbivores and livestock depredation by tigers (Panthera tigris) and leopards (Panthera pardus) are the most prominent forms of human-wildlife conflict in the landscape. This study assessed the farmers' perception of the conflict situation in the RFD and the factors which influence the attitudes of farmers towards wildlife conservation.

Interviews were conducted with 120 farmers from four villages using a structured interview schedule. The interview schedule consisted of two sets of questions. The first set of questions enquired about their economic status, their perception of the primary form of human-wildlife conflict in their village, the amount of crop loss in the last season, the wild animal responsible for most of the damage, the season in which damage occurs the most, number of people involved in guarding, reasons for conflict, possible solutions, and role of forest department in the conflict mitigation. The second set of questions assessed their attitude towards wildlife conservation.

When asked about the different forms of HWC in the village, 96% (n = 120) of the respondents said that the crop-raiding by wildlife is the most severe form of conflict. Respondents on average reported 44% loss in wheat and 41% loss in paddy due to wildlife (n = 120). More than half of the respondents (58%, n = 120) reported wild pig (Sus scrofa) to be the main raider of their crops whereas nilgai (Boselaphus tragocamelus) was mentioned as the main raider by 21% (n =120) of respondents. Most of the respondents reported that crop-raiding occurs in wheat in the seedling stage (47%, n = 120) and the mature stage (37%, n = 120) of the crop. Whereas, in the paddy, most of the farmers reported crop-raiding in the mature stage (83%, n = 120).

86% (n = 120) of the interviewees believe that the crop-raiding by wildlife has increased in recent years. 53% (n = 120) of the respondents believe that such an increase in crop raiding is due to an increase in the population of wild animals inside the forest. Almost all the respondents (96%, n = 120) were not satisfied with the compensation scheme. Most of the number of those interviewed (54%, n = 120) mentioned that making the settlement process easier for the farmer might make the compensation scheme useful.

The results of the study indicate that the crop-raiding by wild herbivores is the most severe form of human-wildlife conflict in the landscape with both the staple crops, wheat, and paddy, being equally impacted. The amount of damage self-reported by farmers should be accepted with caution it could be higher than the actual damage. However, perceived damage to the

crop is also important as it might influence farmers' attitudes towards wildlife conservation. Farmers are highly dissatisfied with the government's compensation scheme and suggest that an easier process of claim settlement is needed.

Keywords: Crop Damage, Human wildlife conflict, perception, farmers

Introduction

Human-wildlife conflict (HWC) is one of the most difficult issues associated with wildlife and forest conservation. It can be defined as a situation when the needs and behavior of wildlife negatively impact the goals of humans or when the goals of humans negatively impact the needs of the wildlife (Madden, 2004).

Governments and conservationists around the world have been trying to conserve wildlife and its habitat in times when economic development is vital for human welfare. Setting up protected areas like national parks, wildlife sanctuaries, and conservation reserves is one of the primary methods for in situ wildlife conservation (Naughton-Treves et al., 2005). However, many times in the process of doing so, the local communities feel alienated. Such lack of inclusion while managing the protected area may not be beneficial to the objective of wildlife conservation in the long run (Hough, 1988). Economic damage to farmers because of crop-raiding and livestock depredation by wildlife makes the situation worse for the farmers.

Local communities might develop adverse attitudes towards wildlife conservation if the mitigation of the conflict situation is inadequate or ineffective (Ogra & Badola, 2008; Woodroffe et al., 2005). Such adverse attitudes towards wildlife can manifest into retribution killing of the wildlife, poaching, and non-cooperation with park managers (Bagchi & Mishra, 2006; Karanth et al., 2013; Nyhus & Tilson, 2000). Hence, resolving such conflict situations is imperative for wildlife conservation.

In India, compensating the aggrieved is one of the methods that has been adopted to mitigate HWC. While the decision on compensation amount is easier for livestock depredation cases, it becomes a difficult decision in the crop-raiding case (Watve et al., 2016). In the event of crop-raiding, the difference in the farmer's perceived loss and estimated loss by the government official is a source of conflict between people and park officials (Bayani et al., 2016).

Therefore, for building a positive attitude of farmers towards wildlife and garnering their support for conservation, addressing the perceived loss might be more important than the actual amount of crop lost to wildlife.

Farmers of Ramnagar Forest Division (RFD), Uttarakhand have been experiencing crop damage by wildlife for past many years. This study attempted to understand the farmers' perception of the conflict situation in Ramnagar Forest Division and factors which affect the attitude of farmers towards wildlife conservation. It was hypothesized that the attitude of farmers towards wildlife conservation should be affected by many factors. Age of the individual, livestock holding, economic status of the household, total land holding, the amount of crop lost to wildlife in last season, the number of cattle lost to wildlife in last five years, and location of the household with respect to forest edge should influence the attitude towards wildlife conservation.

Study Area

Ramnagar Forest Division (RFD) (N29°33'-29°13', E79°06'-79°32') is located in the Uttarakhand state of India (Figure 1). It is present on the eastern boundary of Corbett Tiger Reserve. It has an area of approximately 487 km^2 and is divided into five forest ranges, namely – Kosi, Kota, Dechauri, Kaladhungi, and Fatehpur. The vegetation is made up of dense mixed forest which is dominated by Sal (Shorea robusta). Fauna includes tiger (Panthera tigris), leopard (Panthera pardus), elephant (Elephas maximus), nilgai (Boselaphus tragocamelus), cheetal (Axis axis), sambar (Rusa unicolor), barking deer (Muntiacus muntjac), wild pig (Sus scrofa), and many more species of mammals, reptiles, and birds found in the Himalayan biogeographic region.

Villages are widely scattered in the division. The dominant source of livelihood in the area is agriculture. People also earn their livelihood from daily wage labor activities. Major crops grown in the farmlands are paddy, wheat, sugarcane, maize, and vegetables. Crop raiding by wild herbivores and livestock depredation are the two primary forms of human-wildlife conflict reported in the division.

Methods

Interviews were conducted, using a structured interview schedule with the farmers of four villages in RFD, namely – Parewa, Kunkhet, Patkot, and Rampur. Selection of these villages was done purposively ensuring that the agricultural practices are representative of the other villages in the landscape. The sampling unit was individual households. In each of the households, one adult member present at the time of visit was interviewed. Even though households were selected non-randomly, it was tried to sample the households such they are at some distance from each other and are spread across the village. Such a selection of households made sure that each interview is independent of the other, and the sample is representative of the village.

The approval of the ethical committee or the waiver of ethics approval was not required as the present study does not deal with any kind of clinical trials on humans and animals or any other intrusive method. The participants were recruited by approaching potential respondents in their households during the field visits. The purpose and the methods of the research study were explained to them, and verbal consent was taken before starting the interview. There was no written documentation of the consent. The individuals approached for the interview were free to decide whether they wanted to be a part of the study.

120 respondents were interviewed out of which 100 were men and 20 were women. Questions were asked about their economic status, their perception of the primary form of HWC in their village, the amount of crop loss in the last season, the wild animal responsible for most of the damage, the season in which damage occurs the most, number of people involved in guarding, reasons for conflict, possible solutions, and role of forest department in the conflict mitigation.

To assess their attitude towards wildlife conservation a set of eleven questions were asked (Table - 1). Six of these questions are adapted from Suryawanshi et al. (Suryawanshi et al., 2014).

Table 1: *Questions, responses, and scoring system used to assess the attitude of farmers towards wildlife conservation*

Questions	Responses	Score
Should wild animals be killed?	No	1
	Yes	-1
	Can't say	0

Is there any benefit of wildlife living inside the forest?	Yes	1
	No	-1
	Can't say	0
Is crop raiding biggest problem to agriculture?	Yes	-1
	No	1
	Can't say	0
Are the officials of Forest Department supportive?	Yes	1
	No	-1
	Can't say	0
Have local people benefited from tourism in Corbett Tiger Reserve?	Yes	1
	No	-1
	Can't say	0
Would you like to see wild ungulates/elephant close to your farmlands? *	Yes	1
	No	-1
	Can't say	0
Should wild animals have legal protection? *	Yes	1
	No	-1
	Can't say	0
Should kids be taught about wildlife in schools? *	Yes	1
	No	-1
	Can't say	0
Do you think that conservation of wildlife is beneficial for the environment of Ramnagar Forest Division? *	Yes	1
	No	-1
	Can't Say	0
Where should animals be protected? *	Forest	2
	Everywhere	1
	Corbett Tiger Reserve	0
	Zoo	-1
	Nowhere	-2
What should be done when your farms are raided?*	They also need food	2
	Nothing, I can bear it	1
	Can't do anything	0
	Chase it away	-1
	Kill it	-2

**Questions adapted from Suryawanshi et al. (2014)*

Different scores were assigned to different responses to the questions. The scoring scheme was kept the same as mentioned in Suryawanshi et al. (2014) except for one question. Scores from questions adapted from Suryawanshi et al. (2014) and new questions were significantly correlated, $r_s(120) = 0.7$, $p < 0.05$. Attitude scores from both sets of questions were added to get the total attitude score for each respondent. The attitude score for a respondent could be

any value between -13 to 13. However, none of the interviewees had an attitude score of more than five. The Cronbach's alpha value for the complete set of attitude questions was 0.714.

Progress out of Poverty Index® (PPI®) for India was used as a proxy variable to measure the economic status of the respondents (Toohig, 2007). PPI® for each of the respondents can be calculated based on her or his response to a set of 10 questions. These questions are pre-coded and are standardized for a country.

Multinomial logistic regression models were built to predict the attitude of farmers towards wildlife conservation with different explanatory variables. Multinomial logistic regression was performed using the total attitude score as the dependent variable. The independent variables used were the PPI®, age, sex, landholding, livestock holding, number of livestock lost to wildlife in last five years, amount of wheat crop lost in last season, the amount of paddy lost in last season, and location of the household to forest edge as independent variables (Table – 2). Statistical analyses were done using SPSS software (v.20).

Table 2: *List of independent variables used in the multinomial regression*

Independent Variable	Category name	Category interval
Progress out of Poverty Index (PPI®)	Not applicable	Not applicable
Age (in years)	Age 1	18 - 22
	Age 2	23 - 30
	Age3	31 - 40
	Age 4	41 - 50
	Age 5	51 - 60
	Age 6	Above 60
Land Holding (in m^2)	Land 1	0 – 3243
	Land 2	3244 - 4864
	Land 3	4865 – 6486
	Land 4	6487 - 8107
	Land 5	8108 - 12971
	Land 6	Above 12971
Livestock lost in last five years (number of individuals)	Not applicable	Not applicable
Gender	Women	Not applicable
	Men	Not applicable
Location in village	Fringe	Not applicable
	Center	Not applicable
Wheat crop damage (percentage of total produce)	Not applicable	Not applicable

Results

Description of crop-raiding

A vast majority of respondents (96%, n=120) mentioned that crop-raiding was the most severe form of HWC when compared to livestock depredation and human casualty. On average, 44% loss in wheat and 41% loss in paddy crop were attributed to crop-raiding by the respondents (n = 120). Wild pig (*Sus scrofa)* (58%, n=120) and nilgai (*Boselaphus tragocamelus)* (21%, n=120) were reported to be the top two raiders. Regarding the wheat crop, most of the respondents reported that crop-raiding in the seedling stage (47%, n = 120) and mature stage (37%, n = 120). Whereas, in the paddy, most of the farmers reported crop-raiding in the mature stage (83%, n = 120).

Paired-sample t-test was done to compare reported crop loss between wheat (44%, SE = 2.01, n= 120) and paddy (41.33%, SE = 2.2, n = 120). The results were statistically not significant, p =0.351 (Table -3).

Table 3: *Paired-sample t-test for difference in reported damage between wheat and paddy*

Crop	Mean (SE) (%)	*t*	*df*	p-value
Wheat	0.44 (0.020)	-0.937	119	0.351

Similarly, we conducted independent sample t-test to check if men (wheat = 44%, SE = 2.1; paddy = 39%, SE = 2.3; n = 100) and women (wheat = 43%, SE = 5.6; paddy = 51%; SE = 6.4, n= 20) report a different amount of crop loss for wheat and paddy. Results for difference in reported damage between men and women were – Wheat -t (118) = -0.194, p = 0.847; Paddy - t (118) = 1.97, p = 0.051 (Table - 4).

Table 4: *Independent sample t-test for difference in reported damage between men and women in wheat and paddy crops*

Crop	Mean (SE) (%)	*T*	*df*	p-value
Wheat	Women – 0.43 (0.056) Men – 0.44 (0.021)	-0.194	118	0.847
Paddy	Women – 0.51 (0.064) Men – 0.39 (0.023)	1.970	118	0.051

In most of the households, one individual had to go for guarding of crops at night. The most popular methods of guarding were reported to be machans (45%, n = 120) and night visits (39%, n = 120).

Perceived reasons for conflict

On the question of a change in the crop-raiding in recent years, 86% (n = 120) of the interviewees mentioned that it has increased. Further, while talking about the reasons for the, 53% (n = 120) of the respondents said that such an increase is due to an increase in the population of wild animals inside the forest. Another 25% (n = 120) of farmers believe that the legal protection of animals is the main reason for conflict.

Government interventions and expectations

Almost all the respondents (96%, n = 120) were not satisfied with the compensation scheme. Most of the number of those interviewed (54%, n = 120) mentioned that making the settlement process easier for the farmer might make the compensation scheme useful (Table 5).

Table 5: *Perception of respondents on the compensation scheme and expectations from the government*

Questions	Responses	Percentage of respondents (N = 120)
Are you satisfied with the compensation scheme?	No	96
	Yes	4
Why are you not satisfied with the compensation scheme?	Low compensation amount	7.5
	Delay in compensation	10.8
	Complicated process	26.6
	Corruption	24.1
	All of the above	21.6
What should be done to improve the compensation scheme?	Increase amount	21.6
	Make it speedy	22.5
	Make the process easier	54.1
	Other	1.6
What can be the best step taken by the government to mitigate the conflict?	Build a concrete wall	47.5
	Install electric fences	37.5
	Improve compensation scheme	5
	Allow hunting	7.5
	Relocate village	0
	Others	2.5

When asked about the interventions that governments must undertake to mitigate the crop-raiding problem, most of the respondents demanded a protective structure encircling the village to restrict the movement of wild animals - boundary wall (47%, n = 120) and fence (37%, n = 120).

