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HUMAN WILDLIFE CONFLICT IN INDIA: A REVIEW OF ECONOMIC IMPLICATION OF LOSS AND PREVENTIVE MEASURES

UPMA MANRAL, SHRUTI SENGUPTA, SYED AINUL HUSSAIN, SAKSHI RANA AND RUCHI BADOLA

Wildlife Institute of India, Chandrabani, Dehradun (Uttarakhand)
E-mail: ruchi@wii.gov.in

ABSTRACT

In a developing economy like India where majority of human population depends heavily on natural resources, the forest-dwellers have co-existed with the wildlife for long. However, the growing human dependency on natural resources and degradation of wildlife habitats, have resulted in a conflicting situation between humans and wildlife, and authorities involved in wildlife management. With significant conservation and economic consequences, human wildlife conflict (HWC) undermines well-being of both the parties and threatens the conservation goals. It impacts the people's food security and livelihood and psychosocial wellbeing. We reviewed articles that deal with monetary loss incurred by involved communities and discuss the effectiveness and the short comings of measures taken to address the issue and prevent the loss, in the Indian scenario. There is a lack of studies dealing with monetary cost associated with HWC and no realistic estimates are available for involved species. Majority of the studies are from protected areas with un-protected forests represented poorly. It is imperative that action plans, which target offsetting economic loss of locals and enhance public participation, are put in-place to meet the integrated conservation and development goals in a landscape where human and wildlife can coexist.

Key words: Carnivores, Human Wildlife conflict, Opportunity cost, Primates, Ungulates.

Introduction

Human - Wildlife Conflict (HWC) is defined as 'interaction between humans and wildlife where negative consequences, whether perceived or real, exists for one or both the parties when action of one has an adverse effect on the other party' (Conover, 2001; Decker *et al*., 2002). It has been in existence for as long as wild animals and humans have co-existed and shared the same resources. Historical records from Nile Delta revealed that hippopotamuses raided crops while crocodiles attacked livestock in Egypt while elephants had been raiding crops all across Africa and other parts of world (Barnes, 1996). The famous "Taung skull" discovered in South Africa in 1924 belonged to a child victim of an eagle attack that occurred some two million years ago (Berger, 2006). Such conflicts have negative impacts on conservation of wildlife populations or of their environment; and social, economic or cultural life of humans (WWF, 2005). The negative consequences for local communities include attacks upon humans (Löe and Röskaf, 2004; Packer *et al.*, 2005; Jadhav and Barua, 2012), depredation of livestock or game (Thirgood *et al.*, 2005; Banerjee *et al.*, 2013), destruction of stored harvest or crop-raiding (Pimentel *et al.,* 2005; Perez and Pacheco, 2006; Karanth *et al.*, 2012) and spread of zoonotic diseases to humans or stock (Daszak *et al.*, 2000; Singh and Gajadhar, 2014; Hegglin *et al.*, 2015). At times people have to make lifestyle choices and bear opportunity costs due to presence of wildlife or protected areas (Woodroffe *et al.*, 2005; Barua *et al.*, 2013). Species involved may vary from grain eating sparrows or rodents to man-eating tigers; affecting from marginal agro-pastoralists of developing countries to elite section of developed world. Consequences are no better for wild species which bear the brunt in the form of retaliatory killing and lethal control (Liu *et al.*, 2011; Mateo-Tomás *et al.*, 2012; Northrup *et al.*, 2012; Bergstrom *et al.*, 2014). The intensity of the problem is increasing because of a number of factors such as increase in human populations, anthropogenic encroachment into wildlife habitats resulting in transformation of wildlife habitats into urban and sub-urban areas and agrarian ecosystems and fragmentation of wildlife habitat causing constriction of wildlife populations into marginal habitat patches (Siex and Struhsaker, 1999; Conover, 2001; Sillero-Zubiri and Switzer, 2001; Nyhus and Tilson, 2004; Hegel, *et al.*, 2009; Estes *et al.*, 2012; Yadav *et al.*, 2012). Recovery of declining populations of many large mammals due to efficient wildlife management and large network of protected areas worldwide has also lead to increased conflicts (Saberwal *et al.*, 1994; Fall and Jackson, 2002; Vijayan and

Growing human dependency on natural resources and degradation of wild life habitats have resulted in human wild life conflict.

Patil, 2002; Woodroffe *et al.,* 2005). Stochastic events such as fire and climatic change also augment conflict situations *e.g.* higher number of cases of livestock depredation by wild predatorsduring seasonal rains in Kenya while during dry season in Zimbabwe (Butler, 2000; Nyhus and Tilson, 2004; Patterson *et al.*, 2004).

