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Human-Wildlife Conflict: Issues and Managements

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Introduction

Human-wildlife conflict (HWC) is fast becoming a critical threat to the survival of many globally endangered species, in particular to large and rare mammals such as the Sumatran tiger (*Panthera tigris sumatrae*), the Asian lion (*Panthera leo persica*), but also to less endangered species such as the snow leopard (*Uncia uncia*) and the Red colobus monkey (*Procolopus kirkii*). Human-bear conflict (HBC) is also an international problem involving all eight species of bears across much of Europe, Asia, North America and the South American Andes. The numerous cases from countries all over the world demonstrate the severity of human-wildlife conflict and suggest that an in-depth analysis is essential to understand the problem and support the conservation prospects of threatened and potentially endangered species.

However, what is the exact definition of HWC, when and where does it usually occur? According to the World Conservation Union (World Park Congress 2003), it occurs when wildlife's requirements overlap with those of human populations, creating costs to residents and wild animals. Direct contact with wildlife occurs in both urban and rural areas, but it is generally more common inside and around protected areas, where wildlife population density is higher or scarcity of palatable food in the forest and animals often stray into adjacent cultivated fields or grazing areas.

HWC has far-reaching environmental impacts. Species most exposed to conflict are also shown to be more prone to extinction (*Ogada et al., 2003*) because of injury and death caused by humans; these can be either accidental, such as road traffic and railway accidents, capture in snares set for other species or from falling into farm wells, or intentional, caused by retaliatory shooting, poison or capture. Such human-induced mortality affects not only the population viability of some of the most endangered species, but also has broader environmental impacts on ecosystem equilibrium and biodiversity preservation.

Human-wildlife conflicts also undermine human welfare, health and safety, and have economic and social costs. Nuisance encounters with small animals, exposure to zoonotic diseases, physical injury or even death caused by large predators' attacks have high financial costs for individuals and society in the form of medical treatments to cure and prevent infections transmitted from animals through human contact. Humans can be economically affected through destruction and damage to property and infrastructure (e.g., agricultural crops, orchards, grain stores, water installation, fencing and pipes), livestock depredation, transmission of domestic animal diseases, such as foot and mouth. Negative social impacts include missed school and work, additional labour costs, loss of sleep, fear,

restriction of travel or loss of pets (Hoare, 1992). Such broad environmental, human health and safety economic and social impacts suggest that governments, wildlife managers, scientists and local communities need to recognize the problem and adopt measures to resolve it in the interest of human and environmental well-being.

This chapter provides insights into HWC, based upon some review of selected case studies and provides a summary of key lessons suggested. It highlights common problems and solutions across biogeographical regions and demonstrates that conflicts have similar causes and effects and that detailed information is the key to the development of appropriate strategies for resolving the problem and conserving different ecosystems and their inhabitants.



Wildlife conservation has three facets: preservation of rare forms of wildlife, wise use of numerically abundant wildlife, and mitigation of wildlife damage. The first of these is the primary goal of parks. However, success in wildlife preservation usually makes conflict mitigation a concurrent necessity. Many human activities, such as hunting, logging, animal husbandry, collection of non-timber forest products (NTFP), agricultural expansion, and developmental projects adversely impact wildlife and parks. In India, the increase in human and livestock populations has created pressure on all natural resources. Most protected areas are fragmented, degraded and disturbed from anthropogenic activities. Forests, pastures and wastelands have been brought under cultivation to sustain increased demand for cereals and other food products. Unsustainable land-use patterns in rural areas have further altered landscapes. This habitat modification has caused many wildlife species to become ecologically dislocated. Although some species have adapted to humans and have become locally overabundant others stray out of protected areas and damage human life and property to a varying degree.

