

Human resettlement and tiger conservation – Socio-economic assessment of pastoralists reveals a rare conservation opportunity in a human-dominated landscape



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ABSTRACT

Resettlement of people for conservation is a contentious issue, but remains an important policy for conserving species like tigers which require vast, inviolate habitats. Recommendations to resettle communities should ideally be supported with careful evaluation of the needs of wildlife, socio-economic characteristics of dependent communities and their attitudes, and we present one such case study. Using a semi-structured questionnaire survey of 158 households across a gradient of tiger occupancy, we found overwhelming preference for resettlement among pastoralist Gujjars and hence an unexpected conservation opportunity to expand inviolate areas for tigers in the western Terai Arc Landscape. The main 'push factors' identified were declining forest productivity adversely affecting incomes and lack of access to education and health facilities. Thus, our findings represent a rare instance where excessive extraction of natural resources, recognized to be detrimental for biodiversity, is also the primary driver for resettlement. The desire for resettlement was also re-enforced by losses of livestock to diseases (72.7%) and carnivores (25.1%), which was uncompensated in 89% of the cases, and positive experiences from previously resettled households. Demand for resettlement was uniformly strong regardless of local tiger occupancy, but we suggest that funding for resettlement be prioritized for households in high tiger occupancy areas, given higher livestock depredation and possibilities for conflict. Our findings, therefore, represent a novel landscape-level conservation strategy that takes account of socio-economic circumstances across a gradient of predator pressure, and could build a constituency for tiger conservation among local communities consistent with national and global objectives.

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1. Introduction

Conserving large carnivores has become a global priority, owing to the alarming decline in geographic ranges and population sizes. Despite their high existential value with international audiences (Macdonald, 2001), conserving them at the local scale is often fraught with challenges given the diverse costs associated with their presence (Macdonald et al., 2010). Tigers (*Panthera tigris*) typify the challenges associated with large carnivore conservation as they require vast home ranges to satisfy their requirements for food and undisturbed breeding refuges (Karanth, 2003). Therefore, securing and strengthening protected areas or breeding sources in exclusion of anthropogenic disturbances, while ensuring that the

larger landscape matrix is permeable to movement of tigers between the embedded source sites have become the cornerstones of tiger conservation (Walston et al., 2010; Wikramanayake et al., 2011).

Creating a "permeable landscape matrix" is hugely challenging in policy terms because tigers can inflict considerable economic and human losses on poverty-stricken communities such as traditional pastoralists (Little et al., 2008; McPeak and Barrett, 2001). Various options have been discussed including compensation payments for losses, 'coexistence payments' and perhaps most controversially, resettling communities outside tiger range (Dickman et al., 2011; Rastogi et al., 2012). However, prioritizing these conservation alternatives and successfully implementing them is contingent upon local acceptance of these actions (Cowling et al., 2004). Particularly for conserving tigers, which inhabit some of the poorest and most populous nations (Dinerstein et al., 2006), integrating social considerations for conservation planning assumes critical importance (Cowling and Wilhelm-Rechman, 2007; Knight et al., 2008).

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In India, which harbours the largest population of tigers worldwide, ‘inviolable’ protected areas maintained in exclusion of human-use is recognized as the central component of tiger conservation policy (Karanth, 2003; Rastogi et al., 2012). However, this approach has been highly contentious as it has necessitated the physical displacement of 100,000–600,000 people (Lasgorceix and Kothari, 2009), and often imposed diverse socio-economic costs on the displaced communities (Rangarajan and Shahabuddin, 2006; Agrawal and Redford, 2009). Owing to poor execution and little follow-up to the long-term rehabilitation process, severe impoverishment and destitution has been documented in some cases (Kabra, 2009). Furthermore, documented case studies remain rare with respect to benefits to the resettled communities (Karanth, 2007) and recovery of wildlife in the vacated habitats (Harihar et al., 2009). Consequently, practitioners are often hesitant to recommend this approach (Chatty and Colchester, 2003; Sanderson and Redford, 2003; Rangarajan and Shahabuddin, 2006).