Attitude towards wildlife conservation

Although attitude scores measured using the interview schedule could have ranged from +13 to - 13, none of the respondents had an attitude score of more than +5 and less than -11. Attitude scores were categorized into three categories – highly negative (-11 to -6) (n = 24), negative (-5 to 0) (n = 60), and positive (1 to 5) (n = 36). 67.5% of the respondents were categorized as having a 'negative' to 'highly negative' attitude towards wildlife conservation.

A multinomial logistic regression model was built to predict the attitudes of farmers towards wildlife conservation. The final statistically significant model has land, age, and damage in paddy crop in last season as explanatory variables for the total attitude score of the respondent, $\chi 2 = 55.86$, $p < 0.01$, Nagelkerke R2 = 0.427. (Table 6).

Table 6: *Results of multinomial logistic regression in the final model showing variables significantly affecting the farmers' attitude towards wildlife conservation*

Attitude category		B	Std. error	Wald	df	Sig.	Exp(B)
Highly negative	Intercept	1.230	1.559	.622	1	.430	
	Age 1	-2.839	1.488	3.641	1	.056	.058
	Land 3	2.514	1.336	3.540	1	.060	2.349
Negative	Intercept	3.941	1.431	7.584	1	.006	
	Age 0	-2.524	1.136	4.935	1	.026	.080
	Age 1	-2.551	.983	6.734	1	.009	.078
	Paddy damage (40-60%)	2.337	1.320	3.134	1	.077	10.350
	Land 3	2.436	1.206	4.075	1	.044	11.422

Economic status of farmers living in the center and fringe of the village

The PPI scores of farmers living on the fringe of the village were not significantly different from those living in the center of the village (Table 7). However, farmers living on the fringe had significantly less land holding than those living at the center of the village (Table 7).

Table 7: *Independent sample t-test to compare the economic status of farmers living on the fringe and center of the village*

Indicator of economic status	Mean (SE)	*t*	*df*	*p*-value
PPI®	Fringe – 31.9 (1.8)	-0.862	118	0.39
	Center – 34.3 (2.1)			
Land	Fringe – 0.74 (0.06)	-2.249*	118	0.026

Discussion

Farmers of RFD are almost in consensus that the crop-raiding is the most problematic form of HWC and they report an equal but a significant proportion of crop loss in their paddy and wheat crop attributed to crop-raiding by wildlife. Valid arguments can be made that the self-reported crop losses could be an overestimation by farmers who might be doing so in expectation of higher compensation from the authorities (Gillingham & Lee, 2003). However, due consideration should be given to the fact that a higher than the actual value of crop damage might be reported by farmers because they also take into account the time, money, and energy involved in raising the crop and protecting throughout the season (Linkie et al., 2007). The indirect cost of raiding is also evident in this study as one or more members of the household engaged in the agriculture activities have to stay in with the crops at the night to guard them against the wildlife. Since guarding is to be done in adverse weather conditions, the indirect cost of raiding may go up due to increased health expenses. Moreover, a person deprived of sleep during the night might not be able to work in daily-wage activities during the daytime. This opportunity cost would also add to the indirect cost of crop-raiding. Therefore, even though there is a possibility of over-reporting, but the perceived cost is more important for wildlife managers because such a perception of high crop loss amongst farmers might shape their attitudes against the objective of wildlife conservation (Wywialowski, 1994).

Most of the respondents in the study said that wild pigs (*Sus scrofa*) and nilgai (*Boselaphus tragocamelus*) are the species that inflict the most damage to crops. However, the literature suggests that species with higher visibility are usually unjustly implicated whereas it might be the rodents and invertebrates which are responsible for a larger amount of crop loss (Linkie et al., 2007; Naughton-Treves et al., 2005). Therefore, it is recommended that future studies in RFD focusing on crop loss due to wildlife should also take into account the damages inflicted by the rodents and invertebrates.

It is believed that crop-raiding by wildlife is not a recent phenomenon but has a long history (Crosby, 1986; Sukumar, 1995). However, in the RFD, most people think that crop-raiding has increased in recent times. This perception along with the reasoning that the increase in raiding is because of legal protection to wild animals and growth in the wildlife population is alarming for wildlife conservation. This negative perception linked with the legal protection of wildlife is further strengthened by dissatisfaction with the government-sponsored compensation scheme. 96% of the respondents did not find the compensation system of any help in mitigating their crop loss.

A majority of respondents expected the government to build walls and fences around the villages (Table - 5). This result suggests that the farmers do not think that the compensation scheme is a lasting solution to the problem of crop-raiding. However, if the compensation system is the only intervention government is willing to make in the region, then the process has to be made more farmer-friendly, and adequate amounts of compensation should be timely delivered (Table 5).

The logistic regression model built to predict the attitude of people towards wildlife conservation has three variables affecting the attitude score, namely landholding size, age, and crop damage in paddy in the last season. Therefore, according to the results of this study, apart from minimizing the damage to the crops, a park manager can do little to change the status of other factors which are shaping the attitudes of people towards wildlife conservation. Coefficients of the independent variables in the model give information about the magnitude and the direction of effect on the dependent variable (Table 6).

According to the developed statistical model, young people are more likely to have a positive attitude towards wildlife conservation as compared to middle-aged or senior citizens. One possible reason for the negative attitudes of the older age group could be accumulated unpleasant experiences with wildlife and the forest department over their lifetime or more dependence on agriculture as a source of income (Shibia, 2010).

Even though the model could not find the role of gender in shaping the attitude towards wildlife conservation, the literature suggests that the role of gender cannot be ignored (Hill, 1998). Hill (1998) while commenting on the difference in the attitudes of men and women towards elephant conservation in Uganda mentions that such a difference could be due to women being less educated than men, being less widely traveled, and having less access to outside

information disseminated through media, public meetings, and educational programs. Since a similar context for women prevails in India, it would be prudent to conduct a study with a higher statistical power before deciding on the role of gender in shaping the attitudes towards wildlife conservation.

The model also suggests that possessing mediocre landholding increases the odds of having a 'highly negative' or 'negative' attitude towards wildlife conservation. Landholding in an agrarian setting also indicates the economic situation of the farmer. A higher landholding and a higher standard of living might provide a cushion for the losses due to wildlife conflict and hence, the individuals should have a more positive attitude towards wildlife conservation (Naughton-Treves & Treves, 2005). On the contrary, an increase in the economic status of a person decreases his/her dependence on the forest resources and hence, makes him/her less likely to appreciate the natural resources and services provided by the forest.

In Northern Sumatra, Indonesia, farmers living close to forest edge have more negative attitudes towards orangutans than farmers living away from the forest edge (Campbell-Smith et al., 2010). Even though in RFD, farmers living close to forest edge have significantly smaller landholdings than those living in the center of the village (Table 7), No association between the location of the farm and attitude towards wildlife conservation was found. However, the lack of evidence for the role of location of the household to the forest edge could be because of the inadequate statistical power of the study.

Lastly, it was hypothesized that crop loss and livestock loss should influence the attitudes of the farmers towards wildlife conservation. However, only crop loss in paddy was found to be significant in the final model. This part of the model should be interpreted with caution. When the estimation of economic loss is done by interviewing people, over-reporting is easily possible (Cannell & Henson, 1974). Therefore, it is a possibility that farmers with a negative attitude towards wildlife conservation might over-report crop loss to get some favor or attention from the authorities.

Conclusion

The study provides evidence that crop-raiding is perceived to be the most problematic form of HWC in RFD. Even with the possibility of over-estimation of crop damage by the farmers, tackling the perceptions of the farmers living in close affinity with wildlife and forest should

be one of the major activities in the management of parks. The present situation in the RFD becomes more critical for wildlife conservation when people start believing that the increase in wildlife population and subsequent increase in crop raiding is because of governmental laws and policies.

While compensation for crop loss is one of the major tools used by the authorities to mitigate the conflict, it might be jeopardizing the objective of wildlife conservation in at least two ways. First, it fails to meet the expectations of the farmers and leads to a feeling of dissatisfaction, and secondly, it reinforces the notion that the wildlife belongs to the government and not to the general public (Watve et al., 2016). For compensation scheme to become a useful measure of conflict mitigation, a farmer-friendly mechanism should be developed which should ensure timely delivery of adequate compensation amount. An innovative compensation model described by Watve et al. (2016) can be piloted in the region as it is claimed to be free of corruption as it operates on the assumption that all the stakeholders in the model work for a selfish motive.

The logistic regression model developed in the study indicates that the park managers should target middle- and old-age people, people who suffered damages in paddy crops, and people from the middle-income group for their outreach programs to develop a positive attitude towards wildlife conservation in the region.

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People's perception on human-wildlife conflicts in Saranda Forest Division

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Abstract

Human-Wildlife Conflict (HWC) is a significant and critical threat to conservation across the world. Although, HWC has been occurring since the existence of man, it has become one of the most serious conservation challenges faced by the humanity. Saranda Forest Division (SFD), West Singhbhum, Jharkhand is the largest Sal forest in the world as well as a prime elephant habitat noticed a decline in elephant population from 371 in 2005 to 200 in 2016 in the last decade that has a significant relation with the decrease in forest cover. Mining activity, encroachment and conversion of lands for cultivation, human settlements and commercial forestry operations are the major activity that elicit conflict. SFD faces conflicts with mainly three wild animals Asian Elephant, Sloth Bear and Wild Boar. However, human death, crop damage, house damage, harm to livestock, injury to human are the consequences of conflict mostly with elephant in SFD. The main challenges for the conservation community are to manage elephant population for which they require support of local people. Hence, this study has attempted to understand people's mind set on elephant conservation in the Saranda Forest Division.

The study was conducted during September, 2016 to December, 2017. Information on occurrence of HWC during 2000 -2016 was collected both from primary and secondary sources. The objective of the study was - to estimate socio economic status of local people; to understand perception of the local people towards activity of elephants and conservation problem; and to document various mitigating measures used by the local people against human –elephant conflicts. The assessment of the human-elephant conflict and collection of ethnographic data was carried out using combination of social survey methods, semi-structured questionnaire survey of households, on-site focal group discussions, formal and informal interviews and key informant interviews in 20 severely affected villages out of total 31 affected villages. Around 185 people were interviewed during the present investigation. Socio-economic indicators such as family size, land holding size, educational level, migration, gender and ethnicity were estimated. Due to rain fed system of irrigation the major crops grown in the area were paddy followed by maize. People perceived crop depredation as the major problem caused by the wild animals. Most of the respondents (78%) believed that extent of HWC was increasing. Nearly 43.24% responded that the poor availability of food in the forest was the main problem. Delayed and ineffective way of compensation payment was the reason for development of less tolerance level in people towards wildlife. More than 90% of the villagers extracted the firewood from the nearby community forest. A total of 97.29% of the respondents used vocal sound as a traditional mitigation strategy to scare away elephant. The findings indicate that a systematic approach is required to create awareness among local communities regarding the ecological value of wildlife and forest. A long-term solution for coexistence of man and wildlife can only be possible if efforts are made to recover the lost forest cover and provide less fragmented habitat to wild animal.

Keywords: HWC, elephant, wildlife, depredation

Introduction

Human–wildlife conflict is a global issue, possessing a significant and critical threat to conservation, afflicting both developed and developing countries (Treves and Karanth, 2003; Nyhus *et al.,* 2005; Woodroffe *et al.*, 2005;). Conflict with elephant is not a new phenomenon rather crop raiding has been taking place for centuries. In India crop damage incidents have been occurring ever since man took to agriculture within elephant habitats. One of the earliest cases of crop-raiding by elephants could be found in Nilakantha's Matanga-Lila (The Elephant-Sport), when anguished people report to the king of Anga, Romapada, that all their crops of grain were being destroyed by wild elephants (Anonymous, 2010). Conflict situations are generally concentrated at the fringes of reserves where wildlife enjoys protection and land is often fertile, leading to a wealth of agriculture. Conflict generally arises from economic losses to agriculture, including loss of cattle through predation and destruction of crops. The major cause of conflict with wildlife is crop damage, there are other socio-economic costs associated with human-wildlife conflict which can outweigh the direct costs of agricultural damage and be a major component of the conflict as perceived by local people (WWF, 1997). The extreme example of this is human death, but other examples include restrictions on movement, competition for water sources, the need to guard property (which may lead to loss of sleep), poor employment opportunities, reduced school attendance (through loss of sleep, or fear of travel), increased exposure to malaria, and psychological stress (Sukumar, 1990; Naughton-Treves, 1998; Hoare, 2000). The nature of casualty differs from site to site as it depends upon the way human and elephant use habitat. Casualty occurs when elephants face taunts and human harassment while driving them into forests from human dominated landscapes using kumkis (Lenin and Sukumar, 2011), as they become frustrated from being prevented from reaching crop fields by guarding farmers (Sukumar, 1989), when these traumatized, injured, harassed elephants, in musth, or females with young which are calves (Leggat *et al.*, 2001), comes in contact with people causes depredation.

A range of regular direct or indirect negative interactions between human and wildlife leads to conflict situation. Negative attitudes about wildlife develops among human due to such frequent negative interactions with wildlife with a decrease in human appreciation of wildlife and potentially severe detrimental effects for conservation (De Boer and Baquete, 1998; Nyhus *et al.*, 2000). Conflicts not only appear between human and wildlife but also occur between humans about wildlife. The goodwill and tolerance level among affected people seems to be

compromising over time as the concerned protected area authorities fails to address the needs of local people who are suffering that could lead to animosity towards the elephant conservation (Madhusudan, 2003). The major reason for the unbalanced conflict conditions today is devalued feeling among local people and more concerns for wildlife over their needs (Sillero-Zubiri *et al.*, 2006). Although, it is known that the humans and wildlife have a long history of co-existence, the frequency of negative interaction has grown in recent times, mainly because of the exponential rise in human populations and consequential expansion of human activities into natural areas affecting wildlife (Woodroffe, 2000; Woodroffe *et al.*, 2005). Mega-herbivores such as elephants has large home range and food requirements, are among the species most affected due to alteration in habitat and loss of connectivity within habitat. In, India around 400-450 people lose their lives annually due to such conflict in India and around 100 elephants are killed in retaliation for the damage they cause to human life and property (Menon *et al*., 2017).