With the accelerated human growth in India, the demand for arable land increased drastically during the twentieth century. Huge areas of marginal lands, pastures and forests were converted to cultivation areas irrespective of their suitability for sustained agriculture. Still today, the situation in rural areas is very much characterized by irrational and unsustainable land-use pattern. With increasing irrational conversion of and later encroachment on forest lands, wildlife in the country was reduced drastically following loss of habitats and degradation of habitat quality and as a result, certain species have become ecologically dislocated over the time period. This has led to raising conflicts between people existing on subsistence agriculture in the surrounds of potential wildlife habitats and the surviving wildlife. The existing protected forests even in remote areas are not free from human activities, cattle grazing and overexploitation of resources. The situation is further compounded in many areas where large tracts of forests are fragmented with accelerated shifting cultivation and developmental programmes such as hydro and irrigation projects, etc., forcing animals into conflicts with human beings due to confinement. Although improvement of agricultural technology and practices, rural community development and approaches to integrated forest management practices are progressing, these measures alone will not help attainment of the long-term solutions to the above problems leading to balanced natural systems. The situation for both wildlife and rural people is rather

tragic especially in and around many of the protected areas and managed forests. There is an urgent need for development of strategies that can reduce the man-wildlife conflict to tolerable levels.

Rural people can ill-afford to have their cultivation raided by elephant, deer, nilgai, blackbuck, wild boar, etc. and sustain livestock depredation by large carnivores. It is not simply a matter of attitude, but in essence a matter of survival. The problem of man-killing by tigers and depredation of livestock has been investigated by Seidenstecker *et al.*, 1970. Although the tiger population is only a fraction of what it is believed to have been at the turn of the century, incidences of man-killing and cattle-lifting by tigers every year have continued. Lions in Gir take heavy toll of cattle annually and recently man-killing incidences are on the rise. Similarly, cases of stock and child lifting by leopards and wolves have been reported from several regions. Crop raiding by elephants is taking alarming proportions, and the number of people killed in encounters with elephants while protecting their crops seems to be increasing.

Extensive crop-raiding is reported from all places where elephants survive in fragmented and disturbed habitats. The problem of crop damage by deer, nilgai, blackbuck and wild boar is widely reported from several states such as Uttar Pradesh, Bihar, Rajasthan, Gujarat, Haryana, Punjab, Madhya Pradesh, West Bengal, Karnataka, Tamil Nadu, Maharashtra, etc., but the data on the nature and extent of damage is very scarce. Due to these damage problems, conflict between man and wildlife is constantly increasing and thus, acceptance of conservation ideals by people is greatly affected.

Another important issue is forest fire impacting rural people and wild animals. Forest fires are one of the most important and prevalent type of disasters and they can create great environmental problems for Nature. It is known that they are detectable and easily preventable. When a wildfire burns out of control, the size of the losses can be almost immeasurable. The cost of such disaster may be millions of trees, in addition to losses of structures, animals (wild and farm), and human life. One and possibly the most important method for protecting forests from wildfires is their early detection. The earliest possible detection enables a rapid response to minimize the spread. Moreover, information regarding the seat of the fire is invaluable for the rapid deployment of fire-fighters. Therefore, early detection, containment at the early stages and extinguishment of a fire before it spreads are crucial for wildfire management. Recently, many different forest fire detection and fire management system have been developed and successfully applied. It is fact that forest fire detection and forest fire management should be distinguished to understand how to set up new systems for fire detection and containment. Hence, we divided forest fire detection and management systems into different classes. A great deal of research into forest fire management has been published in recent years, presenting a variety of solutions and management techniques. Some research has combined forest fire management and detection methods (Lee *et al.*, 2002; Kolaric *et al.*, 2008 and Merino *et al.*, 2006). One group of researchers has studied forest fire prevention through an analysis of cause (Mutlu *et al.*, 2008; Vining and Merrick, 2008; Peckham *et al.*, 2008 and Lavrov *et al.*, 2006). The typical effects include loss of crop, dairy, timber (forest fires), increased unemployment and loss of biodiversity. The study on occurrence of forest fires and their impacts will help suggest mitigation measures in the benefit of people and wild conservation.

The overall premise of this chapter is to highlight the wildlife damage problems and conflicts between rural people and wild animals in future. Conservation efforts can substantially be reduced through a combination of area planning for resources, habitat management, education of people and protection measures.