Indian scenario

India is a mega-diverse country owing to its large climatic and topographic gradient. With only 2.4% of the world's land area, it harbors around 8% of all recorded species including 91,000 species of animals and 45,000 of plants (MoEFCC, 2014). Out of 34 global 'Biodiversity Hotspots', four fall fully or partly within Indian political boundaries. With more than 100 National Parks and more than 500 Wildlife Sanctuaries, the country has an extensive network of protected areas and wildlife reserves. The protection of forests and wild life by the State has been mandated by the Indian Constitution through its article 48A of part IV as Directive principles and as citizens of India it is also one of our fundamental duties as laid down by the Constitution of India in article 51A of part IVA (Bakshi and Kashyap, 2012). As the country is a fast developing economy and among most populous countries with around 17% of the world's human population, the protected area landscapes are not untouched of human presence. High rate of human population growth put the wilderness areas under threat due to increasing interference, deforestation, fragmentation of natural habitats and expansion of agricultural lands in the forested landscapes. As human settlements expand and protected areas become conservation islands surrounded by human-dominated landscapes, the negative interaction between human and wildlife species, particularly large mammals, increases. The situations are no better outside protected areas, as humans continue to encroach natural habitats and become prone to conflicts as wild animals seek to fulfil their nutritional, behavioural and ecological needs (Sukumar, 1991). A close interface between large mammals such as tigers, elephants, lions and others with humans and their land use has caused serious conflicts countrywide over space and resources (Sukumar, 1994; Madhusudan and Mishra, 2003; Banerjee *et al.*, 2013; Karanth *et al.*, 2013). Overgrazing by livestock in the wildlife habitats results in decline or local extinction of wild herbivore populations (Mishra *et al.*, 2003) while a disproportionate presence of wild and domestic ungulates amplifies cases of livestock depredation by wild predators (Mishra, 1997). The attacks on human and livestock and incidences of crop raiding have significant consequences for people's food security and livelihood and psychosocial wellbeing (Barua *et al.*, 2013). Most of the studies done on HWC in India are either single species oriented or area oriented. For the present study we conducted an extensive review of the current situation of the negative interaction between human and wildlife in the country and its impact on the livelihood security of the affected community. We also discuss here the effectiveness and the short comings of measure taken to address the issue, and suggest possible strategy.

Methodology

Literature on the Human wildlife conflict and associated economic cost was gathered through online web based search engines using keywords such as Human wildlife conflict, crop raiding, livestock depredation and names of problem species. Studies were restricted to India and search was made with the key words based on biogeographic zones, states and country name. Online technical databases which were searched to download relevant literature, primarily included Science Direct, JSTOR, Wiley Online Library and Google Scholar. The collected literature was then thoroughly reviewed for major conflict animals, economic loss to humans due to various conflict events and amount spent on preventive measures. Study primarily focused on conflict associated with large-bodied mammals.

Results and Discussion

Species involved

Livestock depredation is globally the most common form of human–wildlife conflict and can involve a variety of taxa including *felids, canids, ursids* and raptors (Thirgood *et al.*, 2005). In India, human population densities are high while populations of several large mammals reside outside protected areas that result in frequent negative interaction between human and many mammalian species (Karanth and Madhusudan, 2002). Almost all large carnivore species are known to attack and kill people and attack domesticated ungulates whenever an opportunity arise (Karanth *et al.*, 1999; Karanth and Gopal, 2005). Besides livestock depredation, crop damage is another form of human-wildlife conflict. Agricultural crops and fruit orchards are often raided by wild ungulates, primates and granivores and frugivores birds which cause damage to both food crops and young shoots of other crops and plantations (Jhala, 1993; Sekhar, 1998; Dave, 2010; Gubbi *et al.*, 2014). Conflict-prone species include tiger (*Panthera tigris*), leopard (*Panthera pardus*), Asian elephants (*Elephas maximus)*, sloth bear (*Melursus ursinus*), Himalayan black bear (*Ursus thibetanus*), wild pig

(*Sus scrofa*), nilgai (*Boselaphus tragocamelus*) and gray wolves (*Canis lupus*) (Table 1). Conflicts between large carnivores and humans have always been a serious issue since historic times. The conflict involving carnivore species particularly conflict-prone large felids is considered having potentially catastrophic consequences for both wildlife and humans (Karanth *et al.*, 2012; Dhanwatey *et al.*, 2013; Athreya *et al.*, 2016). In the Gir landscape, livestock of *Maldhari* community form an important part of lion's diet. The restricted distribution of the animal has led to frequent attacks on humans and livestock in the region (Saberwal *et al.*, 1994; Banerjee *et al.,* 2013). Both Tiger and Leopard have wide ranging behavior due to large habitat requirements resulting in increased chances of becoming involved in conflict with humans residing in adjoining areas (Rastogi *et al.*, 2012; Dhanwatey *et al.,* 2013; Karanth *et al.,* 2013; Athreya *et al.,* 2016). In the fragile Trans-Himalayan ecosystem where humans compete for limited resources with wildlife, Snow leopard causes huge economic loss to the local communities through livestock predation (Bagchi and Mishra, 2006; Jackson *et al*., 2010). Though, wild dog (*Cuon alpinus*) has its range across Indian sub-continent, but it's involvement in livestock depredation is mainly reported from north-east India where species has been reported to prey upon mithun (*Bos frontalis*) (Lyngdoh *et al.,* 2014). Similarly, livestock depredation and attacks on humans by Indian wolf (*Canis lupus pallipes*) has long history in the country which has escalated in recent times (Krithivasan *et al.*, 2009; Agarwala *et al*., 2010).