Although comprising of only 10% of India's elephant population, still Jharkhand, Chhattisgarh and Odisha face 65% of human casualty from elephants nationwide (Sivalingam , 2014). The major threat for the conservation of elephants in central India is habitat fragmentation which is caused due to mines and mining activity, encroachments and conversion of lands for cultivation, increase in human settlements and commercial forestry operations and repeated cycle of Jhum cultivation (Chowdhury ,2006)

Elephants migrate to other places as unregulated discharge from iron ore mining in Singhbhum forests has resulted in increase in the turbidity and TSS (total suspended solids) of water thus polluting elephant's riverine habitat (Koina River) (Chowdhury, 1999). Rapidly depleting elephant corridors and anthropogenic disturbances such as mining activities in Saranda forest in West Singhbhum district of Jharkhand has resulted in substantial number of human and elephant causalities in the recent times. Now, the main challenges for the conservation community are to conserve Asian Elephant as there lies a threat from escalating trends of Human Elephant conflict in Saranda forest division (Tchamba, 1996; Hedges, 2006). Therefore, it is necessary to know local people's perception on human elephant conflicts. As it is the perception that defines the complexity of the problem rather than the problem itself, so an attempt was made to understand people's mind set on HEC with the following major objectives: 1. To estimate socio economic status of local people; 2. To understand perception

of the local people towards activity of wild animals and conservation problem; 3. To document various mitigating measures used by the local people against human –wildlife conflicts.

Study Area

The Saranda Forest Division (22 0'00" to 20 26' 00" N and 85 06'00" to 85 26' 00" E) is situated at the tri junction of Odisha, Jharkhand and Chhattisgarh and comprises of 3989.93 ha of protected forests and 81664.17 ha of reserved forests. Moist Deciduous peninsular Sal forest and rest dry deciduous peninsular Sal forest are the major forest type of the division. Saranda Forest division comprises 42 revenue villages and 10 forest villages with tribal communities comprising of Munda, Ho, Santhal, Birhor, and Uraon, among which the Ho tribes are the dominant one. Saranda forest is not only a prime habitat of elephant but also has 25% of the known iron ore deposits in the country with Chiria as the biggest iron ores deposit in Asia. Koina and Karo river are the two perennial rivers along with several hill streams inside the forest. The major fauna include Sloth Bear (*Melursus ursinus*), Wild Boar (*Sus scorfa*), Dhole (*Cuon alpinus*), Gaur (*Bos gaurus*) and Asian Elephant (*Elephas maximas*). There are two corridors that connects Saranda forest division with other forest division: Ankua – Ambia, and Karo – Karampada.

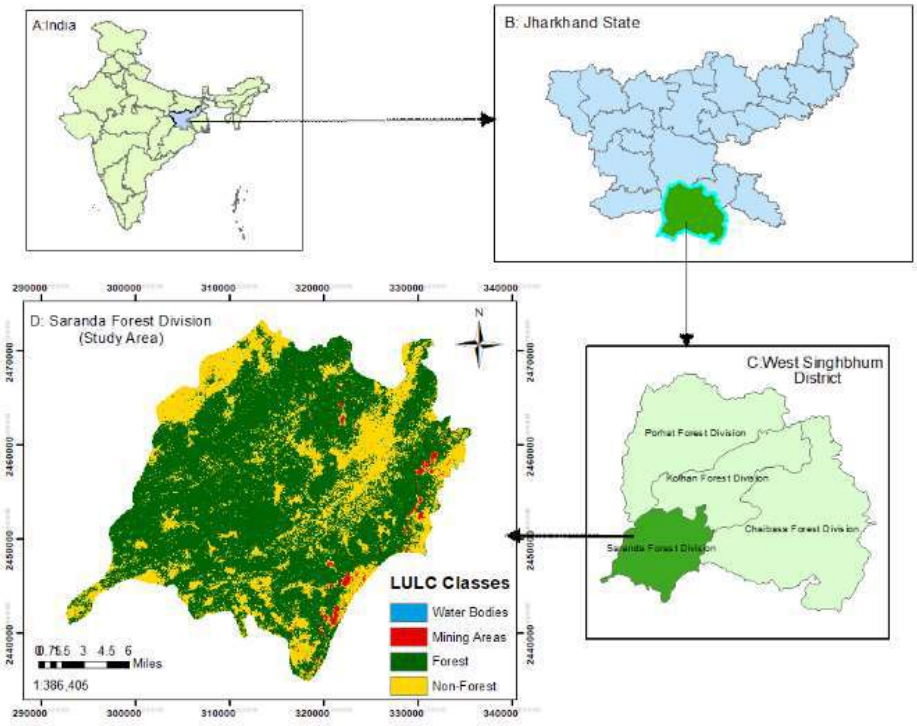

Figure 1: *Saranda forest Division in West Singhbhum of Jharkhand with Land use and Land cover map (LULC)*

Methodology

Based on secondary data and information collected from forest department that include baseline information on animals coming into conflict with human, human-elephant causality, compensation paid for damage caused etc., a village or cluster of villages was selected using random sampling method for the present study during 2016-17. Out of 31 affected villages during the study period 20 most affected villages were surveyed. From each village, 10-15 people along with victims were interviewed. The questionnaire was conducted for 185 people from the study site by involving participatory techniques such as focus group discussions, key informant interview and formal and informal interviews, semi-structured questionnaire survey of households and on-site observations. The information regarding socio-economic condition, energy consumption pattern, major conflicting animals, crop loss, major season and time of conflict, local techniques to mitigate the HWC, attitude of local people towards future prospects and effectiveness of present techniques and local people's ideas on HWC mitigation were extracted from local people.

Results

Socio-Economic profile of the respondents surveyed

During this study period, demographic and social characteristics of 185 respondents were surveyed out of which 56.76% were male and 43.24% were female (Figure 2). The age variation of respondent was from 16-67 years. More than 50% of the respondents fell into the age group of 30-49 (Figure 3). The average family size was 6 persons (Figure 4). About 21.08 % of the respondents were illiterate. Only 35.13 % had primary education and 5.40 % had secondary education (Figure 5).

The economic aspects of the household's viz. land holding size, agriculture activities, and income sources and livestock population were also observed during the survey. It was found that all of the respondents had their own land. The average size of land holding was 1.5 acre. All of the respondents had their own house. Only 30% of the respondents had agriculture as the main source of income, rest were engaged in subsistence agriculture for their basic livelihood. The major crop grown once in a year were paddy, maize, wheat and mustard. Paddy was the only crop cultivated (July –Nov) in large scale due to rain fed irrigation system, while Maize was grown (April - June) irregularly and in small scale due to poor irrigation facility.

Poor availability of water has decreased the cultivation of crop varieties. Cultivation of vegetables such as potato, tomato, brinjal and leafy vegetables etc. are done in small scale only to fulfil family needs**.** Pulses such as masoor, arhar, channa and kurthi dal are also grown for basic livelihood and not as a source of income. All of the households had multiple livestock's comprised of cattle, buffalo, goat and chickens. The average number of livestock per households (HHs) was around 15 (Figure 6). Purpose of rearing livestock was to meet family needs like meat, milk and eggs (Figure 7). They usually do not sell livestock to the market rather they give in marriage and other rituals that they follow.

Villagers living close to mining area were involved in mining activities as labourers and drivers. Some are involved as workers in constructions and developmental activities such as constructions of check dams, roads, bridges, houses and other activities that are being carried out by the forest department (Figure 8). People of villages close to town areas are involved in business activities like shopkeepers, vegetable sellers. People are involved in making plates from leaves and ropes from grasses using machines provided by forest department. Women are involved as Anganvadi workers and school teachers. Most of the people used firewood collected from nearby forest. Few villages close to town area were provided with gas facilities. Use of kerosene was a substitute. People's dependence on LPG gas and Kerosene was less as compared with their dependence of forest for firewood (Figure 9).