Forms of Human-Wildlife Conflict

Most parks in South Asia have human settlements adjacent to or within them. In the larger landscape matrices that harbor these parks, there usually is a lengthy “edge” where wildlife habitats interface with human settlements. At this interface, conflicts inevitably arise because of the nutritional, ecological and behavioural needs of animals. There is evidence that large-bodied animals are more likely to come into conflict with humans than smaller ones. Species that range widely such as elephants or cats of the *Panthera* family may enter human settlements during daily foraging, seasonal migrations, or territorial and dispersal movements (Sukumar, 1994; Woodroffe and Ginsberg, 1998) nutritionally; both cultivated plants and livestock are attractive resources respectively for wild herbivores and carnivores (Karanth, 1998; Madhusudan and Mishra, in press; Sukumar, 1991). The damage to human interests engendered by contact with such animals can include economic losses of crops, property, or livelihood opportunities. Frequently, human limbs and lives may be lost (McDougal, 1987; Rajpurohit, 1999).

Damage to Agricultural Crops and Pastures

Crop damage by wild animals is probably the most widespread and persistent form of human-wildlife conflict in the tropics (Blair *et al.*, 1979; Nath and Sukumar, 1998; Newmark *et al.*, 1994; Sekhar, 1998; Sukumar, 1998; Williams and Johnsingh, 1996). Such damage adversely impacts staple food grains (rice, wheat, maize, sorghum and millet); non-grain food crops (potatoes, peanuts, vegetables, sugarcane, bananas, cassava, coconuts and cocoa), and commercial crops (rubber, tea, coffee and spices). Damage results not only from the animals feeding on crops, but also from trampling, rooting and other forms of wastage. Taxonomically, the animals involved in crop raiding are varied. They include elephants (grain crops, sugarcane and fruits), wild pigs (almost all crops), nilgai and black buck antelopes (sorghum, wheat and millet), gaur (rice and rubber), sloth bear and black bear (maize, sugarcane and peanuts), jackals (sugarcane, maize and fruits), bonnet and rhesus macaques (most crops and vegetables), giant fruit bats (all orchard crops and areca nuts), and porcupines (areca nuts, coconuts and vegetables). Crop damage results in the loss of staple foods for the poorest class of rural people and in destruction of commercial crops that may take several years to re-establish. Because agriculture usually employs a significant proportion of rural workers, such crop losses lead to indirect loss of livelihood opportunities on a wider scale. Although people generally do not tolerate such crop losses to wildlife, a few communities in north-western India do show cultural acceptance of crop damage caused by wild antelopes. Even among these communities, however, the traditional levels of toleration appear to be slowly disappearing with recent cultural and economic changes.

Loss of Livestock and Domesticated Animals

Animal husbandry is a major economic and livelihood activity around many parks. Killing of domesticated stock by carnivores is often a serious problem. Such instances of conflict include killing of domesticated bovids, equids, sheep and goats by tigers, lions, leopards, snow leopards, wolves, dholes, striped hyenas, brown bears and black bears (Chellam and Johnsingh, 1993; Chundawat *et al.*, 1999; Mishra, 1997; Oli *et al.*, 1994; Saberwal *et al.*, 1994; Schaller *et al.*, 1992). Retaliatory killing of “problem predators” by humans is a major consequence of this conflict. The local people’s perceptions of the losses incurred, however, often appear to exceed the actual value of the livestock lost to predators. The variety of other domestic animals that were lost to predators in South Asia includes

ducks, geese and chickens killed by smaller felids, viverrids, canids, mustelids and raptorial birds. Otters and crocodiles are considered serious threats to inland fisheries in many areas. The change in predatory behaviour of sloth bear appears to be due to the increasingly degraded and fragmented nature of the habitat and a shortage of natural food for bears in the Nilgiri Range (Mardaraj *et al.*, 2012). Yellow throated martens destroy valuable apiaries in the Western Ghats of Karnataka, India. Transmission of lethal diseases to livestock from wild ungulates, which is a major problem in parts of Africa, is not reported as a widespread problem in South Asia.

