SOCIO ECONOMIC EVALUATION OF HUMAN WILDLIFE CONFLICT MANAGEMENT - A CASE STUDY FROM UTTARAKHAND, INDIA

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Introduction

Human-wildlife conflict around most of our protected areas (PAs) is emerging as one of the biggest management problem to be tackled. One of the main reasons of such conflict is frequent problem of crop and livestock depredation by wild animals (Bauer, 2003; Madhusudan, 2003; Sekhar, 1998). Such losses directly affect food security of local community through a reduction in staple food grains (Banskota and Sharma, 1995), and indirectly through reduced household incomes (Weladji and Tchamba, 2003). Crop-raiding and loss of livestock can therefore reduce tolerance of local people towards wildlife (Hill, 1997; Siex and Struhsaker, 1999) that are already threatened and may also negatively influence local attitudes towards conservation (Chalise and Johnson, 2001; Hill, 1998; West *et al.*, 2006). Therefore, as a retaliatory response, affected communities often indulge in poisoning and electrocuting of animals, intentional burning of forests, and damaging wildlife habitats around their settlements leading to development of a negative attitude of PA authorities towards the local people. Thus, human-wildlife conflict can damage the relationship between local communities and PA administration (Kideghsho *et al.,* 2007; Songorwa, 1999; Weladji and Tchamba, 2003) severely undermining biodiversity conservation objectives with long term support of local communities (Terborgh *et al*., 2002; West *et al.*, 2006).

There is no single management solution that can successfully deal with the problem of human-wildlife conflict. One way of reconciling this conflict has been directly compensating the local communities affected by crop and livestock depredation (Nyhus *et al.*, 2003; Ogra and Badola, 2008). But such schemes have not always been successful because of inadequate compensation and problems related to the evaluation of claims of damage, determination of fair values for losses, timely delivery of payment (Nyhus *et al.*, 2005). Methods such as use of power fence to prevent crop and livestock depredation have been implemented in many PAs, but are not always effective (Thouless and Sakwa, 1995). Their effectiveness depends on the design, construction and proper maintenance besides active support of the PA neighboring community. If the local communities do not perceive a positive experience of the adjacent conservation effort, they will not be willing to collaborate (Nyhus *et al*., 2000). For example, without their awareness of benefits of the power fence in preventing crop and livestock depredation rather than perceiving it as a barrier prohibiting their access to the forests, and willingness to maintain the fence, installation of a conflict mitigation barrier cannot be successful in dealing with the problem. It is therefore important to keep the community well informed about the benefits and let them be a part of such a project.

Despite major studies in filling gaps in knowledge of the extent of the crop and livestock depredation problem around PAs (Fungo, 2011; Hill, 1999; Kagoro-Rugunda, 2004; Madhusudan, 2003; Sitati *et al*., 2003), mitigation strategies used for managing conflict (Nelson *et al.*, 2003; Osborn and Parker, 2002; 2003), community perception and attitude towards the problem (Chalise and Johnson, 2001; Hill, 1999), and policy options for intervention (Dublin and Hoare, 2004; Kangwana, 1995), there has been very little or no attempt to study as to how to involve local communities in human–wildlife conflict management. The current study therefore aims at:

a) Economic evaluation of the crop loss due to crop raiding animals and the cost of crop protection borne by the community,

b) Assessing community's willingness to pay the initial cost of power fence and subsequent maintenance cost,

c) Evaluating the community's attitude towards reconciling human-wildlife conflict.

Through this study, we expect to gain a deeper understanding of both the existing limitations of effective deterrent methods such as power fence used for mitigating human-wildlife conflict, and the potential ways in which community can contribute to positively shape people's abilities to cope with human-wildlife conflict. Ultimately, this study aims to help the PA management in empowering the local people to better coexist with nearby PAs and support conservation efforts.

Material and Methods

Study area

The study was conducted in Bullawala, an

agricultural village located at the northern boundary of Rajaji National Park (29^{0}52' 41'' to 30^{0}15'56'' North latitude and 77^0 57' 7'' to 78^0 23'3'' East longitudes) in the western range of north Indian state of Uttarakhand. The park, along with its adjoining areas, currently protects elephant (*Elephas maximas*) population of approximately 1,000. Other globally endangered resident species of this park include the tiger (*Panthera tigris*) and leopard (*Panthera pardus*). Bullawala is a typical small fringe village situated over approximately 67 ha, and consists mainly of agricultural fields that border the park on two sides. We collected basic demographic data for the village which indicated a resident population of approximately 717 people comprising 110 households. Mean family size was 8 consisting of 4-5 adults and 3-4 children. Most residents belonged to Garhwali community (44%) followed by Sikhs (20%) and Muslims (13%). In terms of wealth, we found that 93% of households owned at least one cattle. Typical landholdings were small, however—83% possessed less than 1 ha of land. Crops were grown at the subsistence level for all except a few households and major crops included wheat, paddy and sugarcane. In addition, a few farmers grew maize but in small quantity. There are two major cropping seasons; *kharif* (June - September) and *rabi* (October - March). Paddy is the main *kharif* crop and wheat is the main *rabi* crop. Sugarcane is the main cash crop grown here. Farming was the primary occupation for the head of family in 73% of households, but additional economic contributions helped to support the family in almost all (94%) households. Such income was contributed exclusively by male members; sources include daily wages for manual labor, employment in Government and private jobs, and petty business.