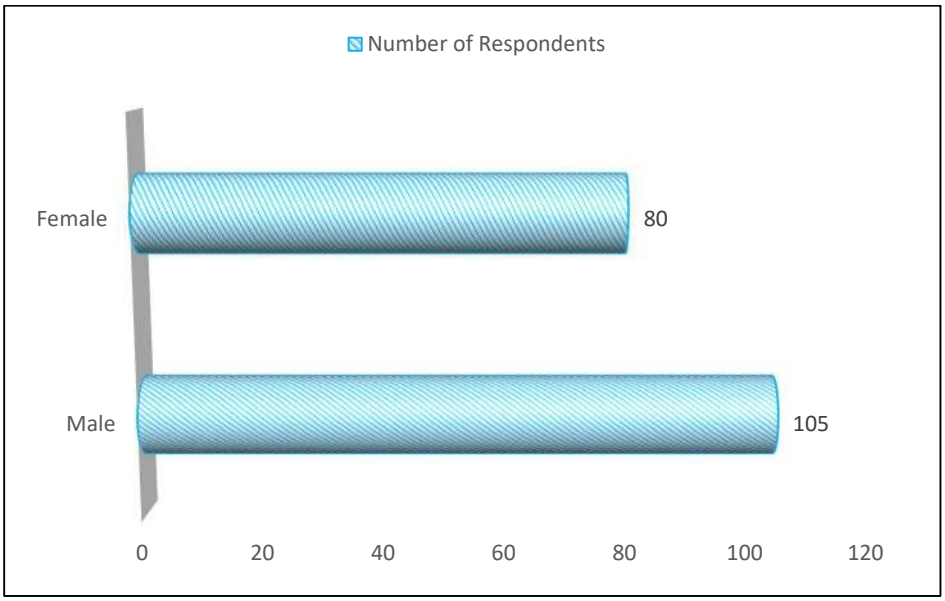

Figure 2: *Sex profile of the respondents*

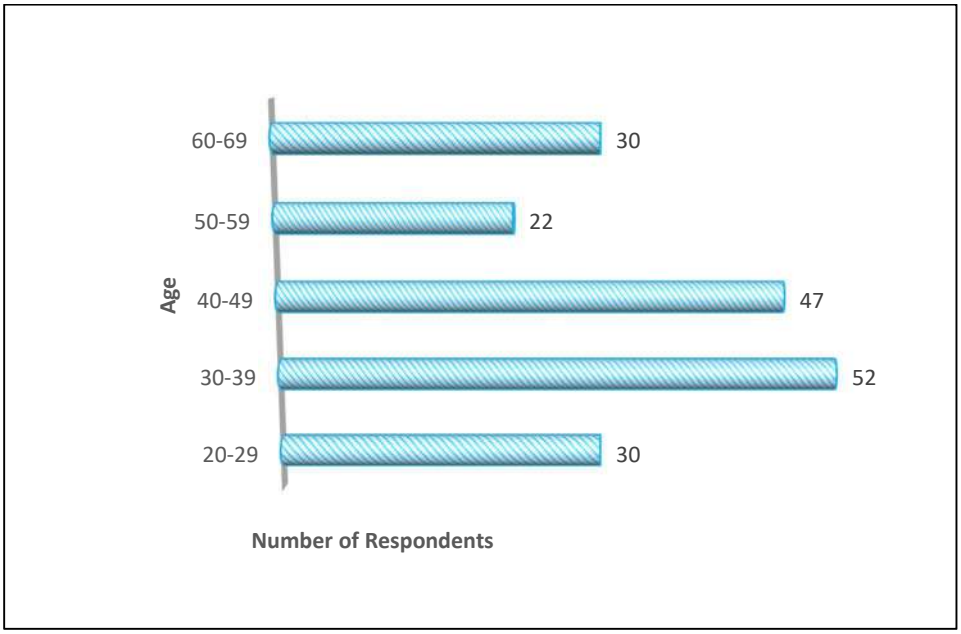

Figure 3: *Age of the respondents*

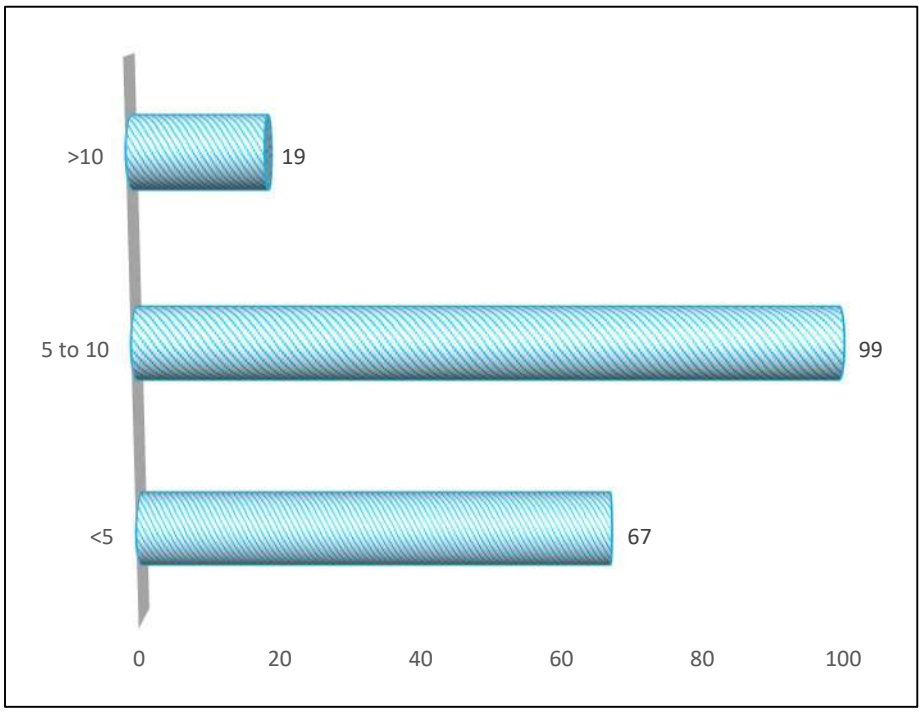

Figure 4: *Household size of respondents*

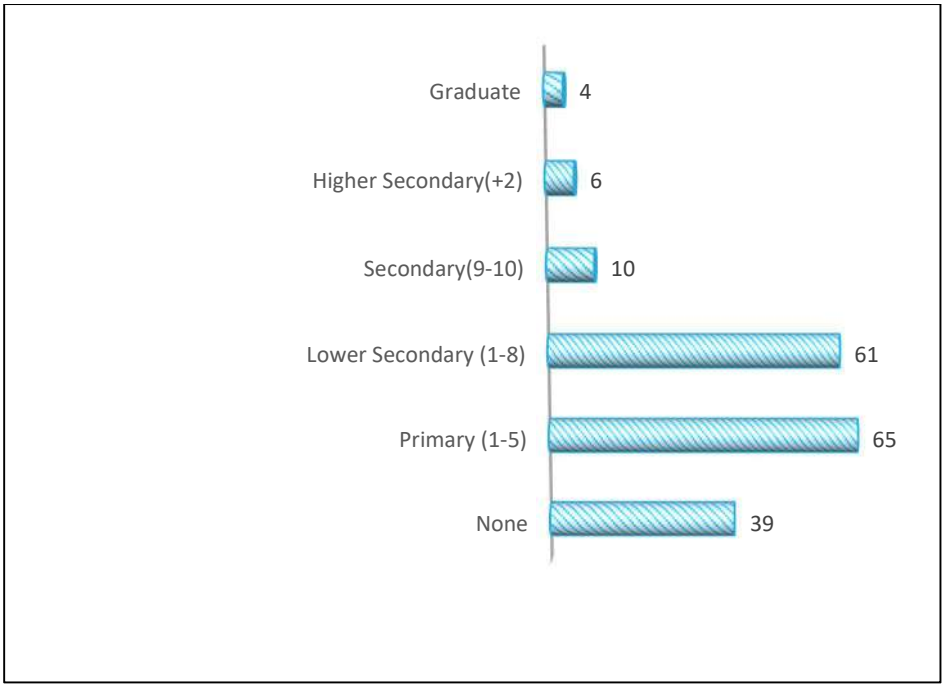

Figure 5: *Educational profile of respondents*

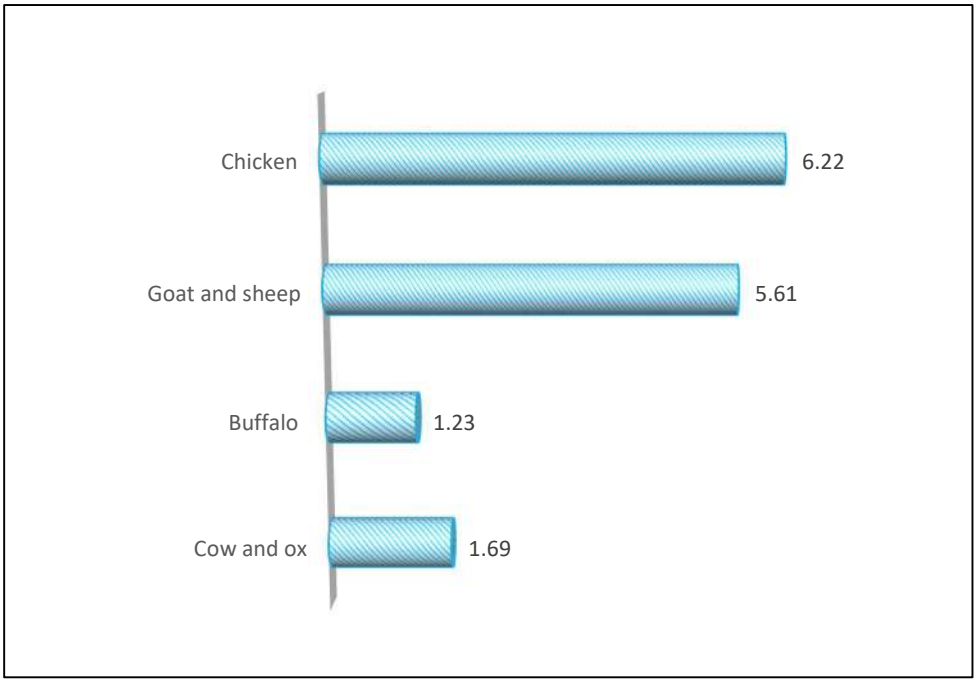

Figure 6: *Average no. of livestock per Household*

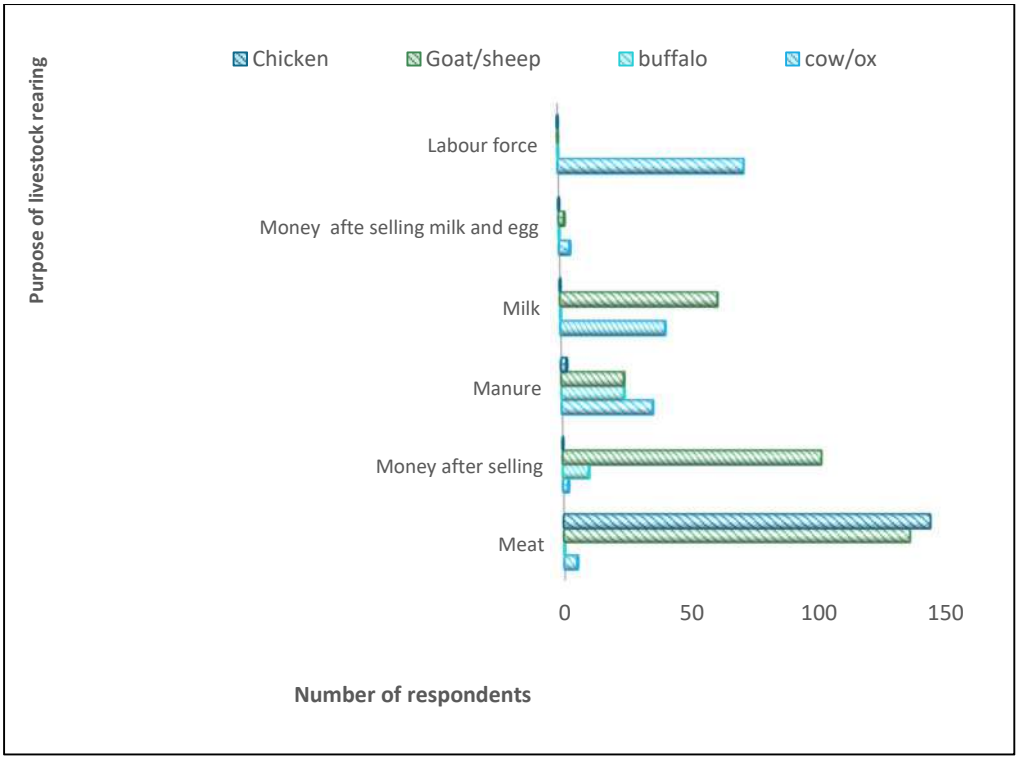

Figure 7: *Purpose of livestock rearing of each household (in %)*

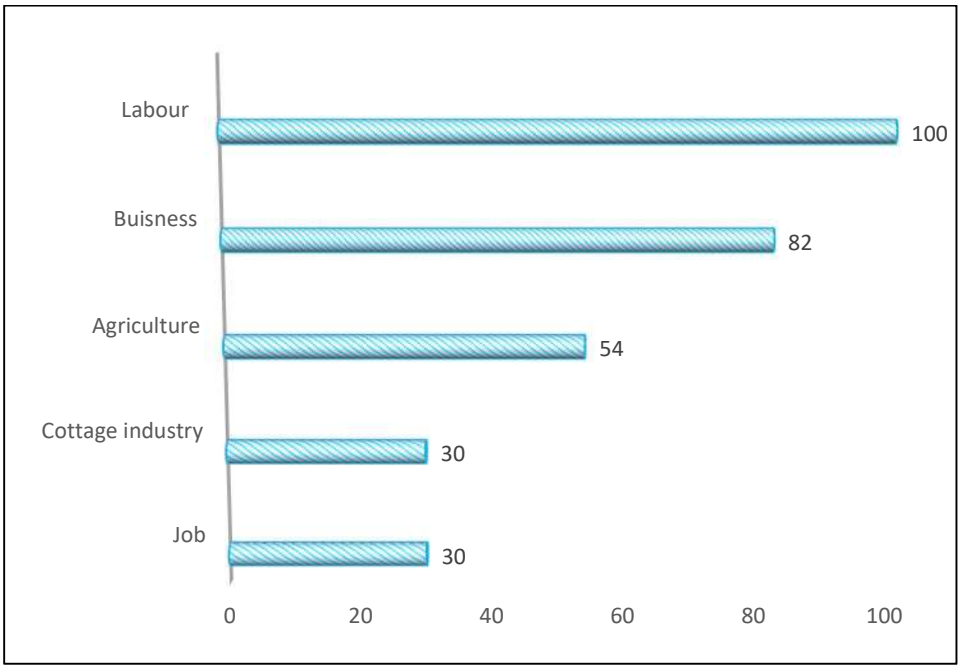

Figure 8: *Sources of income of surveyed households*

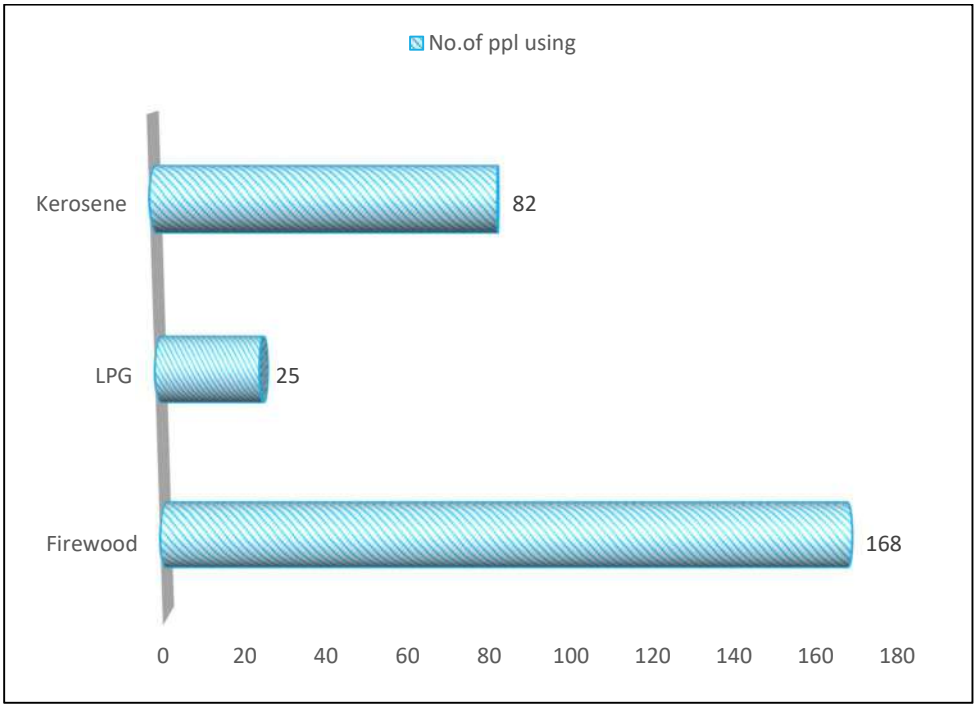

Figure 9: *Sources of cooking energy used by respondents*

People's Perception

1. Perception of People on HWC

Most of the respondents (78%) believed that extent of HWC is on rise. While around 45% of the respondents believed trend of HWC to be decreasing and about 30% believed that degree of HWC was same as before (Figure 10).

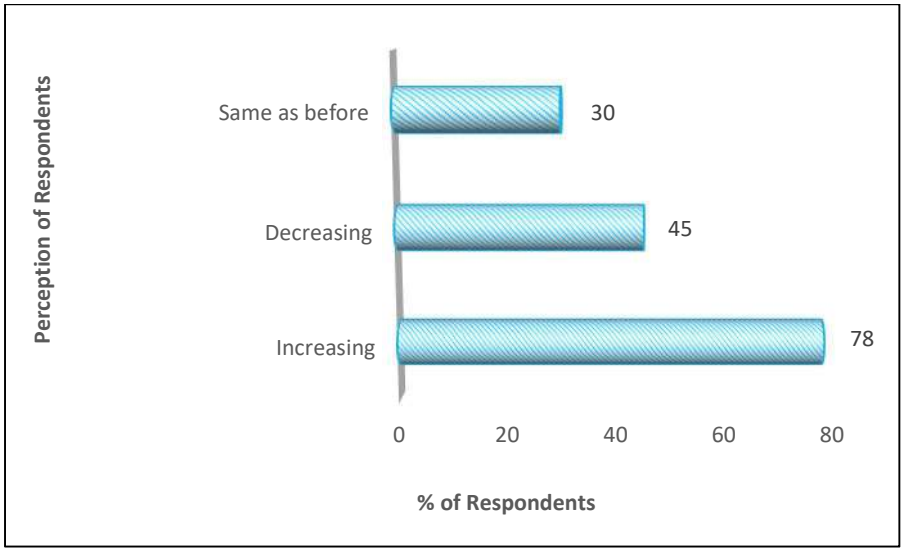

Figure 10: *People's perception on trend of HWC in the study area*

2. People's perception on why the wild animals visit cropland

Most of the respondent perceived that food deficiency in the forest (43.24%), deforestation (24.32%) and scarcity of water (18.1%) are reason for wild animal to visit crop land (Figure 11).