Killing of Humans by Wild Animals

Human-wildlife conflict attains its most serious form when people are injured or killed by wild animals. Although big cats, bears and wolves in southern Asia are readily recognized and targeted for such manslaughter, wild elephants probably kill more people than large carnivores in this region.

Persistent predation on humans is the most severe category of conflict. Man-eating tigers, leopards and (rarely) child-lifting wolves (Jhala and Sharma, 1997) cause panic over entire regions, inducing massive retaliatory killings and antagonism against wildlife. In some regions such as the Sundarbans of India and Bangladesh, the endemicity and persistence of man-eating tigers suggest that this acquired behaviour may be being transmitted culturally across generations of animals.

Some Major Conflict Issues

In India, traditions and cultural/religious attitudes towards wild animals make local people more tolerant towards wildlife, despite the damage to crops and livestock it causes. Orthodox Hindus, for instance, consider monkeys to be sacred animals, to be revered and protected. This religious belief and traditional attachment to monkeys greatly influences people's perception of the conflict, resulting in its partial acceptance (Imam and Malik, 2002). The general reverence towards plants and animals in some Indian regions has often been reported to be the main reason for people not persecuting large carnivores and a positive attitude towards wildlife and nature reserves (Madhusudan, 2003; Sekhar, 1998; Mishra *et al.*, 2003; Vijayan and Pati, 2002). Many species of wild herbivores are blamed for crop raiding in the region: Nilgai (*Boselaphus tragocamelus*) and wild boar (*Sus scrofa*) are reported to be responsible for at least 50% of the damage, while other species as sambar (*Cervus unicolor*), chital (*Axis axis*), common langur (*Presbitys entellus*), rhesus monkey (*Macaca mulatta*) and parakeets (*Psittacula krameri*) accounted for the rest. Nilgai usually raids crops in the evening and tends to favour the degraded edges of forest villages. Wild boar instead, acts at night, while other ungulates such as sambar and chital are usually confined to forest cores. Some study data on crop damage relevant data revealed that the annual crop losses varied according to the type of crop grown. In general, the depredation increased with closer proximity to the reserve.

Among wild carnivores, the main livestock predators were reported to be tigers and leopards, with the former preying on large domestic animals such as cattle and buffaloes and the latter on smaller animals like goats, sheep and calves. Tigers were reported to be a major threat in villages located inside and close to the reserve; leopards instead, avoided competition with tigers and frequented areas further outside the villages. The calculation of the economic impact was based on domestic animal prices provided by those agro-pastoralists interviewed during the survey, which revealed that this is much less than crop losses and is certainly enhanced by the villagers taking their domestic animals into the reserve for grazing throughout the year (Sekhar, 1998).

Snow Leopard and Tibetan Wolf

In the Indian state of Himachal Pradesh, around Kibber Wildlife Sanctuary, despite the fact that conflict among agro-pastoralists and wildlife is increasing in relation to the growing livestock population, villagers have not resorted to killing the main source of the problem: the snow leopard. In 1995, wild carnivores killed 18% of the total livestock holding; this amounted to an annual loss of 12% for families with the livestock holdings. Almost all the deaths were caused by the snow leopard, which is not persecuted. However, retaliatory action is performed against the Tibetan wolf, whose pups were reported to have been captured and killed almost every year in the 1980s (Mishra, 1997). Never the less, such a response has been reported elsewhere.

Lion and Leopard Conflict

In India, in the state of Gujarat, in the proximity of Gir National Park and Sanctuary, the Asian lion (*Panthera leo persica*) and leopard (*Panthera pardus*) use the extensive plantations of sugarcane and mango to find shelter and water and to hunt prey such as buffaloes, cows, pigs and dogs. Several lions are reported to have strayed outside the park boundary and into plantations for more than a week, while leopards have chosen it as permanent habitat and even breed in cultivated fields bordering the edge of the park (Vijayan and Pati, 2002). Once again, the overlapping of wild animals' home ranges with human settlements has resulted in cattle depredation and attacks on farmers and labourers. The problem in this area is of similar nature to the others described above: the safety of rural people is threatened, livestock depredation is common and the overall ability to address the conflict is weak.