Among all the crop-raider ungulates, Asiatic elephant is most studied and is known to cause large scale damage to crops and human lives across its range in India (Gubbi, 2012). In north-east India, the incidences of conflict with the species have increased due to reduction of forest cover below 30-40% in the area (Datta-roy *et al.*, 2009; Chartier *et al.*, 2011). A number of ungulate species including wild pig, nilgai, barking deer, spotted deer, and wild ass cause damage to both food crops and young shoots of other crops and plantations (Rao *et al.,* 2002; Madhusudan, 2003; Chauhan *et al.*, 2009; Dave, 2010; Karanth *et al.,* 2012; Meena *et al.,* 2014). Both sloth and black bears cause human casualties and have been reported to attack without apparent provocations. Along with attacks on humans, bears have been reported to cause crop raiding and livestock depredation (Rajpurohit and Krausman, 2000; Bargali *et al.*, 2005; Charoo *et al.*, 2011).

Primates, primarily Rhesus Macaques and Hanuman Langur are also nuisance species that share food and space with humans in the rural and urban areas and are known to cause distress and economic loss by means of crop raiding and looting and attacks on humans (Imam *et al.*, 2002; Chauhan and Pirta, 2010a; b). Apart from large mammals, small animals like insects (locusts and

Table 1: Monetary value of loss incurred by local communities due to Human Wildlife Conflict

Species	Location	Extent of loss/ monetary loss	Reference
Blackbuck	Gujarat	48,600 kg of Sorghum crop in two villages of value ~ US$ 558	Jhala, 1993
Snow leopard	Kibber Wildlife Sanctuary, Himachal Pradesh	18% of household's livestock holdings with economic loss that equaled to 25% of annual income/ household	Mishra, 1997
Wild ungulates, tiger and leopard	Sariska Tiger Reserve, Rajasthan	6 - 27% of total crop yield per ha, valued at US$ 48 to 67/ household/ year	Sekhar, 1998
Snow leopard and wolf	Hemis National Park, Jammu & Kashmir	492 cattle in 14 months valued at US$ 23,500	Jackson and Wangchuk, 2001
Ungulates, leopard and Himalayan black bear	Nanda Devi Biosphere Reserve, Uttarakhand	40% of sown area with crop loss of US$ 50 while livestock loss of US$ 5/ household/ year	Rao *et al.*, 2002
Elephants, tiger and leopard	Bhadra Tiger Reserve, Karnataka	11% of the annual production from agriculture and animal husbandry in the area lost, valued at US$ 5404	Madhusudan, 2003
Tibetan wolf, snow leopard and lynx	Proposed Gya-Miru Wildlife Sanctuary, Jammu & Kashmir	2.9% of household' livestock holdings, valued at US$ 190/ household/year	Namgail *et al.*, 2007
Wild ungulates	Kanha National Park, Madhya Pradesh	US$155 from crop loss/ household/ year	Karanth *et al.*, 2013
Wild ungulates	Ranthambore National Park, Rajasthan	US$ 264 from crop loss/ household/ year	Karanth *et al.*, 2013
Wild ungulates	Nagarahole National Park, Karnataka	US$ 546 from crop loss/ household/ year	Karanth *et al.*, 2013
Wild dog	Arunachal Pradesh	20.3% of the total monetary value of livestock valued at US$ 134,493 for two years in 48 sampled villages	Lyngdoh *et al.*, 2014

caterpillars) and rodents, hares, birds and porcupines can be involved in conflict with humans over game species, crops, apiaries, poultry and fish and have devastating impacts on harvest (Rao *et al.,* 2002; WWF, 2005). The inherent fear of snakes in humans has caused a lot of negative interactions between the two. As the two taxa live in close association in rural and urban areas and human encroach more into natural habitats, the cases of snake bite victims are on rise (Nath *et al.*, 2012).

Threatened livelihood security - Humans at the receiving end

HWC results in damage to crop, water sources and property and livestock depredation, which threaten the livelihoods of millions across the globe and costs lives of both human and wildlife, thus, jeopardizing wildlife conservation goals (Oli, 1994; Sekhar, 1998; Rajpurohit and Krausman, 2000; Ogra and Badola, 2008). The research on HWC has primarily been focused around natural science with a resultant well-understood ecology of some conflicts (Woodroffe *et al.*, 2005). However, it involves people, and it is very essential to understand attitudes, beliefs and values of stakeholders to mitigate conflicts (Redpath *et al.*, 2004; Ogra, 2008). In rural areas where livestock holdings and agriculture are an important part of household's livelihoods and incomes, competition between local communities and wild animals for the use of natural resources is intense thus escalating conflict (Mishra *et al.*, 2003).