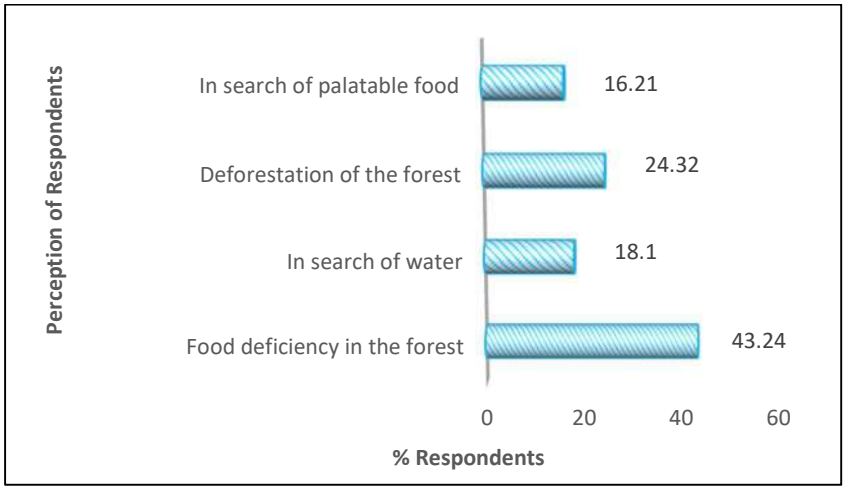

Figure 11: *Respondents opinion on wild animals visiting crop land*

3. People's perception on Forest Cover Loss:

Majority (67.56%) of fuel wood and NTFP collectors believed that, forest has become thin in the past 10 years, 8.1% believed that forest is still dense and 24.32% of the respondents believed that the forest is same as before (Figure 12).

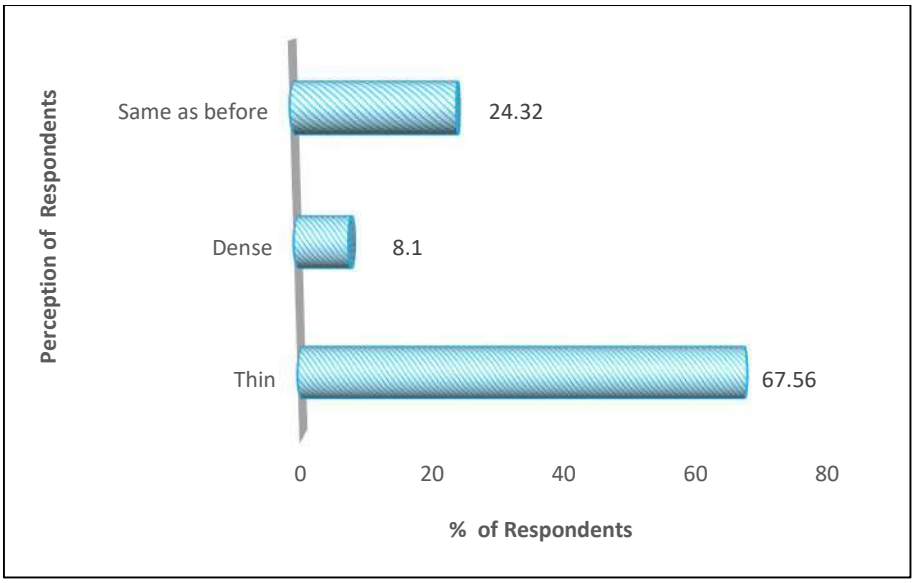

Figure 12: *Respondent's perception on status of forest*

4. People Perception on Compensation Payment

Perception of people differs according to the types and frequency of damages suffered. Victims or victim's family, who have been paid compensation, had a mild attitude towards wildlife and Government. But those whose compensation has not been totally paid for the losses especially for crop loss (n=50) due to lack of documents or irresponsibility of the department in delivering their amount had developed a negative attitude. Victims (n=5) not living in the periphery of the forest were not willing to approach forest department for minor injuries because some were unaware (n=2) of the scheme and some find it difficult to travel to Forest Dept. Office.

Mitigation Measures adopted by locals to reduce HWC

Most of the people applied one or more measures to cope with HWC. One common feature observed in the cultivated area was the vocal sound by the people (shouting in loud voice either singly or in group, clapping in group) (97.29%). Other methods included were noise making tools like drum, stone and dust throwing, chasing with fire (91.89%), regular watching wild animal through high point (Machaan) (48.64%). Dogs were a serious problem during encounter because elephants would chase dogs and in retaliation caused property damage. Some respondents used clothes and stone (43.24%) to chase away the wild boars while there are some group of chasers that use arrow to chase away elephants and wild boars (16.21%) (Figure 13). During certain period of high crop vulnerability, farm household members would take the turns to guard the field crops. They used different methods to cope with HWC (Figure 14). Some of the respondents preferred to kill the small crop raiding animal like Wild Boars than chasing. Use of crackers was an effective tool for chasing elephants but the supply of crackers was less in number from Forest Department.

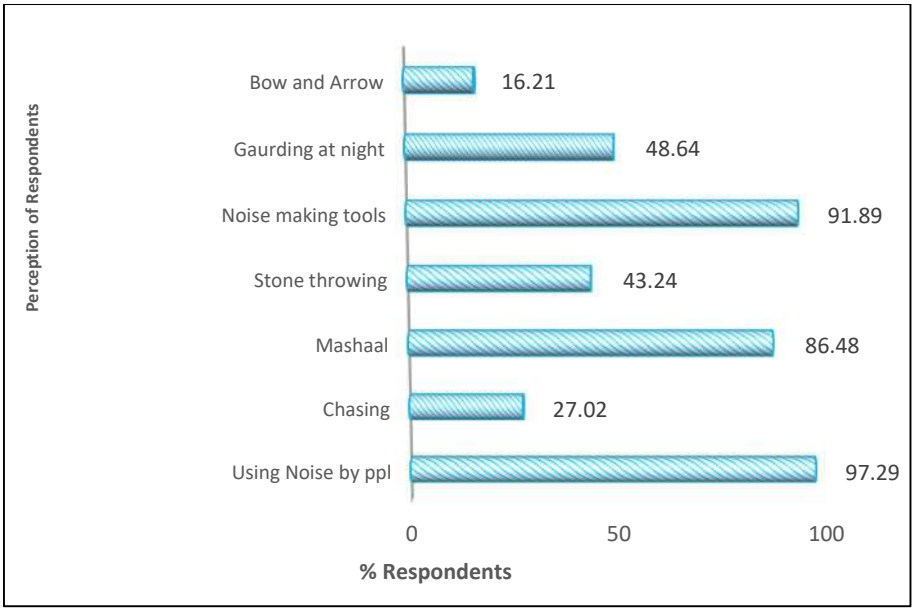

Figure 13: *Measures undertaking by the locals to mitigate HWC in the study area*

Discussion

Central India comprises of one of the most fragmented habitats for elephant due to various anthropogenic causes such as deforestation, shifting cultivation, encroachment and mining activities. Although only 10% of the elephant population of the country resides in states like Jharkhand, Chhattisgarh and Odisha but about 65% of human wildlife conflict occurs here (Sivalingam, 2014). Loss of dense and open forest cover during 2011-2017 of Saranda forest division could be important factors for migration of elephants and increased incidence of HWC.

During the survey, human-wildlife conflict was recorded in 31 villages, out of which 20 villages were severely affected. Saranda is not only a prime habitat for elephant but also comprises of 25% of the known iron ore deposits in the country**.** On one hand Saranda Mines contribute in boosting local economy by giving employment to local people, but simultaneously it also contributes to various environmental problems such as biodiversity loss due to clearing of forest for mining, increased chances of smuggling of costly timber like Teak, Bija due to engagement of surplus labour, pollution of waterbodies such as Koina and Karo river, thereby adversely affecting the local people, their cattle ground and aquatic flora and fauna. Many natural streams have dried up and is polluted due to leaching from mines, rendering its water useless for humans and wildlife**.** Water scarcity is not only a problem for the local people but also a greater problem for big animals such as elephant that requires surplus amount of water. Poor availability of water has decreased the cultivation of variety of crops.

Due to rain-fed system of irrigation, paddy is the only crop grown in large scale by all the villagers and unfortunately, paddy is also the most raided crop by elephant and wild boar in study area. Only 30% of the respondents had agriculture as the main source of income, rest were engaged in subsistence agriculture for their basic livelihood. Rearing of livestock is an option for income but increased number of livestock may lead to over grazing and ultimately deforestation.

Most of the respondents (67.56%) believed that, forest has become thin in past 10 years, 8.1% believed that forest is still dense and 24.32% of the respondents believed that the forest is same as before. As majority of the villagers (80%) extracted firewood from the nearby forest and few had alternative energy sources for cooking, there is an increase in the pressure on forest. Collection of NTFP and firewood is not only a cause of conflict with sloth bear in Saranda but also due to commercialised collection has caused habitat degradation of Ankua-Ambia Corridor thus hindering elephant movement (Menon *et al.,* 2017).

Most of the respondents (78%) in the present study believed that there was an increase in the trend of HWC. Expansion of land near Koina river has not only led to destruction of elephant habitat but also has increased the frequency of conflict as human and animal both need water for survival. Most of the respondents believed that food deficiency (43.24%) is the main reason behind wild animals visit to crop land. Another reason perceived was loss of habitat (24.32%) forces the wild animals to visit the crop land. This statement is supported by the fact that, the nearby forest was degrading in recent year than previous year. Increase in built up mining areas by 0.3% and simultaneously decrease in forest cover has 8.61% since 1992 to 2014 (Kayet *et al.,* 2015) clearly indicates that Saranda is losing its compactness along with the decline of elephant population from 371 in 2005 to 200 in 2016.

The major reason for the instable conflict conditions today is devalued feeling among local people and more concerns for wildlife over their needs (Sillero-Zubiri *et al.*, 2006). The important aspect in managing conflict is the effective disbursement of compensations which is not getting momentum due to official corruption in India thereby, causing widespread dissatisfaction in the process of filing compensation claims (Nath and Sukumar, 1998), as cases may go unreported (Madhusudan, 2003). Those victim or victim's family, who have received compensation, had a mild attitude towards wildlife and government. But a negative attitude was observed in people whose compensation has not been totally paid for the crop loses (n=50)

whether due to lack of individuals land documents or irresponsibility of the department in delivering their amount. The goodwill and tolerance level among affected people seems to be compromising over time as the concerned protected area authorities fails to address the needs of local people who are suffering that could lead to animosity towards the elephant conservation (Madhusudan, 2003). Affordability and distance from forest departments were also the reason why victims (n=5) who had suffered from minor injuries and crop damages were not willing to approach forest department. Some of the victims (n=2) were unaware of the scheme and failed to have done treatment at hospital. Proper management of compensation payment may help reduce conflict level.

An understanding of people's perceptions about the conflicts along with scientific understanding of wildlife damage is required for managing conflict (Manfredo *et al*., 1998; Marker *et al*. 2003; Naughton-Treves *et al*., 2003; Naughton-Treves and Treves, 2005). The cheapest and effective method of chasing elephants to prevent crop loss is the traditional method. But there lies a high risk of life as people may come in direct confrontation with elephants (Nath and Sukumar, 1998; Desai, 2002; Nelson *et al*., 2003; Boafo *et al*., 2004; Fernando *et al*., 2008). In Saranda, most of the local people adopted multiple traditional mitigation measures, such as use of vocal sound, stone and dust throwing, use of noise making tools like drum, chasing with fire (Mashaal) regular watching wild animals through high point (Machaan). The need to guard property (which may lead to loss of sleep), reduced school attendance (through loss of sleep, or fear of travel) and psychological stress are some of the losses that outweighs the crop loss (Sukumar, 1990; Naughton-Treves, 1998; Hoare, 2000) and often lead to development of low tolerance level among the sufferers towards wildlife. During certain period of high crop vulnerability, farm household members would take the turns to guard the field crops. The effective toll for chasing away the elephants were the use of crackers and torches but unfortunately its supply they were very less from forest department. Repetition of these traditional methods renders it ineffective as elephants that resides close to villages remains unaffected rather these elephants retaliate back (Parker *et al.*, 2007).

Conclusion

People have been living with wild animals since the millennia but, in recent times these conflicts are a serious obstacle to wildlife conservation and the livelihoods of people worldwide. The study area notice rise in HWC, due to reduction of dense forest cover, increase

in mining activities as well as increase in anthropogenic pressure. Elephant being a keystone species provide essential unique services to the ecosystem and its disappearance will lead to ecosystem misfunctioning. A long-term solution is very much necessary for making coexistence of man and animal possible. A more systematic effort is needed to create awareness among local communities about the ecological value of wild animals and forest. A proper management of conflict is needed for a better conservation. A step towards regeneration of forest in non-working or abandoned mining areas can help recover the lost forest cover. Management of conflict is not possible without the involvement of local people's support. So, awareness not only on wild animal's behaviour, habitat, food habits, and its foraging activities is required but also about the ex-gratia/compensation available to the victims must be provided to minimise conflict. Dependency on forest for NTFP and firewood collection can be reduced if an alternative livelihood options can be provided to the poor tribal. Effective disbursement of ex-gratia/compensation amount on time may help in controlling the tolerance level among the sufferers. A systematic approach to deal with chasing of wild elephant and attending depredation by setting up Flying squad and an alert system and also sufficient crackers and search light. History is a witness to this cruel fact that developmental activities have never been inclusive, it has favoured the growth of some and brought the others down. Although, these developmental activities contributes to the state economy but the benefits from the state seldom trickles down to the local people on ground who have to deal with and pay the real price of this development in the form of damaged environmental quality and loss of livelihood. Whenever it comes to the question of conflict, the focus is upon the losses suffered by the human due to this man animal conflict and not upon the very fact that it's the human who are the first encroachers and trespassers upon the land leading to the unavoidable interaction with the wild. Although, a strong argument exist that the increasing population increases the demand for land and development but one must not forget the fact that the well-being of the environment is an important element of human growth. So, the conservation activities should go hand in hand with the development activities so that there is more balance than conflict.

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Community Perceptions on Human-Wildlife Coexistence around Manas National Park

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Abstract

Human-wildlife conflict (HWC) is one of the most critical threats facing many wildlife species today, and the topic is receiving increasing attention. However, most mitigation studies investigate only the technical aspects of the conflict. Still, people's attitudes towards wildlife are complex, with social factors as diverse as religious affiliation, ethnicity and cultural beliefs shaping their perception. We sought to understand the key challenges that people in these communities face due to HWC, the types and levels of HWC they experience, and their attitudes toward it. The study was carried out in 19 villages under the Bhuyanpara and Bansbari ranges of Manas National Park in Assam. A total of 120 interviews were conducted in July and August 2021 among rural communities living near the southern boundary of the National Park. An in-depth study of the current mitigation measures was carried out in the villages and from this study marked differences in perceptions of affected villagers between areas with power fences and those that did not were observed; in addition, perception, and belief systems of affected villagers towards wildlife and their reluctance to retaliate were also analysed. Based on the analysis, the paper recommends developing efficient, impactful policies and actions to mitigate human-wildlife conflict that can lead to a peaceful coexistence of humans and wildlife where both can co-adapt and share the landscape in a sustainable manner.