Tiger Conflict

In the Sunderbans, the tiger had always been at the centre of people's economic, social, cultural and religious life. This was the case in the past and still is today. The conflict between humans and tigers in the Sunderbans is rooted in the socio-economic condition of the local people and the tigers' man-eating habits. The overall annual loss due to large feline (tigers and leopards) depredation is reported to be approximately 12% of the total family livestock. An interesting detail is that although large carnivores had a considerable negative impact on the cattle population, the villages overcompensated the loss with purchases.

Elephant Conflict

The ensuing conflict is often characterized by destruction of crop, house or property by elephants, human injury and mortality and retaliatory killing of elephants by people. On an average, in India, nearly 400 humans are killed annually by elephants while about 100 elephants are killed in retaliation. The Elephant Task Force (ETF), of the Ministry of Environment and Forests, in its report *Gajah*, calls the resultant stress, suffering and loss "all too real". Incidents of crop damage have been occurring ever since man took to agriculture within elephant habitats. One of the earliest references to 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. Cut to the present day and farmers continue to lose millions of dollars each year in crop-raids, apart from the real risk of losing their lives. Moreover, cultivated crops are a concentrated source of forage for the elephants and crops like the succulent finger millet or the sweet sugarcane, are not only highly palatable but they also contain much more protein and other nutrients such as minerals as compared to the coarse, wild grasses. On an average, according to *Gajah*, elephants annually affect crops over an area of 0.8 to 1 million hectares in India, and affect the livelihoods of at least 500,000 cultivators by way of these persistent attacks.



Bear Conflict

In India, all the four species of bears are in direct conflict with human beings in the form of human casualties and economic loss by crop and livestock depredations. Bears are now threatened due to poaching for bear parts and retaliatory killings to reduce crop/livestock depredation.



The black and sun bear is also hunted for consumption in some parts of north-east India. Habitat loss, degradation and fragmentation are largely due to development projects, encroachment and human dependence on forests for fuel wood, fodder and other forest products. In the north-east Indian states,

jhum (shifting cultivation) and conversion to commercial plantations has led to serious impacts on black and sun bear habitats. Villagers living at the fringe of forest were vulnerable to bear conflict. This kind of observation may be because of the continuous degradation and fragmentation of the habitat, available habitat is not suitable and food is also scarce for sloth bears (Mardaraj and Chauhan, 2011). Most of the bear habitats also suffer anthropogenic pressures and many bear habitats that occur outside the PA network but form corridors or links to protected bear populations remain unprotected.

Ungulate Conflict

According to a 1997 study, 73% of Indian parks and about 39% of protected areas have livestock grazing within them. Intense livestock grazing could have two effects on wild ungulates. Alien competition for food within the park could drive wild ungulates to look for more nutritious diet in the fields surrounding the parks. This is not always the case and sometimes the livestock actually act as lawnmowers, improving the quality of the forage in the parks and allows the ungulates to stay within and forage. However, when open grasslands at the edges of the forests and protected areas are converted into crop fields, each ungulate species has its own favorite crop, as evidenced by the study in Tadoba. Wild boar, partial to sugarcane, would raid throughout the season whereas nilgai, favouring soybean, would raid only after fruiting. Moreover, blackbuck likes cereal. In lean times, the nutritive value of staple (cereal) crops serves as a huge draw for foraging wild ungulates. Moreover, in summers, crop fields around the parks are better sources of water and food, attracting ungulates to raid the fields.