In Kibber Wildlife Sanctuary, pastoralist communities incurred a loss of 18% of their livestock holdings to snow leopard and wolf attacks, an economic loss equaled to 25% of annual income per household (Mishra, 1997). Snow leopard and wolf killed 492 animals within a period of 14 months around Hemis National Park, valued at US$ 23,500 (Jackson and Wangchuk, 2001). In another study from Trans-Himalaya of Ladakh, Namgail *et al*. (2007) estimated that livestock depredation, particularly of valuable livestock such as yak and horse, by Tibetan wolf, snow leopard and lynx resulted in an annual monetary loss of US$ 190/household/year or approximately US$ 12,120/ year for the three study villages combined. Local communities of Bhadra Tiger Reserve lost an approximate 11% of their crop to elephants and 12% of livestock to large cats annually (Madhusudan, 2003). The overall annual loss to sampled households was 11% of the monetary value of annual production, estimated at INR 243,167 (US$ 5404). Similar was the case of Sariska Tiger Reserve where agriculture and livestock rearing are main economic activity of 117 villages situated in and around the reserve. Damage to crops of chickpeas, maize, mustard, wheat etc. from wild ungulates was 6 - 27% of total crop yield per ha. The total economic loss from crop damage and livestock depredation by tiger and leopard was INR 2500 (US$ 48) to INR 3500 (US$ 67) per household (Sekhar, 1998).

Situations are no different when it comes to crop raiding, as studied by various workers. A small population of blackbuck around two villages in Gujarat caused loss of 48,600 kg of Sorghum crop in a single season accounting for economic loss of INR 29,000 (US$ 558) (Jhala, 1993). In Nanda Devi Biosphere Reserve, more than 40% sown area was damaged with an average monetary loss of INR 2590 (US$ 50) per household, annually. Locals in the reserve also suffered from livestock depredation with an average loss of INR 272 (US$ 5) per household annually. The projected total values of livestock and crop losses for buffer zone villages were estimated at INR 10,24520 (US$ 29272) and INR 538620 (US$ 15389), respectively (Rao *et al.,* 2002). Karanth *et al.* (2013) reported an annual loss of US$ 155, 264 and 546 from crop loss per household in Kanha, Ranthambore and Nagarahole National Parks, respectively as annual household incomes averaged US$ 300 per household. Livestock depredation by wild dog in Arunachal Pradesh resulted in loss of around 20.3% of the total monetary value of livestock in sampled villages which was around US$ 134,493 for two years in 48 sampled villages (Lyngdoh *et al.*, 2014).

Such financial losses are particularly damaging if occurring in regions with underdeveloped economies (Mishra *et al.,* 2003). The relative impact of damage caused on household's income varies greatly according to the economic dependence on agriculture and livestock and for households with subsistence economies even small losses can be significant (Oli, 1994; Rao *et al.,* 2002). Costs are escalated if investments are made in fencing or mitigating measures or if the conflict is severe, families abandon cultivation of otherwise profitable land (Naughton-Treves *et al.,* 1998).

Ways to mitigate Human Wildlife Conflict

Prevention of conflict between humans and wildlife has been a challenge for management authorities and local community and very less success has been documented. Thus, it becomes imperative to examine the preventive measures such as putting barriers or *post facto* options including compensatory measures to manage the conflict.

Preventative measures: A number of studies have discussed preventive measures to deal with HWC (Sukumar, 1991; 1994; Mishra, 1997; Karanth and

Madhusudan, 2002; Madhusudan, 2003; Mishra *et al.,* 2003; Jayant *et al*., 2007; Karanth *et al.*, 2013). Here, measures which might either put extra economic burden on households or improve their economic conditions are discussed. However, the cost benefit analyses of various mitigating measures are rare. In Sonitpur, Assam, an investment of INR 10,00,000 (US$ 19,231) in Human-elephant conflict mitigation strategy saved value worth more than 80 times of the investment made (Fernando *et al.*, 2008). Following are few examples of preventive measures:

Physical barriers: Barriers, whether natural (rivers and mountain ranges) or man-made (stone-walls, chain-fence, electric fencing and hedge) spatially separate wild population and adjacent communities and have been proved successful (Mishra, 1997). Fencing is not feasible and does not provide satisfactory solution for the problem always (Choudhury, 2004). Electronic fencing has been proved successful in reducing human - elephant conflict in many places in India (Gubbi, 2012) but fails due to inadequate or poor maintenance (Chauhan and Chowdhury, 2002). It has been successful in limiting elephant incursions into farm lands in some parts of Coorg and Anamalai hills in Karnataka (Fernando *et al.*, 2008). In case of Gir National Park, Gujarat, fencing was proved economically impractical (Vijayan and Patil, 2002). In Rajasthan, farmers claimed that wild boar were able to dig beneath stone wall while nilgai could jump over 1.5 m fence (Sekhar, 1998). Similarly, digging trench has also been proved unsuccessful due to human error or environmental factors (Nath and Sukumar, 1998; Choudhury, 2004; Jayant *et al.*, 2007). In Tamil Nadu, the cost of digging a trench was estimated to be around US$ 2,160 per km (Fernando *et al.*, 2008). Jayant *et al*. (2007) rated a trench built alongside an electric fence as highly effective in eliminating human-elephant conflict in Karnataka. Both Nath and Sukumar (1998) and Jayant *et al.* (2007) found private and individually owned fences to be effective than the government owned fences in reducing crop raiding by elephants in Karnataka. In Hemis National Park, villagers' nighttime livestock pens or corral were predator-proofed through Appreciative Participatory Planning and Action or APPA. The imported materials including wire mesh, cable fasteners, poles, etc. were provided by Snow Leopard Conservancy (US $ 400 to $ 800 per village) while mud and stones were brought by villagers along with their time and labor for constructing the corral. Though the initial costs were high, however, it prevented the mass-attacks on livestock particularly sheep and goats by snow leopard and the associated economic impact on households (Wangchuk and Jackson, 2004).

Disrupting stimuli: Use of electronic devices which produce stimuli such as sounds, chemicals or light annoying to animals when they approach a protected resource has been tested but are very expensive and complicated to use. However, their use in Indian scenario needs to be tested (Chaudhury, 2004). In Tamil Nadu, the Forest department distributed high power search lights to farmers worth INR 1.5 lakh (US$ 3,250) to scare away the elephants straying into farm lands (Fernando *et al.*, 2008). In Sonitpur, Assam, Zimmermann *et al.* (2009) found hand-held spotlights to be popular and effective in reducing events of crop raiding by elephants when used with other methods such as noise, fencing and chili smoke. In villages around Manas National Park in Assam, a mix of methods including use of torch lights and fire and making noise through shouting and beating drums have been found to give good results to prevent elephant movement (Fernando *et al.*, 2008).

Taking out the problem party - translocation of problem animal or human population resettlement: The process of eliminating problem animal and releasing it to other site has been practiced in India for few species (Fernando *et al.*, 2008; Athreya *et al.*, 2011). However, it has been found that this does not mitigate the problem in many areas, even increasing the conflict in release sites (Nath and Sukumar, 1998; Athreya *et al.,* 2011). In Karnataka, the cost of translocation of 20 elephants from different regions to Bhadra Wildlife Sanctuary was estimated to be around US$ 375,000 (Fernando *et al.*, 2008). Displacement has been suggested as an alternative to segregate people and wildlife spatially to reduce conflict (Ogra and Badola, 2008), however shifting families to locations with livelihood options new to them e.g. providing agricultural land to pastoralists or forest dwelling communities, might prove futile (Gubbi, 2012). Relocation of communities to areas with better socio-economic opportunities, substantial benefits, no cultural, political or social opposition and low or no risk of losing property, provides adequate solution and can be successful in long run (Madhusudan, 2003; Treves and Karanth, 2003). However, such resettlements are limited to small homogenous communities who have been living inside the protected areas.

Buffer of multiple use areas or unpalatable crops: Gubbi (2012) suggested addition of multiple use forest as buffer of Nagarhole National Park in India to reduce conflict with elephants. Rao *et al.* (2002) in a study in and around Nanda Devi Biosphere Reserve, suggested replacing agricultural

crops with medicinal plant species which will also enhance household's income. In Chirang-Ripu Elephant Reserve in Manas National Park, Assam, experiments are being carried out to study the viability of cultivating alternate crops such as capsicum, beetle nut, lemon and Patchouli plants or other economically viable crops as elephant deterrents and to improve income of affected community (Fernando *et al.*, 2008). However, in many parts of the country the agriculture lands around the elephant habitats are owned by small farmers who are not willing to adopt practices different to the traditional farming of subsistence crops.

Compensatory measures: In the absence of tangible economic gains, local communities are often unable to support conservation - friendly production and consumption practices, thus, programs are required to offset their economic loss (Mishra *et al.,* 2003). Tools for mitigating financial loss of locals involve direct cash compensation and indirect compensation through insurance schemes, integrated conservation development programs and alternative source of income such as ecotourism or wildlife tourism (Sillero-Zubiri *et al.*, 2006).