Keywords: Human-wildlife conflict, Community Perception, Manas National Park, Coexistence

Introduction

Human-wildlife conflict (HWC) has a long history, and with the growth and spread of human populations, the perception and interpretation of HWC have changed and led to more vociferous complaints. HWC occurs where the needs of human beings and wildlife meet at a common point, like in the case of space, crops, and other natural resources. The conflict between humans and wildlife is one of the most widespread and intractable issues facing conservation today. This issue encompasses various situations and species, from grain-eating rodents to man-eating tigers Panthera tigris (Pimentel, Zuniga & Morrison, 2005; Barlow, 2009). Living alongside such species has the potential to impose a variety of high costs upon

the local people, including depredation upon livestock or game (Thirgood, Woodroffe & Rabinowitz, 2005), crop-raiding or destruction of stored food (Pimentel et al., 2005; Perez & Pacheco, 2006), attacks upon humans (Loe & Roskaft, 2004; Packer et al., 2005), disease transmission to stock or humans (Thirgood et al., 2005) and opportunity costs, where people forgo economic or lifestyle choices due to impositions placed upon them by the presence of wild animals or conservation areas (Woodroffe, Thirgood & Rabinowitz, 2005). Such conflicts can result in a desire for species control and considerable setbacks for local wildlife and habitat conservation (Hoare, 1992; Lamarque et al., 2009). Expectations with conflict resolution are often straightforward, and once the appropriate strategies have been put in place to deal with the reported issue, animosity towards the species concerned should abate. However, long-term conflict resolution is rare, even where such strategies have been implemented (Marker, 2002; Webber, Hill & Reynolds, 2007). United Nations Environment Programme (UNEP) (2018), modern societies living in the protected areas (PAs) have been much characterised with the occurrence of conflicts between human beings and wildlife, resulting from the competition for access to limited resources and space. With regards to conservation, the attitudes of local communities adjacent to, or residing within, protected areas are of great importance (Digun-Aweto, Fawole, and Ayodele 2015). Having a clear understanding of people's perception and tolerance towards wildlife is a critical ingredient for understanding and planning for conservation management strategies.

This suggests that the reason for antagonism towards wildlife and the possible solutions to the conflict are often complex and deep-seated, and a broader approach must be utilised to ameliorate such conflict fully in the long term. In this manuscript, we discuss the perception of the local community towards HWC around the fringe villages of Manas National Park, Assam, India, based on a questionnaire survey.

Study Area

Manas National Park is situated at the foothills of the Bhutan Himalayas in Baksa and Chirang districts of Assam, India (26°35'-26°50'N & 90°45'-91°15'E) within Chirang Ripu Tiger Reserve. It lies on the border with Bhutan, 41 km north of the Barpeta Road township and 175 km northwest of Dispur (Guwahati), the state capital. It was declared as a National Park in 1990 with an area of 519 km2. The Park also forms the core area of the Manas Tiger Reserve, which has an area of 2837 km2. Altitude within the Park ranges from 50 to 200 m above MSL.

MNP is one of the prime habitats of Asian elephants within the Bhutan Biological Conservation Complex in the Eastern Himalaya Biodiversity Hotspot (CEPF 2005) and facilitates transboundary movement of elephants and other wildlife species. MNP spans both sides of the Manas River and is bordered in the east and west by Reserve Forests, to the north by Bhutan and to the south by thickly populated contiguous human settlements. There are 61 recognised fringe villages within ~2 km distance from the park boundary. The Bodo tribal community dominates the population in these villages. Other communities in the region are Assamese, Bengali, Nepali and a localised population of Adivasis (Tea Tribes) near the tea garden.

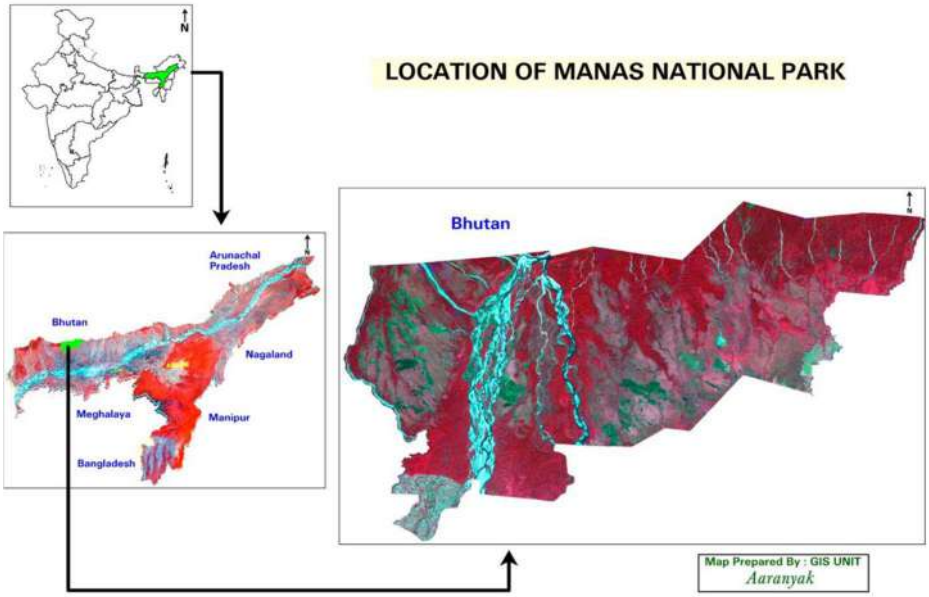

Figure 1a: *Map of the study area, the Manas National Park.*

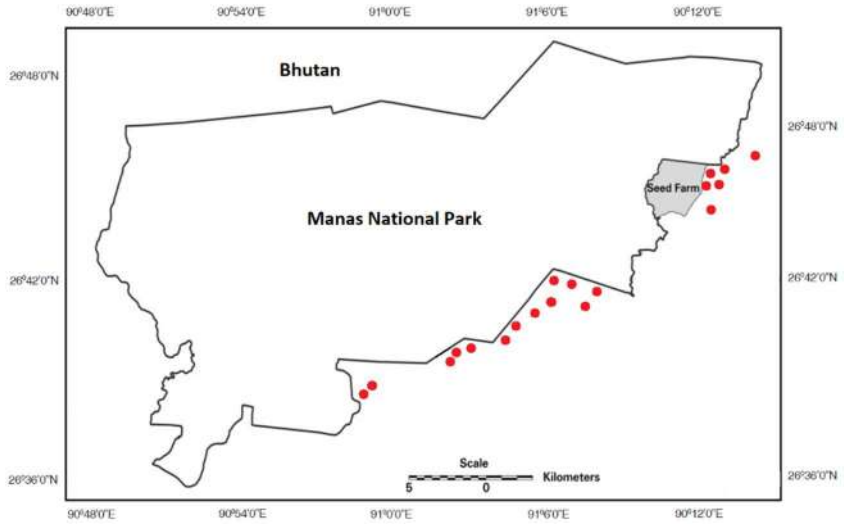

Figure 1b: *Map of the study area showing the location of the villages (red dots) surveyed*

Materials and Methods

Information on community perceptions on human-wildlife coexistence around Manas National Park was collected through interviews with local people, using a semi-structured questionnaire (Hill, 2004). The survey was conducted during the months of July and August 2021. The questionnaire consisted of both open and close-ended questions. Snowball sampling was used for selecting households of respondents and study participants were asked to encourage others to come forward. Snowball sampling is where research participants recruit other participants for a test or study. A total of 120 people were interviewed from 19 fringe villages. The questionnaire consisted of sections focusing on the experience of conflict, perceived reasons of conflict, experience with filing for compensation and the perceived solutions for HWC.

Results

Of the 120 people interviewed, 56.67% (n=68) were male and 42.34% (n=52) were female. The respondents were between the ages of 24 and 75, with a median age of 50 years. The majority of the people interviewed were tribals (76.67%, n=92) from the Bodo community, and just less than half (45%, n=54) of the respondents had no formal education. The majority of the people were subsistence farmers (85%, n=102) without any other source of livelihood. Out of all the people that applied for ex-gratia compensation, 87.5% (n=105) mentioned the conflict species to be wild elephants and the rest, 12.5% (n=15), mentioned wild boar to be the conflict species. 85% (n=102) of the cases were instances of crop-raiding, and in the rest of the cases, 15% (n=18), the conflict resulted in infrastructure damage in addition to crop damage. In almost all of the cases of infrastructure damage, the conflict animal was an elephant, and the damage was done to the granary containing paddy or salt. The damages to crops are the most important factors affecting the livelihoods of the local community (Brandt et al., 1997).

Reports of crop-raiding were found to be maximum from December to March and then again from June to September. Crop raiding in MNP is a dual season phenomenon (Nath et al., 2009), is also conforming to this finding. Respondents also mentioned that instances of crop-raiding increased with increasing crop maturity as they became more palatable during this phase. (Tchamba 1995) and (Parker et al. 2007) reported similar findings during their studies in the African continent.

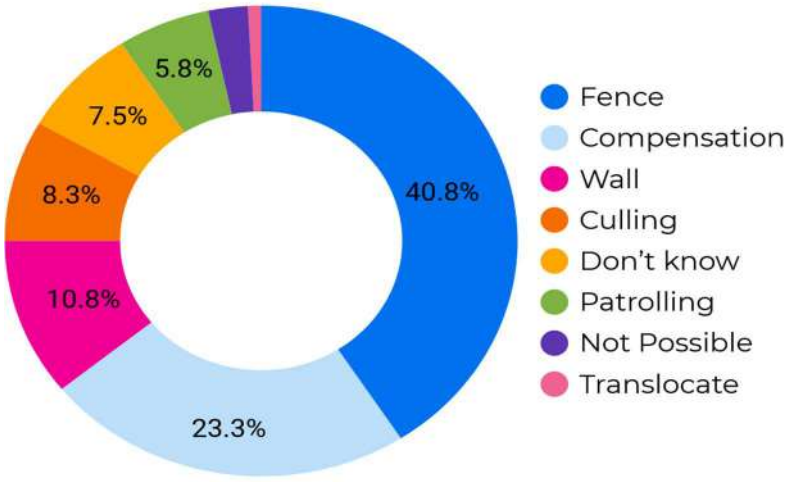

Figure 2: *Mitigation measures suggested by the respondents*

Perception and expectations

A majority of the respondents believed that since the forest department stopped them from accessing forest resources, it was also the responsibility of the forest department to prevent wild animals from crossing over to the human settlements. About 64% of the respondents said they were scared of HWC and saw it as a potential threat to life. While not explicitly considering HWC as life-threatening, the remaining respondents did, however, believe it to be a major hindrance to day-to-day life and a significant factor affecting livelihood. Around 44% of the respondents said they had grown up among HWC and had accepted it as a part of their life, linking it to themes like 'destiny' and 'fate'. Additionally, 56% of the respondents identified sleep loss as a significant outcome of HWC, affecting their quality of life. When asked about reasons behind HWC, about 54% believed that HEC happens because the animals get better food outside or linked HWC to themes related to habitual behaviour associated with food, while 16.67% believed that conflict was happening due to increasing wildlife population. The rest of the opinions were divided between the absence of a fence-like barrier (11.34%), expansion of the jungle, habitat fragmentation (4.17%), translocation of animals from other protected sites (5.83%), while 8% of the respondents said they did not know why HWC occurred.

When the respondents were asked to give suggestions to make HWC mitigation more effective, 40.84% (n=49) responded that they wanted a fence to be installed or the existing fence to be improved, 21.67% (n=26) wanted the compensation mechanism to become transparent and the money to reach them quicker, 15%, (n=18) suggested the construction of a more substantial barrier like a wall, 8.34%, (n=10) people recommended better and more frequent patrolling by

the forest department, 6.67%, (n=8) responded that they didn't know or had no idea, 4.16%, (n=5) suggested selective culling of problematic individual animals or species whose population are not under threat. Of the remaining respondents, 2.5% (n=3) believed it was impossible to resolve this conflict, and 1 person suggested that some animals be translocated to other areas.

Experience of compensation mechanism

People's perception about living alongside wild animals around protected areas can give valuable insights about the compensation policies in the area. Out of the 120 respondents who had applied to claim compensation, none had received their due. Most of them also did not get any response from the concerned authorities even after repeated follow-ups. Multiple respondents had not received compensation for instances that had happened two to three years earlier. This left the people frustrated with the entire process, and many of them had started contemplating not applying in the future until they received compensation for the past occurrences. Besides, the cost of filing for compensation can range from Rs 150 to Rs 200, which further adds to the economic burdens of the local community. This dissatisfaction with the compensation process was because the entire mechanism is highly bureaucratic, opaque, and the compensation amount is often grossly inadequate. A communication gap between the local community and the forest department was clearly visible. Additionally, the proactiveness of the forest ranger or the officer-in-charge plays a significant role in the compensation process. The villagers would routinely mention specific forest rangers under whose tenure the compensations mechanism ran smoothly. This shows the amount of influence the person in charge can have on the entire process. Decentralisation, simplification, or a revamp of the mechanism is vital to overcome such dependence on one person. Moreover, people can become antagonised with the forest department and delays in the system, which may hinder conservation efforts in MNP. Delayed and low compensation could lead to increased attacks on wildlife by people (Wakoli and Sitati 2012).