Primate Conflicts

Most primate species are constrained by their lifestyles to remain within the small forest fragments that we have earmarked for them; a handful is less decorous in their behaviour, and willfully enters our fields and homes to ravage and pillage them. Many of the Asian macaques fall squarely into the latter category – hardy and highly adaptable; they have lived in close contact with human beings for centuries. India boasts a high number of macaque species that are found in most parts of the country; the bonnet macaque and the lion-tailed macaque are found in southern India, the rhesus macaque in central, northern and north-eastern India, the Assamese macaque, pig-tailed macaque, stump-tailed macaque and Arunachal macaque in north-eastern India and the crab-eating macaque in the Andaman and Nicobar islands. All macaque species in India are threatened by anthropogenic pressures such as hunting, trapping and habitat loss, to greater or lesser degree. In turn, humans also face various disturbances due to macaques, such as crop- and kitchen-raiding, damage to household articles when they enter houses as well as occasional bites and injuries.

Crocodile Conflict

Since the mid-1970s, communities, conservationists and the government have worked hard to protect the area's declining crocodile population. However, villages have been growing simultaneously and getting closer to the animals' habitat around the crocodile inhabiting areas, most villages along the river and its branches depend almost exclusively on these waters for bathing and washing clothes as well as for drinking water. Minimal safety measures are in place and there have been deaths reported along with several near-misses.



World Scenario on Growth in Human-Wildlife Conflict

Driving Forces

A set of global trends has contributed to the escalation of HWC worldwide. These can be grouped into human population growth, land use transformation, species habitat loss, degradation and fragmentation, growing interest in eco-tourism and increasing access to nature reserves, increasing livestock populations and competitive exclusion of wild herbivores, abundance and distribution of wild prey, increasing wildlife population as a result of conservation programmes, climatic factors and stochastic events.

Human Population Growth

Demographic and social changes place more people in direct contact with wildlife: as human populations grow, settlements expand into and around protected areas (IUCN, World Park Congress, 2003) as well as in urban and sub-urban areas. In India, human population growth has led to encroachment into wildlife habitats, constriction of species into marginal habitat patches and direct competition with local communities. In the state of British Columbia, Canada, conflicts are not restricted to nature reserves or rural areas but often occur in urban conglomerates as well. In the last few years, human population growth is correlated proportionally with the number of encounters and serious incidents with cougar (*Puma concolor*), black bears (*Ursus maritimus*) and grizzly bears (*Ursus arctos*) (Ministry of Water, Land and Air Protection, British Columbia, (2003).

Land Use Transformation

This driving force is very much associated with the previous one, as the transformation of forests, savannah and other ecosystems into agrarian areas or urban agglomerates is a consequence of the increasing demand for land, food production, energy and raw materials. In Kenya, in many areas with abundant wildlife, such as Samburu, Trans-Mara, Taita and Kwale, conflict is intensified by land use fragmentation and the development of small-scale farming. In fact, state and trust ranches have been

subdivided and sold as smallholdings and cultivated with commercial horticultural crops (Kenya Wildlife Service, 1996). In the Indian state of Gujarat, on the periphery of Gir National Park and Sanctuary, intense and escalating conflicts with Asian lions (*Panthera leo persica*) and leopards (*Panthera pardus*) are due to the rapid and extensive change in land use associated with the conversion of groundnut (*Arachis hypogea*) and great millet (*Pennisetum typhoides*) fields into sugarcane (*Saccharum officinarum*) and mango (*Mangifera indica*) cultivation. These crops create favourable habitats for predators and play a major role in influencing the natural distribution and abundance of wildlife communities (Vijayan and Pati, 2002).



Species Habitat Loss, Degradation and Fragmentation

Species habitat loss, degradation and fragmentation are also interconnected with population growth and land use change. Again in Sumatra, the alteration of forest areas into agriculture and grazing land has restricted the Sumatran tiger's (*Panthera tigris sumatrae*) home range to a few patches of forest. Currently, only about 500 individuals remain on the entire island (Nyphus and Tilson, 2004b).