Residents of Bullawala village were vulnerable to human-wildlife conflict owing to its location at the border of the park. Elephant (*Elephas maximas*), Rhesus monkey (*Macaca mulatta*) and wild boar (*Sus scrofa*) damaged the crops most. Elephants preferred sugarcane, but damaged paddy and wheat crops by trampling rather than consuming. Monkeys fed on wheat and paddy crops at all stages of plant growth. While wild boar in small groups of 4-5 destroyed wheat and paddy crops at night, spotted deer (*Axis axis*) occasionally raided these crops at day time. The mean herd size of crop raiding elephant in the study area was six. Villagers relied on guarding fields, making loud noise by shouting, beating empty drums, using noisy fire-crackers, making fires by fire torches, and using stone-slings to drive animals away from their crop fields. Villagers also construct thorny fences to prevent wild animals from entering their fields, as well as using scarecrows as a visual deterrent. We observed that all of these techniques were less effective.

As a part of eco development scheme (Mishra *et al*., 2009; Panwar, 1992), a 4.0 km long power fence was constructed in Bullawala by Ms. Equinox Security (Wildlife Management Systems), a Bangalore based company on behalf of the park management to prevent wild animals from entering the village. The fence consists of five strands of galvanized wires, set on metallic poles spaced six meters apart. The height of the poles was 2.4 meters and a total number of 670 poles were used. Big size poles for extra support were placed at a spacing of 200 meters and a total of 20 such poles were posted. When such fences are properly looked after and the voltage along the fence is maintained, cent per cent success can be expected. But, digging trenches below the fence wire which we noticed in this village for easy access to the park provided passage to wild boar, deer and monkeys, and rendered the fence ineffective. To be effective, the area under the power fence must be kept free of grass and weeds. Branches and other vegetation which are near the fence or touching the fence must be removed. If the fence is not kept free of vegetation, electricity is lost into the ground and the fence becomes ineffective. We noticed that the Ecodevelopment Committee formed in this Bullawala for implementation of ecodevelopment work was no longer functional. There was not much initiatives either from the PA management side to involve local people in fence maintenance!

Data collection and analysis

Interviews were conducted using a set of semi structured open ended questions in all the 110 households to gather information on demography and general socio-economic data, cropping pattern, area cultivated under each crop type and average crop yield, type of crop damage each animal species causes including time of the year and pattern of crop raiding, crop protection measures adopted, and farmer's general perception about human-wildlife conflict. Farmers were also asked if they had experienced injuries and deaths to livestock, or other property damage by wild animals and if they stayed out at night to guard their crops from elephants. Matrix ranking of problem animal was done using participatory evaluation methods (Mukherjee, 1995). Farmers were asked to rank problem animals according to a set of criteria such as amount of crop damage each species causes in a year, average group size, threat to human life and property and time span of problem in a cropping year. Likewise, ranking was done for the most affected crop.

Table 1
Matrix ranking of problem animals

Problem animal	Crop damage per year	Group size	Threat to human life	Time span of problem	Total score	Problem rank
Elephant	1	2	1	3	7	1
Wild pig	2	3	5	2	12	2
Rhesus	3	3	4	2	12	2
Spotted deer	4	5	5	5	19	3

Rank 1 being the greatest problem and 5 the least

Whenever there was an incidence of crop raiding in the village, the affected farmers were asked to rank the extent of crop damage on a 0-5 scale and the expected yield of that crop in the absence of crop depredation event keeping in mind the quality of crop (poor, medium and good). Following this, actual estimation of the extent of crop damage was done in the affected crop field following standard methods (Hill, 1997; Hoare, 2001; Naughton-Treves, 1998). By comparing the mean perceived crop losses with that obtained from the field based on actual estimation using a Mann-Whitney test (n=31), there was no significant difference ascertaining reliability on farmer's information. Structured close ended questionnaire were therefore administered to 96 households with agriculture fields within 500 m. from the park boundary (Zone-I is within 250 m. and Zone-II is between 250 to 500 m.) for crop loss estimation in the previous farming year. We asked the target farmers their perceived yield per unit area of farm land (*bigha*) and the quantity of yield per *bigha* lost to crop raiding wild animals in the previous crop season. Based on those figures, we estimated the perceived monetary value of crop production and perceived losses per farmer to crop depredation using local market prices of each crop. However, crop loss due to insects, birds, rodents and Rhesus monkey was not taken in to account in this study owing to want of suitable methods of damage estimation. To estimate the cost of crop protection, human labour involved in guarding the crop field (age, sex and time spent in field every day during a cropping season) and the prevailing wage rate of male, female and children labour was recorded. Those who spent money on fire crackers, kerosene oil to lit fire and fencing crop fields, were also meticulously recorded. Likewise, annual maintenance cost of power fence was calculated based on information generated through discussions with a group of villagers and arriving at consensus pertaining to cost of human labour (man days per year x wage) required for regular monitoring of the power fence and cleaning grass and weeds below the fence. We used an ANOVA to evaluate whether the differences of crop damage between zones and crop types were statistically significant.