However, despite these dissatisfactions, statements calling for the culling of animals or reduction of the forest were rarely encountered, and a majority of the people had a positive perception about the ecosystem benefits. This is in agreement with a study by (Sodhi et al. 2010), which noted that poor and educated local people near the protected areas put more value on the ecosystem services. The perceptions and attitudes of the communities affected by HEC

play a more significant role in devising ways of mitigating conflicts (Adams and Hutton 2007; Treves and Bruskotter 2014). Compensation schemes can make people more tolerant towards HWC and ensure the community's support in the conservation efforts. Provision of compensation for losses due to conflict instils a positive attitude toward wildlife and increases their tolerance toward elephants (Sodhi et al. 2010; Hartter and Goldman 2011; Brooks, Waylen, and Mulder 2013; Hartter et al. 2014; Snyman 2014). Additionally, it is equally essential to reflect the actual loss incurred and reach the applicants on time.

Reluctance to retaliate

In India, traditional, cultural, and religious attitudes towards wild animals make local people tolerant towards wildlife despite damage to crops and livestock (Imam et al. 2002). In MNP, the intensity of conflict is not severe (Nath et al., 2015); low-cost mitigation measures such as flashlights, burning firewood, pelting stones, and making noise is usually sufficient to chase away animal. Moreover, in MNP, the crop fields are adjacent to the forest boundary hence the local community. Additionally, single bull elephants were involved in crop-raiding incidents significantly more frequently than herds (Nath et al., 2013); consequently, the villagers, who have become accustomed to HWC, find it easier to chase away the animal rather than retaliate against it.

A general reverence towards certain plants and animals such as bananas and elephants, both of which are considered of religious importance, was also prevalent in the community. The banana plant finds widespread use in religious ceremonies, while the elephant is associated with Lord Ganesh. Furthermore, the awareness about legal frameworks such as The Wildlife (Protection) Act, 1972 and the penalties it entails functions as an additional deterrence to retaliation.

Discussions

The consequences of living alongside wildlife can be extensive (Hoare, 1999), and HWC is just one of the aspects of it. In spite of the fact that a large number of farmers suffer from crop-raiding by wildlife, most of the affected communities do not file complaints to the concerned bodies due to the lack of communication (Tesfay, 2016). Another issue is that the farmers view animals as government property and draw the analogy of the government being a bad neighbour, allowing its animal to damage crops but not offering compensation (Naughton-Treves 1998). This often becomes a reason for unenthusiastic and negative attitudes towards

wildlife conservation. Even though it is useful to undertake conflict studies examining factors and the relationships between them, achieving long-lasting conflict resolution will require taking an even broader and more inclusive approach that utilises the knowledge base of other disciplines while trying to understand the dynamics of coexisting with wildlife. Promoting community inclusion for improving coexistence between humans and wildlife was suggested by (Madden 2004) as an essential component for sustaining livelihoods and protecting flora and fauna, especially endangered species (Ghoddousi et al. 2017). Educating and raising awareness among the local community about the importance of wildlife conservation must go along with alternative livelihood generating programmes. Identifying poverty as the most prevalent concern with respect to improving quality of life allows researchers and other stakeholders to focus on improving conservation policy by providing economic opportunities that support conservation efforts through community-based programs (Borgerhoff Mulder & Coppolillo, 2005).

Local communities play a major role in the success or failure of conservation in protected areas, and strained relationships between communities and management hinder substantive progress in conservation. Issues such as distrust of local communities due to failed promises by park management; illegal activities by rangers; ignoring the host communities' complaints, and the communities' lack of adherence to protected area laws all add – be it social, political and/or economic – to human-wildlife conflict (O. Digun-Aweto & P. Van Der Merwe, 2019).

Ultimately, effective conflict resolution will require a hybrid, heterogeneous and truly interdisciplinary approach, and conservation strategies must include the socio-economic, ecological, and cultural conditions under which intense conflicts arise. Integrated systems must be devised that unite multiple actors, starting from the individuals and communities affected by conflict and the conservation biologists investigating that conflict, donors, fellow conflict researchers and professionals from other areas, such as psychology, economics, and anthropology, to generate a complete picture of how humans interact with wildlife in that particular scenario. The increasing intensity of conflict and the threat it poses to both human and wildlife populations signify the pressing need for developing such projects, which are more likely to produce better solutions for effectively resolving one of the most significant conservation problems of modern times. Furthermore, Park–community relationships need to be strengthened, and this, according to Anthony (2007), can be done through a practical and participatory approach that needs to be incorporated into conservation methods, along with the

local population's development needs which must also be attended to and incorporated into the programme.

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Assessing of Conflict and Mitigation Measures between Wildlife Conservation and Agro-pastoral Practices in Pauni Wildlife Sanctuary in Bhandara District of Maharashtra

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Abstract

Different land use management such as agriculture, livestock grazing, and collection of minor forest produce are common across most wildlife protected areas in India. These practices often result in interaction between wildlife and humans and the negative interactions are emphasized as human wildlife conflict. The present investigation examines the conflict between wildlife and agro-pastoralists community in and around Pauni wildlife sanctuary of Bhandara district of Maharashtra (India). This region of Vidarbha, exhibits acute conflict and hence this examination concludes mitigation measures that might be taken to reduce the conflict. The study was based on direct sightings, animal tracks and signs, substantiated by interviewing locals and information from various key stakeholders was elicited. Further, secondary data collected from the office records, journals, newspapers and internet were compiled and analysed. The study reveals that this type of conflict falls into three categories, firstly, agricultural practices, which includes encroachment of the nearest arable land, crop raiding or property damage by wild animals and illegal hunting of wild animals for food or commercial purposes. Secondly, livestock keeping, which includes injury or death to livestock and transmission of several infectious diseases from livestock to wildlife and vice versa. Thirdly, forestry, which includes, damage of forest plantations by wildlife and any kind of human injury or death during collection of forest natural resources and also the psychological stress and fear experienced by the people residing on the fringes of the protected areas. The paper concludes with the issues that need to be solved with priority. Hence, effective mitigation strategies are urgently required in order to amend this conflict in totality.

Key Words: human wildlife conflict, agro-pastoralists community, mitigation strategies

Introduction

Agriculture, livestock grazing, and the collecting of minor forest produce are all prevalent land-use management practises in most wildlife protected areas in India (Mishra, 1997). This often results in human-wildlife encounters which keep altering over time, progressing from positive to neutral to negative, with intensity and frequency shifting from minor to extreme, and unusual to common, respectively (Soulsbury & White, 2015). Graham et al., (2005) classified these unfavourable encounters as human wildlife conflict, highlighting the purposeful antagonism between humans and wildlife. Human-wildlife interactions that are out

of balance have had a negative impact on rural livelihoods and survival, leading to an anti-conservation attitude towards animals and wildlife resources (Nelson et al., 2003).

Tigers (*Panthera tigris*), Elephant (*Elephas maximus*), Leopard (*Panthera pardus*), Bear (*Melursus ursinus*), Nilgai (*Boselaphus tragocamelus*), Wild Boars (Sus scrofa), and Crocodiles are the principal wild animal species involved in the conflict in most of Asia (Bhatia et al., 2013; Choudhury, 2004; McDougal, 1987; Nowell & Jackson, 1996; Sukumar & Gadgil, 1988; ADRIAN Treves & Naughton-Treves, 2005). Anthropogenic pressure with humans encroaching into the forest and converting forest land into agricultural land and residential area (Balmford et al., 2001, 2012; Naughton-Treves et al., 2000; Thouless & Sakwa, 1995; Torres et al., 1996; Woodroffe et al., 2005), habitat fragmentation due to linear developments such as railway and roads (Ito et al., 2013; Seiler, 2001; Singh & Sharma, 2001), lack of policy for surplus populations of wild animals (Kansky et al., 2016; Sripal, 2015), changes in the behaviour and food habits of wild animals (Ditchkoff et al., 2006; Marchini & Crawshaw, 2015; Sillero-Zubiri & Switzer, 2001), and the excess of population of wild animals and less resources available are all factors that contribute to Human Wildlife Conflict (HWC) (Middleton, 2003). Another well-known driver of these confrontations is the people's decreasing tolerance power and a communication gap between the Forest Department and neighbourhood.

From an anthropocentric perspective, crop raiding or property destruction, cattle injury or death, human injury or death and of course psychological stress and fear among those living on the outside of protected areas can all be classified as types of conflict (König et al., 2020). In order to ameliorate such conflict in the long run, effective mitigation strategies are urgently required (Breitenmoser et al., 2009). It is vital for the state to design a comprehensive strategy to guarantee that mitigation measures are tailored to the nature and severity of the conflict, preparedness and resource availability to manage the conflict and the officers' and staff's capacity and skills to do so.

The main objective of this paper is to look at the conflict between wildlife and agro-pastoralists in the Pauni range of the Umred-Karhandla-Pauni Wildlife Sanctuary, which is an area of acute conflict in the Vidharbha region of Maharashtra, and to assess mitigation measures that is being taken to reduce the conflict.

Materials and Methods

Study Site

The Umred Karhandla Pauni Wildlife Sanctuary, which encompasses 180 square kilometres, was formed by Maharashtra Government Notification No. WLP-2012/CR.186/F-1, dt.29/06/2012.The Maru River, which flows near Bhiwapur and meets the Wainganga River, divides the Sanctuary into Nagpur Division (Kuhi and Bhiwapur forest circle) and Bhandara Division (Pauni forest circle). The presence of buffer at Pauni forest circle enables for a human wildlife and mitigation strategies evaluation. Direct sightings, tracks and signs, and interviews with villagers were used to identify wild animals in the Pauni forest circle.

Sampling, Data Collection, and Data Analysis

From April 2019 to March, 2020 data was collected from the various key stakeholders on a monthly basis. Secondary data was obtained and analysed from the office records (registers, reports and other records available at State, District, Block and Gram Panchayat levels). Some secondary data were also collected from other sources such as journals, newspapers, internet, etc. Primary data was gathered through interviewing respondents at different levels as per objectives. The stratified sampling approach was used to pick the samples, which were done using the village records. Considering the population falling in each category, farmers samples were selected randomly.

Results

The area of the Pauni forest circle is shown in Table -1. It is separated into four protected areas, Amgaon, Savarla, Bhuyar and Dhanori, which encompass 15 beats. Agriculture, livestock grazing and minor forest products gathering being the most prevalent activities in and around the Pauni forest circle, with human population densities of roughly 233/km^2, and livestock densities of around 60/km^2.

Table 1: *Area under Pauni Forest Circle, Maharashtra is separated into four protected area that cover 15 beats.*

Amgaon		**Savarla**		**Bhuyar**		**Dhanori**	
Beat	**Area (ha)**	**Beat**	**Area (ha)**	**Beat**	**Area (ha)**	**Beat**	**Area (ha)**
Sirsala-2	505.185	Savarla	1829.218	Bhuyar-1	573.44	Dhanori-1	781.304
Nishti-1	761.104	Gudegaon	1401.596	Bhuyar-2	566.363	Dhanori-2	1068.335
Nishti-2	401.542	Kahnalgaon	999.705	Waegaon	766.676	Mandavgota-1	628.909
		Channevada	1176.622	Sirsala-1	677.778	Mandavgota-2	255.283
Total	**1667.771**		**5407.141**		**2585.201**		**2713.804**

The principal carnivore species found in Pauni forest circle included the Tiger, Sloth bear, Leopard, Wild dog (*Cuon alpinus*), Indian fox (*Vulpes bengalensis*), Wolf (*Canis lupus pallipes*), Jackal (*Canis aureus*) , and Jungle cat (*Felis chaus*) whereas the main herbivore species include Gaur (*Bos gaurus*), Nilgai, Sambar deer (*Rusa unicolor*), Barking deer (*Muntiacus muntjac*), Wild boar, and Spotted deer (*Cervus axis*) (Fig-1).

Table-2 shows the conflict between wildlife conservation with agriculture, livestock and forestry practices in Pauni forest circle. We recorded 167 instances of crop damage by wildlife between April 2019 and March 2020. Nilgai, spotted dear, wild boars and langurs (*Semnopithecus entellus*) were the animals that caused the most agricultural damage. The month of January saw the highest number of crops raiding incidents. During the year, 36 livestock kills and injuries were reported, with tigers, leopards, wolf and jackal being blamed. Livestock losses were evenly distributed throughout the year, with the month of November being most severe. During the study period, four people were reported to have been killed, with Leopards and Tiger being the perpetrators.

Table 3 shows the afforestation activities done in the Pauni forest circle in 2018-19. The tree planting was done through the Compensatory Afforestation Fund Management and Planning Authority (CAMPA), as well as under several state and district development programme. Teak, bamboo, and mixed species plantation were done as part of the CAMPA scheme. It should be emphasised that the majority of afforestation is done under employment scheme, followed by plan scheme and finally district programme.

Tigers (*Panthera tigris*)

Bear (*Melursus ursinus*)

Leopard (*Panthera pardus*)

Wild dog (*Cuon alpinus*)

Wolf (*Canis lupus pallipes*)

Gaur (*Bos gaurus*)

Nilgai (*Boselaphus tragocamelus*)

Sambar deer (*Rusa unicolor*)

Spotted deer (*Cervus axis*)

Fig 1: *Photo of a faunal species taken in the Pauni forest circle*

A survey of mitigation measures used to safeguard crops and livestock were conducted (Table-4). Monitoring at night (50.83%), barriers (40%) and devices to instil fear (25%) were the common mitigation measures used by villagers to protect crops, while monitoring at night (5.83%), devices to instil fear (6.63%), closer monitoring on animals (18.33%), proper disposal of waste or dead animals (5%), use of guard animals (6.67%) and public land being less used (11.67%) were the common mitigation measures used by villagers to protect livestock. Although mitigation measures were generally related to lower losses, no single strategy was highly associated with decreased crop or livestock loss, in our finding.

Mitigating human wildlife conflict is also top priority for the Forest Department. Compensation for the crop damage, injury or loss of livestock, loss of human life, and other damages were sanctioned under state scheme for payment of Rs. 21,09,153 in 2019-20 to guarantee that the afflicted villagers were suitably compensated (Table-2).