Compensation schemes: Monetary compensation is provided by several state governments in India to conflict affected people, to balance their economic loss. However, these payments are often insufficient, delayed and involve time-consuming procedures and fail to reduce anti-wildlife sentiments (Madhusudan, 2003; Ogra and Badola, 2008; Gubbi, 2012). Verification of losses and final payment take time and payments are so measly (rarely meeting market value of lost crop or animals, at times 3% of total loss; Mishra *et al.,* 2003) that people do not apply for compensation (Saberwal *et al.,* 1994; Gubbi, 2012). However, factors like wealth, gender, social networks and pre-existing expectations also influence one's decision of applying for compensation (Ogra and Badola, 2008). In Bhadra Tiger Reserve, payments made to villagers were equal to only 14% of crop losses and 5% of the livestock losses which were accompanied by extended delay (Madhusudan, 2003). The forest department spent around INR 53,090 (US$ 1,021) as compensation for crop loss from elephant raiding in three years which was only 14% of the claimed monetary value of crop loss by the villagers. In Nagarhole National Park landscape, households received a compensation of US$ 30 for crop loss by elephants (Gubbi, 2012). Compensation schemes also put pressure on already limited budget of Forest Departments. The Wildlife Department in Hemis National Park found itself spending 60% of its annual budget as compensation that too when claimants were being paid only 10-30% of animal's market value (Jackson and Wangchuk, 2001). Such compensation schemes cannot do much to reduce HWC and strong institutional support is required to make compensation schemes successful along with clear guidelines, quick and accurate verification of damage, fair payment and sufficient and sustainable funds with concerned authorities (Mishra, 1997).

Insurance programs involving locals: The basic idea of compensation scheme in most of the countries is that forest department is entirely responsible for losses caused to neighbouring human settlements and resultant compensations. However, locals dependent on forest resources in certain areas are contributing or are ready to contribute a small amount to safeguard their crops and livestock through protective measures and to reduce their losses through insurance programs (Madhusudan, 2003; Mishra *et al.,* 2003). In Ladakh, village council left approximately 500 ha area free of livestock grazing and human use for 5 years and in return got a yearly sum of INR 20,000 (US$ 385) from Nature Conservation Foundation for collective work and village development schemes. Livestock insurance program was also initiated in the area with a monthly contribution from villagers and initial funds from International Snow Leopard Trust. Up to 100% of livestock losses are provided depending on total number of livestock killed and the total size of insurance fund. Work is going on for programs to develop and market handicrafts and achieve sustainability of the grazing on set-aside land (Mishra *et al.,* 2003). Madhusudan (2003) suggested a similar insurance scheme in Bhadra Tiger Reserve for mitigating monetary loss to local community due to conflict. Under the scheme, the premium that the interested party (villagers interested in securing their livestock and crops) would have to pay annually could be as low as INR 125 (US$ 2.60) per head of livestock and INR 223 (US$ 4.60) per acre of paddy.

Conclusion - short comings and possible strategies

The review indicates that though Human Wildlife Conflict is well studied in India, however, not many workershave looked into monetary losses to the affected community. There are sporadic studies on certain species (Table 1) but no realistic estimates are available for any species across its range. The economic loss incurred by households put an additional burden on rural households, particularly marginalized sections of society. It is to be understood that the negative interactions between the wildlife and humans undermines well-being of both the parties and threatens the conservation of wildlife, particularly of large-bodied mammals which happen to be problem animals all over their range (Madhusudan, 2003;

Madhusudan and Mishra, 2003; Mishra *et al.,* 2003). Conflict and associated loss lessen the public support and increase hatred towards wildlife and wildlife managers with a decrease in cultural tolerance of locals towards wildlife (Madhusudan, 2003; Ogra and Badola 2008). Intentional and retaliatory killings of carnivores have also increased which pose a threat to carnivore population viability (Jhala and Giles, 1991; Mishra *et al.,* 2003; Maclennan *et al.*, 2009; Lyngdoh *et al.,* 2014).

It was also observed that almost all the studies were done in and around protected areas or proposed protected areas. The protected areas represent a little over 5% of country's geographic area while the forest cover of the country is 21.34% of total area (FSI, 2015). Thus, a large part of country's natural habitat is not under any protection. With increasing human population, the pressure on natural systems will also increase leading to augmented magnitude of such negative incidences. While declaring more of the forest cover as protected might seem as a potential measure to prevent further anthropogenic pressure and degradation, however, without assessing the dependencies of the surrounding local communities and ensuring alternatives it might lead to further conflicts. This will further amplify the negative repercussions for biodiversity conservation and human well-being and livelihoods, thus posing a challenge for policy-makers (Young *et al.*, 2010).

For many state governments, wildlife conservation is considered a non-priority sector with delayed or meager flow of funds. Lack of resources with the authorities to compensate loss of local communities is one major challenge (Jackson and Wangchuk, 2001). In Karnataka alone, over 100,000 compensation claims due to various wildlife conflicts were filed from 2000 to 2010 (Sidder, 2016). Insufficient compensation provided to locals and often time-consuming procedures are considered responsible for augmenting anti-government and wildlife sentiments (Madhusudan, 2003; Gubbi, 2012). Though, compensation could be only a partial strategy to reduce hostility of local communities but timely payment and supportive staff would improve relationships between management authorities and communities and can reduce retaliatory activities of locals. With the little help from technology the whole process of compensation, deemed as time-consuming and costly, can be fastened up as recently illustrated by the WildSeve project in Bandipur-Nagarhole National Parks, Karnataka (Sidder, 2016). The project uses cell phone technology to help the claimants to file and track their claims to get timely compensation and is funded by the National Geographic Big Cats Initiative, Oracle, and The Rufford Foundation. Possibly, such innovative measures could be adopted by forest department of other area and state, along with allocation of more funds so that sufficient compensation is provided.