Farmers representing each of three income class (annual income up to ` 50000, ` 50000 to 80000, and more than ` 80000) were randomly picked up (n=30) and asked how much money they would be willing to pay for the benefits (crop damage reduced by 80%) they would likely to derive from effective functioning of the power fence. This information then extrapolated to the relevant population in order to calculate the total willingness to pay by the community for maintenance of the power fence. The tolerance of farmers toward crop raiding animals was investigated by asking what their likely action would be under one of four scenarios, if problem animals were seen on their agriculture field, on a neighbor's field, near their village, and if they and/ or family members felt threatened by the presence of crop raiding animals. Depending on whether or not their likely action involved driving away, translocation or killing of the problem animals, these responses were categorized as high, medium and low tolerance, respectively.

Result and Discussions

Crop-raiding by wildlife was reported by 97.3% of the interviewees as the single most important determinant of crop yields. Eleven vertebrates were reported by farmers causing damage to crop; most important were elephant, wild pig, Rhesus monkey and spotted deer. However, elephants were considered to be the most destructive crop-raiders in all locations (Table 1). Only a small proportion (13%) of farmers complained about the parakeets. Sugarcane was considered the most affected crop. The interviewees reported twelve different crop protection techniques. Shouting was the most common.

Table 2 depicts the annual crop loss due to depredation by wildlife. We found that farmers having crop fields nearer to the forest boundary incurred heavy loss and the percentage loss was to the tune of 18.37 %, 21.22% and 28.36 % respectively for wheat, paddy and sugarcane. The two way ANOVA showed that variation in terms of crop damage between Zone-I and Zone-II was significantly different (fcal = 4.535746, Df = 1, 0.05 > p >

Table 2
Annual loss due to crop depredation by wild animals.

Crop type	Area cultivated (ha)		Crop loss in farm lands within 250 meters from park boundary		
	within 250 m.	250 to 500 m.	% loss	Quantity (kg)	Monetary value (Rs)
Wheat	21.17	10.97	18.37 (10.19)	8693 (2498)	52158 (14988)
Paddy	20.53	10.97	21.22 (15.13)	8931 (3403)	69662 (26543)
Sugarcane	8.14	19.68	28.36 (25.70)	101574 (222572)	98527 (215895)
				Total	477773

Values in the parentheses refer to crop loss in farm lands within 250-500 meters from park boundary

0.01), whereas that between crop types was not significant (fcal = 0.514792, Df = 2, p > 0.05). This result indicates that crop depredation was higher near to the park boundary supporting the findings of others (Nyhus *et al.*, 2000). The net economic loss due to crop depredation was estimated ` 4 77 773 which is 22.51 % of the monetary value of total crop production in the absence of crop depredation (Table 2). Thus, loss incurred per family works out to be ` 4976 per annum and the majority of households being marginal farmers get severely affected due to crop depredation by wildlife.

The total cost of crop protection estimated to be ` 4984140 of which labour cost alone for guarding crop fields was ` 4932000. This study thus reveals that net economic value of crop the farmers could save from wildlife is ` 1644623, which is one-third of the cost they bear guarding their crop fields. This show what a heavy cost the community bears on account of crop protection justifying adopting an effective protection strategy so that farmers can utilize this money and labour in more productive work adding to their income and welfare.

The cost of power fence installed in the village was ` 603200. Net amount society is willing to pay for maintenance of power fence was estimated ` 19200 per year, whereas actual amount required was ` 11500. Thus, the cost of an effective power fence and annual maintenance cost works out to be ` 614700. Considering cost of power fence including annual maintenance charges (` 614700) against the monetary value of crop loss (` 477773), we estimated that the capital cost of fence can be recovered in just 1.26 years. Our analysis reveals that since the perceived benefits from power fence outweigh the cost borne by farmers owing to crop depredation, it forms the most powerful argument for the critical need to involve community not only taking responsibility of maintenance, but also bearing the initial cost of the fence. One of the key factors determining success of a fence is ownership. A fence that is installed and maintained by a government agency is usually viewed as a government fence. The maintenance is therefore left to the government and the community takes little or no responsibility. Rarely does a government agency have the adequate resources to maintain the fence year after year, and inevitably the fence deteriorates. However, if the community participates in bearing capital cost and involved in proper maintenance of the fence, then success may be more likely. We therefore recommend that before an electric fence is built in any village adjoining a PA, the community must be informed and agree on who will own the fence and who will be responsible for its maintenance. The roles and responsibilities of each partner must be clearly defined.