Growing Interest in Eco-tourism and Increasing Access to Nature Reserves

Recreational activities and growing public interest in charismatic species such as large carnivores and endangered species have increased the human presence in protected areas and raised concern about capacities to manage and regulate public access and large-scale use of protected areas. Associated with the four global trends is a fifth cluster connected to alteration of natural food and water availability.

Increasing Livestock Populations and Competitive Exclusion of Wild Herbivores

Growing densities in livestock populations can create an overlap of diets and forage competition with wild herbivores, resulting in overgrazing and decline or local extinction in wild herbivore populations (Mishra *et al.*, 2003). In India, domestic animals often outnumber wild ungulates within protected areas, reaching densities of up to 1,500/km² and it has been ascertained that livestock graze in 73% of wildlife sanctuaries and 39% of protected area (Mishra, 1997). Under these circumstances, livestock becomes an important source of prey for predators.

Abundance and Distribution of Wild Prey

Many authors recognize that when native prey is abundant, wild predators consume it in preference to livestock and that impoverishment of prey populations is one of the major causes of carnivores shifting their diets to livestock. Clearly, this is due to the ease of capture and limited escape abilities of livestock (Mishra, 1997; Mishra *et al.*, 2003; Butler, 2000). In Venezuela, in Hato Pinero commercial cattle ranch, the correlation between alteration of prey availability and local livestock depredation is evident by the fact that the highest depredation rates have been recorded in areas where prey abundance and diversity are relatively low (Polisar *et al.*, 2003).

Increasing Wildlife Population as a Result of Conservation Programmes

Beyond the ongoing problems of HWC, new questions have emerged. In recent years, the successful recovery of the declining or near extinct species population (Fall and Jackson, 2002) through wildlife management and protection from overexploitation (Messmer, 2000) has also led to new conflicts. Effective protection and habitat management within the Gir National Park and Sanctuary in the Indian state of Gujarat doubled the Asian lion (*Panthera leo persica*) population between 1970 and 1993. The social organization, habitat and prey requirements of the species were difficult to accommodate within the human-defined home range, and resulted in many lions straying out of the reserve into local villages (Vijayan and Pati, 2002). In the ranches of North America, European settlement almost exterminated wolves. Recent recovery programmes, however, have contributed to the recolonization by wolves of their original home range, including rural areas; and in the process have increased the potential for conflict, especially where domestic livestock is a major economic activity (Musiani *et al.*, 2003)

Climatic Factors

Although not often mentioned, perhaps because they cannot be controlled, climatic trends are an important cause of HWC. Seasonal changes in rainfall are directly correlated with predation intensity in Kenya. In Tsavo National Parks, Patterson *et al.* (2004) quantified a positive association between monthly rainfall and attacks, demonstrating that in this region lions are more likely to attack livestock during seasonal rains. During drought periods, ungulates spend most of their time near a limited number of water sources and thus they are easily found and killed; when rain fills seasonal pools, lions disperse into their habitat, change their diets, and prey on easier targets (Patterson *et al.*, 2004). In Zimbabwe, in proximity to the Sengwa Wildlife Research Area, the correlation between seasonal changes and intensity of livestock depredation is also found to be strong. However, contrary to the Kenya Tsavo case, wild predators are more likely to attract attention and attack domestic animals in the dry season months, when the vegetative cover does not facilitate the hunting strategies of lions and leopard that are based on surprise (Butler, 2000).



Stochastic Events (e.g., Fire)

These sporadic events are difficult to forecast and prevent, yet also have an impact on human wildlife conflicts. During 1997-1998, an El Nino Southern Oscillation caused drought and fires, a combination of factors, which resulted in the destruction of large areas of Sumatran forests. During that period, tigers fleeing burning areas near Berbak National Park were reported to have killed a person (Nyhus and Tilson, 2004a).

Management of Conflict Situations and Some Mitigative Approaches

Considering the actual population growth rate of humans, increasing demand for natural resources and the growing pressure for access to land, it is clear that the human-wildlife conflict will not be eradicated in the near future, however it needs to be managed urgently. A wide range of different management tools has been developed worldwide to address HWC, but most of these are strongly site and species/genera specific and are not widely or easily accessible (IUCN, World Park Congress 2003).