Table 2: *Crop damage, Livestock predation, and human loss caused by wild animals and monetary compensation provided in the Pauni Forest Circle, Maharashtra, from April, 2019 and March, 2020*

Sr. No.	Month	Year	Date	Cheque No.	Livestock	Crops	Human Loss	Tree felling at Plantation site	Total	Distributed Amount
1.	April	2019	31/03/2019 and 31/03/2019	30998, 25480	5	41	0	0	46	323653
2.	May	2019	30-05-2019	31004	5	20	0	0	25	153640
3.	June	2019	26-06-2019 and 21-06-2019	31007, 031006	4	27	1	0	32	338240
4.	July	2019	27-07-2019	31013	3	3	1	1	8	187000
5.	August	2019	-	-	-	-	-	-	-	-
6.	September	2019	26-09-2019	31047	6	0	0	0	6	78375
7.	October	2019	-	-	0	0	0	0	0	0
8.	November	2019	30-11-2019	35016	7	2	1	0	10	141000
9.	December	2019	19-12-2019	35022	0	17	0	0	17	147766
10.	January	2020	26-02-2020	35041	6	57	1	0	64	739479
11.	February	2020	-	-	0	0	0	0	0	0
12.	March	2020	-	-	0	0	0	0	0	0
	Total								208	2109153

Table 3: *Tree plantation by forest department under various schemes in 2018-19 at Pauni forest circle*

Sr. No.	Work	Year of Work	Plantation No.	Scheme Name	Plantation Area (ha)	No. of holes	Natural plant no.
1	Mixed Plantation (AR)	2018-19	9	State Scheme	110.00	1222100	-
2	Mixed Plantation (AR)	2018-19	1	District Scheme	10.00	11110	-
3	Mixed Plantation (AR)	2018-19	1	CAMPA	10.00	11110	-
4	Assisted/Aided Natural Regeneration (ANR)	2018-19	3	State Scheme	80.00	15400	61470
5	Natural Regeneration (ANR)	2018-19	5	State Scheme	135.00	0	74322

Table 4: *Mitigation measures employed by villagers at Pauni Forest Circle*

Characteristics	**Amgaon**	**Savarla**	**Bhuyar**	**Dhanori**	**Average**
Crop damage mitigation strategy (% of People surveyed)					
Monitoring at night	53.33	43.33	50.00	56.67	50.83
Fencing	36.67	46.67	33.33	43.33	40.00
Devices to instil fear	23.33	26.67	30.00	20.00	25.00
Loss of Livestock mitigation strategy (% of People surveyed)					
Monitoring at night	6.67	3.33	6.67	6.67	5.83
Devices to instil fear	3.33	6.67	6.67	10.00	6.67
Close monitoring on animals	13.33	16.67	20.00	23.33	18.33
Proper disposal of waste or dead animals	3.33	3.33	6.67	6.67	5.00
Use of Guard animals	6.67	3.33	10.00	6.67	6.67
Public land being less used	16.67	13.33	6.67	10.00	11.67

Discussion

According to survey and published records, the villagers considered three components of HWC to be key issues: 1. wildlife conservation versus agriculture 2. Livestock versus wildlife and 3. Forestry versus wildlife. Crop destruction was the most prevalent of all recorded incident (80.29 percent); 17.31% of the recorded cases dealt primarily with livestock injury or death; however, only 1.92 % of all reported case dealt exclusively with human attacks as a form, and only 0.48 % with tree plantation sites Fig-2.

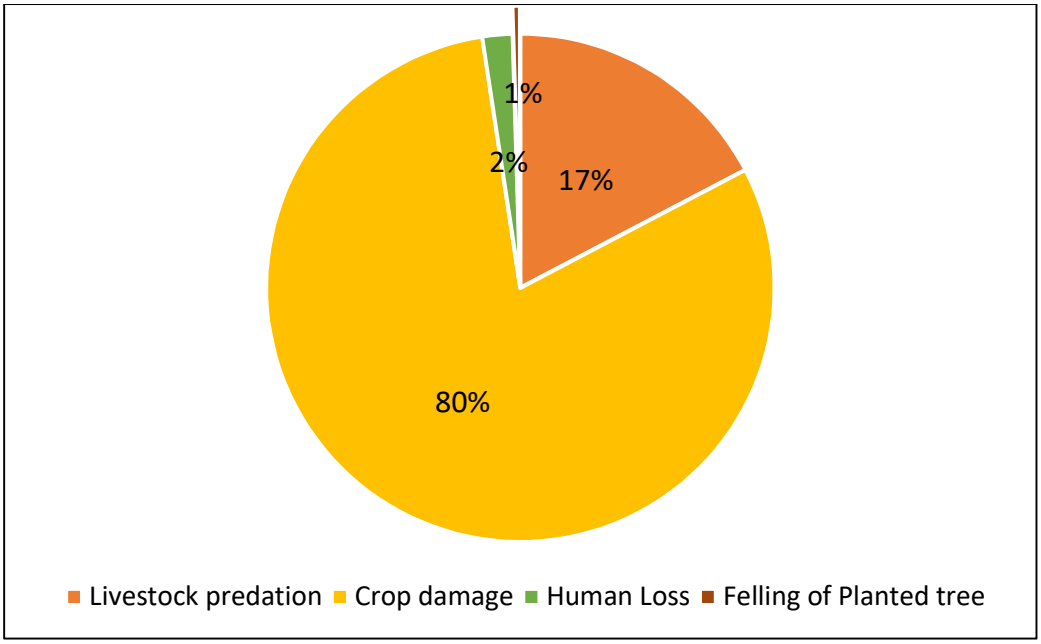

Figure. 2: *Main component of Human Wildlife Conflict in the Pauni Forest Circle, Maharashtra, from April, 2019 and March, 2020.*

1. Wildlife conservation versus agriculture

Separating livestock from agriculture has become vital due to the significant differences in problems. When it comes to the fact that both cultivation and wildlife conservation require land, Land pressure is the most direct and immediate threat to wildlife conservation. Other conflicts arise as a result of a lack of adequate land. Three key factors contribute to and explain land demand. The first is Pauni's population density, which is 233 people per square kilometre and relies heavily on agriculture for food, employment and foreign exchange are concerned (Bose, 2011). With the population expected to nearly quadruple in the next 25 years (MOSPI, 2011), the current arable land will undoubtedly be depleted. Second, as the population grows, the labour force grows as well (Bloom & Mckenna, 2015). Pauni's industrial sector is struggling, so the agricultural sector must absorb the majority of the workforce. Third, the coronavirus outbreak resulted in population shift, with people who were formerly casually employed in towns increasingly migrating to rural areas (Bhagat et al., 2020) . Agriculture is the only likely and most promising source of employment. The following are the long-term implication on wildlife regions as a result of the ongoing population growth in rural areas, which demands more land for cultivation.

(a) **The encroachment of the nearest arable land.** Wildlife may be found practically everywhere in the country, and some of the most fertile agriculture land is found near

wildlife reserves. The majority of such regions are surrounded by densely populated areas (Kanianska, n.d.) . The problem in Pauni Forest Circle is a good example to think about. Crop farms are already within 100-200 meters of the sanctuary's perimeter. Each year, the encroachment on the boundary becomes more pronounced. Farmers will claim a portion of the refugee to be use for agricultural purposes. In various other parts of this country, such claims have already been filed and dealt with the government (Gureja et al., 2003).

(b) **Crop destruction by wild animals:** This is a two-sided conflict. Wild animals that stray onto nearby crop farms, whether purposely or unintentionally, cause damage to the crops (Chhangani et al., 2008; Gureja et al., 2003). These animals are killed inhumanely by farmers themselves or with cooperation of the local poachers (FAO, 2015). Throughout the Pauni forest circle, evidence of crop destruction by herbivorous animals such as Nilgai, sambar deer, barking deer, wild boars, and spotted deer has been abundant. Though estimates on how much agricultural damage was done are available, there are no records of animals killed under this slanderous pretence. The above activities make it clear how much wildlife is lost each year as a result of this problem or conflict.

2. Livestock versus wildlife

In terms of land pressure, the issues with livestock and wildlife have never been as severe as those with agriculture. Wildlife has been known to graze and to freely coexist with livestock in many areas, notably among pastoral communities (FAO, 2009). The cattle in Pauni forest circle's floor coexist peacefully with large congregations of different species of antelope. Even in densely inhabited areas where cattle rearing is the main source of income, huge population of other wildlife species have been seen. Despite this co-existence some problems exist and many more have started to appear. Of these the following are worthy of consideration:

(a) **Wild carnivores – domestic stock relationship:** Wild carnivores, particularly, tiger, leopard or hyena, have been known to infiltrate, attack, and kill domestic stock on occasion, though not as regularly as herbivores damaging crops (Kissui, 2008). The disappearance of wild prey species has been observed to be the cause of this. Many carnivores have been hounded and killed by domestic livestock owners, to the point of

extinction in some locations. It is crucial to note, however, that in areas where wild prey species is abundant, occurrence of such incursions by wild predators have always been rare.

(b) **Illegal hunting:** Unless for customary purposes, most tribes e.g., the Gond and Halba tribes do not hunt, kill or eat wild animals. However, with the booming of commercial poaching, even tribes that are well acquainted with these wild species have recently begun cooperating with the commercial (On et al., 2020).

3. Forestry versus wildlife

Despite the peaceful coexistence of wildlife and forestry, some issues have arisen, and many more are likely to arise. Among the most recent are:

(a) Damage of forest plantations by wildlife:

Wildlife is a natural part of forests and tree plantations. In the Pauni forest circle, the Maharashtra Forest department has planted trees and bushes under several initiatives. Wild animals have been known to cause damage to tree plantation sites by breaking and eating branches, twigs and leaves, chewing barking and felling trees (Radwan, 1963). In the current investigation monkeys, Nilgais, and deers were found to have eaten and damaged the leaves and tender shoots, as well as debarking by buffalo.

In all of the above examples, the economic impact caused by a species is a function of the current damage plus future losses plus the costs associated with replacement. The loss must account for the time it takes to re-establish the tree to a harvestable age. Thus, the resource loss over time is equal to the monetary value expected at harvest plus the monetary value for protection up to the point of damage, plus the time-integrated costs of reestablishment to future harvest.

(b) Forest product and utilization:

The law renders any use of natural resources within the forest illegal. To ensure that people do not trespass on tiger habitats, the forest department has provided alternatives to every forest-dependent activity like grazing, fuelwood and minor forest produce collection. Illegal forest products harvesting and livestock grazing of near or in forests make people particularly vulnerable to carnivore attacks. Despite the fact that tigers and

leopards rarely attack human, confrontation are regular in South Asia (Bhatia et al., 2013; Nyhus J. & Tilson, 2010). Previous studies suggest that the vulnerability of people to attack by large carnivores is influenced not only by the biology of the carnivore, but also by poverty, gender, labour type and age of victims (Gurung et al., 2008; Inskip & Zimmermann, 2009).

In our study area there was no evidence that either species selected targets or attacked based on poverty, gender, labour type and age of victims. Most victims were attacked when collecting forest products inside the forests and of 4 attacks for which we had eyewitness information all were in a crouched or sitting posture when attacked, which is comparable to reports elsewhere (Gurung et al., 2008; Nyhus & Tilson, 2004).

Mitigating conflict

Legal provision of the Wildlife Protection Act of 1972 makes it virtually illegal to kill or capture wild animals even when problem animals are involved in severe conflict situations. Only government officials or agents authorized by the Chief Wildlife Warden of the state government can authorize such killings or captures. While these rigorous legal protections are admirable in principle, they make it extremely difficult for local wildlife managers to deal effectively with critical human wild life conflict.

In the following analysis, we evaluate the utility of different conflict-mitigation approaches in terms of their technical feasibility and social practicality.

Monitoring, barriers and devices to instil fear

Human herders are used to safeguard crops and cattle grazing in and around protected areas, in the Pauni Forest circle, which is a viable and cost-effective traditional technique when such labour is available. Similar remarks were made by (K. K. Karanth et al., 2013; Nyhus & Tilson, 2004).

Mechanical barriers, such as stockades, are ineffective since most attacks on cattle and humans occur when carnivores are free to roam. On the other hand, wooden poles, wire mesh, and nylon netting barriers, are highly effective. Devices to instil fear using electrical 'human dummies' have been tested in the same region. These intriguing solutions devised by villagers

and local wildlife managers have been hailed as a success. However, their application has been erratic and intermittent, with little rigorous research to back up their effectiveness.

Non-lethal aversive conditioning techniques, which are occasionally used in developed countries to deter carnivore attacks (Shivik, 2006; Adrian Treves & Karanth, 2003), do not appear to be very relevant to the technology and resource-scarce social context in which most human carnivore conflict occurs in India.

Compensatory payments

At the pilot scale, our assessment of the Pauni forest circle provided some helpful insights into conflict loss and compensation. The filing of official documentation backed up by evidence such as photographs of the damage, is required for compensation pay-out. Field verifications are done by forest officials to assess damage, but they are usually limited to cases where there is significant crop loss or death or injury to cattle and persons. Compensation schemes for crop damage and livestock, on the other hand, fail for a variety of reasons including the low value of livestock in relation to costs of verifying claims, corruption in the official machinery and among claimants, and a general lack of rural financial that allow for quick transactions. This is consistent with the finding of Karanth et al. (2018) and Madhusudan (2003), which reported that compensation for crop damage and livestock predation, particularly in multi-use forests with grazing rights, is challenging.

In cases of predation on human, no amount of money will ever make up for the loss suffered by the victims' families. The timely distribution of such assistance, on the other hand, has significantly reduced local animosity toward carnivores. Given the rarity of tiger attacks on humans and the public outcry that such attacks evokes, it appears that government compensation arrangements for human lives lost to tigers are working reasonably well (Karanth & Gopal, 2009).

Conclusions

Human wildlife conflict is both sociopolitical and a scientific concern. Anti- conservation attitudes toward animals and wildlife might result from public opposition. We believe that local wildlife managers should increasingly employ a combination of strategies to reduce the conflict in this and comparable ecosystem, including (1) monitoring and limiting human activity within

protected areas, (2) training residents in the area on how to recognise wild animal indication and how to avoid endangering themselves, their cattle, and their crops, and (3) forming swift response teams made up of qualified animal experts to reduce and prevent conflict from growing. We recommend that a systematic examination of the government compensation schemes should be done and made more effective in reducing the conflict. Furthermore, herders in Pauni forest circle appear to accept some degree of carnivore predation as a price for access to forest resources.

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