Studies are also lacking to improve herding practices. Free ranging livestock is more vulnerable to predation which is also partly responsible for the conflict. In Kibber Wildlife Sanctuary of Himachal Pradesh, the livestock density is ten times of Bharal (*Pseudois nayaur*) which results in high levels of livestock depredation by wild carnivores and consequent retaliatory persecution by the herders (Mishra, 1997). It was suggested that inviolate areas should be created for wild herbivore while livestock stocking density should be regulated in other areas. Cultivation of crops unpalatable or repelling to wild herbivore as a buffer to food crops has been suggested as an option to reduce the crop raiding by wild ungulates. However, often there are constraints in marketing of such produce (Maikhuri *et al.*, 2001) thus farmers tend to not prefer such crops. Thus, civil organizations and government departments should work towards creation of market and training of locals in marketing of such produce. Also due to lack of alternative livelihood, such incidents of livestock predation and crop depredation by wildlife hits the local communities hard. Hence, it is crucial that the local institutions, central government and civil society bodies work together in tandem to ensure that not just the ecological diversity but economic diversity is also maintained for a holistic conservation.

Some of the commonly used preventive and mitigative measures are listed in Table 2. But no one mitigative/ preventive measure can be 100% effective everywhere given the diversity of the country. Hence, it is desirable that in various permutations and combinations the measures are used to ensure maximum safety possible. At the end, it is imperative to mobilize and educate the community about the wildlife values and significance of an intact natural habitat. Local youth could be trained to monitor wildlife signs in and around villages and report sightings to local officials so that timely actions could be taken to prevent conflict (Dhanwatey *et al.,* 2013). A participatory strategy where affected community is involved while drafting and initiating a project leads to a sense of project ownership by local stakeholders and results in communal empowerment, self-reliance, and willingness to co-exist with problem species (Wangchuk and Jackson, 2004). It is important to bring down Human Wildlife Conflict and programs are required to offset economic loss of locals to achieve an integrated conservation and development goal.

Table 2: Examples of preventive and mitigation measures used during Human Wildlife Conflict in India

Animal	Loss type	Preventive measures used	Mitigation measure used	Reference
Elephants	Crop Raiding, Property Damage, Killing cattle and people, disruption of daily activities	Guarding, fencing, anti-depredation squad, community based participatory wildlife monitoring, trip wire alarms, barriers, elephant proof trenches (EPT), walls, punji sticks, bio-fences, habitat enrichments, chemicals, artificial water sources, chilies, satellite tracking, scaring squads, translocation, culling, capturing for captivity, alternative livelihood such as bee keeping.	Compensation for loss, relocation of villages	Williams *et al.*, 2001; Singh *et al.*, 2002; Choudhury, 2004; Jayant *et al.*, 2007; Fernando *et al.*, 2008; Lenin and Sukumar, 2008; Datta-roy *et al.*, 2009; Barua *et al.*, 2010; Zimmermann and Ladle, 2011; Gubbi, 2012; Jadhav and Barua, 2012; Palei *et al.*, 2015
Lions	Human attack, livestock damage	Thorn enclosures for livestock, translocation	Compensation for loss	Saberwal *et al.*, 1994; Banerjee *et al.*, 2013
Tigers	Human killing, livestock depredation	Eradication, translocation, preservation, stopping coupe operations, introduction of human face masks and clay models wrapped with energizers connected to electricity, patrolling, nylon net fencing, use of crackers, drums, education and awareness programs, alternative livelihood	Compensation for loss, Voluntary resettlement	Madhusudan, 2003; Ogra and Badola, 2008; Gubbi *et al.*, 2008; Rastogi *et al.*, 2012
Leopards	Livestock depredation, Human Killing	Translocation, lethal control	Compensation for loss	Athreya, 2006; Athreya *et al.*, 2007; Athreya *et al.*, 2011
Snow leopards	Livestock depredation	Lethal control, alternative livelihood such as handicraft and wildlife tourism, predator-proof corrals, guarding, anti-predator livestock management, creating grazing set-asides, wild prey recovery.	Incentive program to reduce grazing in conflict area, livestock insurance program, Compensation, training programs, Promote community-based wildlife stewardship	Mishra, 1997; Jackson and Wangchuk, 2001; Mishra *et al.*, 2003; Bagchi and Mishra, 2006; Namgail *et al.* 2007; Jackson *et al.*, 2010
Sloth Bears	Crop damage, Human Attack	Education and awareness programs, restriction in agricultural practices, alternative livelihood, change in activity pattern	Compensation for loss	Rajpurohit and Krausman, 2000; Bargali *et al.*, 2005
Black Bears	Human attack, livestock damage, crop damage	Retaliatory killing, drumming empty metal containers, use of guard dogs, barbed wire fencing, scarecrow, burning red chilies mixed in cow dung	Compensation for loss	Charoo *et al.*, 2011
Macaques and Langurs	Human Attack, Property Damage	Removal and relocation, surgical sterilization or immune-contraception of macaques, garbage management, development of monkey sanctuaries.	Insurance schemes, compensation	Imam *et al.*, 2002; Chauhan and Pirta, 2010a, b
Wolves	Livestock depredation, human attack	Lethal control, translocation	Incentive program to reduce grazing in cpnflict area, livestock insurance program, compensation, training programs, Promote community-based wildlife stewardship	Krithivasan *et al.*, 2009; Agarwala *et al.*, 2010
Wild pig	Crop raiding, career of infectious diseases, human attack	Fencing, trapping, guarding, pig-proof barriers, loud music.	Compensation for loss	Chauhan *et al.*, 2009
Snakes	Human attack	Removal and relocation, lethal control, awareness programs	Not available	Nadu *et al.*, 2011; Nath *et al.*, 2012; Vyas, 2013
Crocodiles	Human attack, livestock depredation	Removal and relocation, caged-bathing ghats, warning sign boards.	Education program, compensation for loss	Whitaker, 2007