Artificial and Natural Barriers (Physical and Biological)

Barriers have the function of preventing spatial overlapping among wild animals and local communities; they are usually man-made, but natural barriers such as rivers, coasts or mountain ranges may occur along a nature reserve boundary. Spatial separation has been proved to be successful when physical barriers enclose a large reserve Nyphus and Tilson (2004b). However, spatial separation is not always a satisfactory solution; in India, for instance, in the state of Gujarat, chain link fencing of the eastern boundary of Gir National Park was expected to stop lions and leopards from straying out of the park and to prevent illegal grazing at the same time. Instead, it was proved not to be economically viable and was only partially successful. In the same area, other types of barriers are under

experimentation, such as rubble walls and barbed wire fencing, which have been constructed along some sections of the reserve's boundary (Vijayan and Pati, 2002).

In conclusion, all the barriers have some limitations as they cannot deter every single species of animal and they can be breached by particularly strong or agile target species. However, they are an optional technique for mitigating the conflict and must be used in conjunction with other approaches preventing transgression (Treves and Karanth, 2003b).

Guarding

Guarding is also a popular preventative strategy in some parts of India as a study in the Sariska Tiger Reserve, Rajasthan, demonstrates. In this region, the majority of the farmers ranked guarding as the most efficient and common measure to protect their crops, despite requiring additional labour at night (Sekhar, 1998). According to Treves and Karanth (2003b), the utilization of domestic guard dogs appears to be a successful strategy for managing predation risk

Relocation: Voluntary Human Population Settlement

Where alternative land and incentives are available, relocation of local communities to areas offering better access to natural resources and socio-economic opportunities can be an adequate solution to HWC (Madhusudan, 2003). In fact, resettlement schemes aiming to prevent the overlap between wildlife and people can be successful in the long run if some essential assumptions are met: firstly, the villagers should gain substantial benefits such as better access to resources; secondly, they should be relocated to an area where the risk of losing property is lower and thirdly, they should not face any political, social or cultural opposition (Treves and Karanth, 2003b).

Waste Management Systems that Restrict Wildlife Access to Refuse

Good standards of waste management are important to avoid attracting wild animals to human settlements and to prevent wild populations being augmented and artificially sustained by human-induced food availability. Each stage of waste handling should be addressed from collection to transportation to disposal.

Compensation Systems

HWC carries significant economic costs to humans and compensation is a measure which aims to alleviate conflict by reimbursing people for their losses. Compensation systems rely on giving out monetary payments.

Insurance Programmes

Livestock and crop insurance is often proposed as an innovative solution to mitigating the impact of HWC, but it is yet to be experimented broadly. It covers crops and livestock from the risk of wildlife attacks and involves the villagers and local governing bodies paying a premium share of the insurance and allows rural inhabitants to make a minimum annual cost and to be refunded in the event of crop or livestock losses. In addition, the local governing bodies or the forest department are relieved of significant financial expenses, from not having to administer compensation schemes (Madhusudan, 2003).

Conservation Education for Local Populations

Education and training activities at different levels, for instance in schools or in adult education arenas such as farmer field schools, would have the objective of disseminating innovative techniques, building local capacity in conflict resolution and increasing public understanding of HWC. Educating rural villagers in practical skills would help them to deal with dangerous wild animal species and to acquire and develop new tools for defending their crops and livestock.

Wildlife Translocation

Translocation consists of moving a certain number of animals from a problematic zone to a new site. In spite of seeming to be the least sensible of the solutions listed above and the risk of exporting the problem to another site, it may be a practical and acceptable approach in some cases and where there is the availability of a suitable habitat with territorial vacancies.

Habitat Restoration

Forest areas along the fringes of protected reserve and isolated habitats need to be managed specifically for species specific plantation. Regeneration of forests outside reserves and restoration of degraded habitats by afforestation schemes would significantly expand the habitat for the wildlife in its ecosystem.

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