Majority farmers (58%) considered that shouting and driving away the problem animal as the most effective preventative measure towards reconciling human-wildlife conflict, only 17% perceived translocation as the most appropriate action. But, none reported killing because religion forbids such acts. This reveals a higher level of tolerance of local people towards crop raiding wildlife- a strong reason in favor of forging partnership with them in managing human-wildlife conflict. Since local people incur costs from crop damage and mitigation, they in turn should receive greater benefits from ecodevelopment work, which would increase community tolerance of problem animal such as elephants. Options for community beneficiation may range from 'outreach programmes' promoting improved agricultural and animal husbandry practice, supply of alternate fuel and energy saving devices, and providing alternate income generation packages for livelihood support. A positive spin-off from ecodevelopment may further increase community tolerance of wildlife and consternation efforts.

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SUMMARY

The role of community in the management of human-wildlife conflicts, although recognized, has neither been adequately evaluated nor clearly documented. Therefore net economic loss was evaluated due to crop depredation in a PA neighboring village of Uttarakhand, capital cost of a power fence to deter wildlife entering the crop fields and recurring cost of maintenance, and cost of crop protection. Net amount society is willing to pay for maintenance of power fence was estimated ` 19200 per year, whereas actual amount required was ` 11500. Authors compared the cost of power fence with monetary value of crop loss and estimated that the cost of fence can be recovered in just 1.26 years. The analysis revealed that the perceived benefits from power fence were much higher than the cost borne by farmers due to crop depredation suggesting the critical role of community not only taking responsibility of maintenance, but also bearing the initial cost of fence. This study also revealed a higher level of tolerance of local people towards crop raiding wildlife- a strong factor in favour of forging partnership with them in managing human-wildlife conflict.

Key words: Human wildlife conflict, Crop loss, Power fence.

मानव वन्यप्राणि टकराव प्रबन्धन का समाजार्थिक मूल्यांकन - उत्तराखण्ड, भारत में किया गया विशेष अध्ययन

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सारांश

मानव-वन्यप्राणी टकरावों के प्रबन्धन में समुदाय की भूमिका हालांकि स्वीकार तो की गई है। परन्तु अभी तक इसे न तो मूल्यांकित किया गया है न स्पष्टत: प्रलेखित ही। इसीलिए हमने उत्तराखण्ड में वन के पास लगते गांव के एक सुरक्षाप्राप्त क्षेत्र में, फसलों का विनाश किया जाने वाली शुद्ध आर्थिक हानि का मूल्यांकन किया, जिसमें वन्य प्राणियों को फसल लगे खेतों में घुसने से रोकने के लिए शक्ति-चालित बाड़ पर आई पूंजीगत लागत और उसके रखराखव में आने वाली आवर्ती लागत और फसल सुरक्षा पर आती लागत को सम्मिलित किया गया। शक्ति चालित बाड़ की देखरेख पर आता खर्च भरने को तैयार समुदाय की रजामंदी को शुद्धता से ` 19200 वार्षिक अनुमान किया गया जबकि वास्तव में केवल ` 11500 की ही जरूरत पड़ी। शक्तिचालित बाड़ को लगाने में आती धनराशि की तुलना हमने फसल हानि के धन मूल्य से की और आकलन किया कि बाड़ लगाने पर आती लागत केवल 1.26 वर्ष में वसूल हो जाती है। हमारे विश्लेषण से पता लगा कि संकलित शक्तिचालित बाड़ से होने वाले लाभ उसके हानि से कहीं बहुत अधिक हैं जो फसल नाश के कारण किसानों को उठानी पड़ती है जिससे समुदाय की शक्तिचालित बाड़ के रखरखाव की जिम्मेदारी उठाने की जरूरत ही नहीं बल्कि उस बाड़ की आरम्भ में लगाने का खर्च उठाने की युक्तिमत्ता भी समझ में आती है। इस अध्ययन से यह भी पता लगा कि फसलों को वन्य प्राणियों से बचाने के प्रबन्ध में भागीदारी करने के लिए स्थानीय लोगों की सहायता कितनी अधिक है। क्योंकि यह उनके पक्ष में ज्ञात महत्वपूर्ण कारक बन जाता है।

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