Table 3: Cost of various preventive measures used to combat Human Wildlife Conflict

Species involved	Location	Preventive measure	Cost	Agency bearing the cost	Outcome	Reference
Elephant	Sonitpur, Assam	Conflict mitigation strategy including fences, spotlights and training to locals	US$ 19,231	Forest Department and civil agencies	Value 80 times of the investment made was saved.	Fernando *et al.*, 2008
Elephant	Tamil Nadu	Trench around villages	US$ 2,160 per km	Tamil Nadu Forest Department	Various environmental factors and human errors resulted in failure of trench.	Fernando *et al.*, 2008
Elephants	Tamil Nadu	High power search lights	US$ 3,250	Tamil Nadu Forest Department	Efficacy remains to be scientifically tested.	Fernando *et al.*, 2008
Snow leopard	Hemis National Park, Jammu & Kashmir	Predator-proof livestock corral	US $400 to $600 per village	Snow Leopard Conservancy	Mass-attacks on livestock by snow leopard were prevented.	Wangchuk and Jackson, 2004
Elephant	Bhadra Wildlife Sanctuary, Karnataka	Translocation of 20 elephants	US$ 375,000	Karnataka Forest Department	-	Fernando *et al.*, 2008

भारत में मानव वन्यजीव संघर्ष : क्षति एवं निवारक उपायों की आर्थिक जटिलता का एक पुनरीक्षण

उपमा मनराल, श्रुति सेनगुप्ता, सईद एनुल हुसैन, साक्षी राणा और रूचि बडोला

सारांश

भारत जैसी विकासशील अर्थव्यवस्था में जहां अधिकांश मानव आबादी बहुत अधिक प्राकृतिक संसाधनों पर निर्भर है। वन निवासियों का दीर्घकाल से वन्यजीवों के साथ सह-अस्तित्व रहा है। तथापि, प्राकृतिक संसाधनों पर बढ़ रही मानवीय निर्भरता और वन्यजीव आवासों के निम्नीकरण के फलस्वरूप वन प्रबंधन में लगे अधिकारियों तथा मानव एवं वन्यजीव के मध्य संघर्षात्मक स्थिति पैदा हुई है। महत्वपूर्ण संरक्षण और आर्थिक परिणामों के साथ, मानव वन्यजीव संघर्ष दोनों पार्टियों के कल्याण को क्षति पहुंचाते हैं तथा संरक्षण लक्ष्यों के लिए संकट खड़ा करते हैं। यह लोगों की खाद्य सुरक्षा एवं आजीविका तथा मनोसामाजिक कल्याण को प्रभावित करता है। हमने शामिल समुदायों द्वारा उत्पन्न आर्थिक क्षति पर विचार किए गए शोधपत्रों को पुनरीक्षित किया और भारतीय परिदृश्य में क्षति को रोकने एवं विषय के समाधान हेतु किए गए उपायों की प्रभावकारिता एवं कमियों पर विचार किया। मानव वन्यजीव संघर्ष के साथ सम्बद्धआर्थिक लागत से संबंधित अध्ययनों का अभाव है तथा शामिल प्रजातियों के लिए कोई वास्तविक आकलन उपलब्ध नहीं है। अधिकांश अध्ययन संरक्षित क्षेत्रों से संबंधित है, जिसमें गैर संरक्षित वनों का पर्याप्त प्रतिनिधित्व नहीं है। यह अनिवार्य है कि ऐसी कार्य योजना को मूर्त रूप दिया जाए, जो स्थानीय लोगों की आर्थिक क्षति की पूर्ति कर सके और जन सहभागिता को बढ़ाए ताकि ऐसे भूदृश्य में एकीकृत संरक्षण एवं विकास लक्ष्यों को पूरा किया जा सके, जहां मानव और वन्यजीव साथ-साथ रह सकें।

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