Creation of state-controlled protected areas also excludes the participation of the local communities and often adversely impacts traditional livelihoods based on natural resources (Saberwal et al., 2001). This exclusionary model has led to complex historical, legal, management and livelihood issues for communities and has been manifested in widely reported antagonism, and is also seen as one of the reasons behind local extermination of tigers from Sariska Tiger Reserve in 2004 (reviewed in Rastogi et al., 2012). Following this local extinction event, the Prime Minister of India commissioned a task force with a mandate to review existing conservation practices and suggest a new model that shares the concerns of conservationists with the public at large. The task force proposed a dual strategy of managing tiger breeding areas as inviolable and other tiger-occupied areas with co-existence practices (Narain et al., 2005). This consequently led to the amendment of the Wild Life (Protection) Act (WPA) in 2006 which, incorporating issues highlighted in the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (FRA), reiterates the need for a combination of approaches that include the identification of “core or critical tiger habitats” which are to be kept ‘inviolable’, and also areas of ‘co-existence’ in the larger landscape. While “voluntary relocation” of human settlements is mandated from inviolable areas, it also specifies that rights of local people are to be respected in the entire process and there has been considerable debate on the means of implementing these measures in a manner that reconciles conservation and livelihood imperatives of locals within tiger landscapes (Sekhsaria, 2007).

In this paper, we present the case study of pastoralist Gujjars residing in the western Terai Arc Landscape (TAL) – a global priority tiger conservation landscape (Dinerstein et al., 2006), and evaluate the potential for co-existence and relocation as policy options. Specifically, we investigate how Gujjars residing in forests with limited access to basic amenities such as electricity, education and medical relief, fare across a gradient of potential predation risk to their livestock holdings (indexed by tiger occupancy) in terms of their livelihoods, livestock losses and preferences towards improving their well-being. Recent landscape-wide occupancy surveys have revealed that while anthropogenic disturbances have a negative influence on tiger occupancy, Gujjars reside in forests across the entire gradient of tiger occupancy (Harihar and Pandav, 2012). Existing information suggests that this co-occurrence is expected to adversely impact these pastoralists through heightened costs of depredation, although the impact on the sustainability of their lifestyle would depend on their livestock ownership (Lybbert et al., 2004), income levels (McPeak and Barrett, 2001), family size (which would determine per capita wealth distribution) and predation pressure (Suryawanshi et al., 2013). Such an assessment is critical to prioritizing areas where co-existence needs to be promoted (low tiger occupancy, benefits outweigh the costs to the

community), or voluntary resettlement is necessary (high tiger occupancy, costs exceed the benefits for the community).

Our key objectives were to (a) assess the livelihoods of the forest-dwelling pastoralist Gujjars, (b) document the number and nature of livestock losses and identify the correlates of livestock depredation, and finally (c) assess the preferences of Gujjars towards interventions required to improve their well-being. We used a systematic design to ensure adequate representation of households across the gradient of tiger occupancy and gathered data using semi-structured questionnaire interviews for assessing the socio-economic profiles of Gujjars across the ~7000 km² landscape.

2. Methods

2.1. Study area

Our study area within the western TAL was defined by 57 large geographic grid cells (each of 166.5 km²) initially demarcated by Harihar and Pandav (2012) to estimate the occupancy of tigers. The overall land use matrix consists of protected areas (Rajaji National Park (RNP) and Corbett Tiger Reserve (CTR)) and multiple-use forests, bordered by agriculture and horticulture along the northern and southern edges (Fig. 1). These foothill forests face tremendous pressures for natural resources from around 6.9 million people inhabiting this area.

Gujjars inhabit forests across the western TAL in a range of tiger occupancy and are issued permits to cut grass and lop branches off trees for leaves to provide fodder to their livestock holdings (primarily consisting of buffaloes). Historically Gujjars practiced transhumance with their livestock, between the foothills forests (the study area) during winter months and alpine meadows of the Himalayas in summer. However, in recent years, socio-political changes have led to a cessation of their altitudinal migration resulting in them residing year-round in these foothill forests (Gooch, 2009). This has led to deterioration in the state of these forests and negative impacts on the native wildlife (Edgaonkar, 1995; Johnsingh et al., 2004; Harihar and Pandav, 2012).

The first efforts to resettle the Gujjars outside the forests were initiated after the formation of RNP in 1984 under the provisions of WPA (1972) and, in total, 1125 Gujjar families have been resettled in two sites (Pathri and Gaidikhata) created by clearing exotic monoculture plantations at an average cost of USD 360 per household, which included the provision of agricultural land, built houses/land for building a house and cattle shed (Mishra et al., 2007). The resettled Gujjars have adopted an agro-pastoralist lifestyle and gained access to amenities such as education, medical services, veterinary care for their livestock and rural up-liftment schemes sponsored by the federal and state governments. The resettlement has also resulted in significant recovery of wildlife populations in the vacated habitats, as evidenced by a marked increase in the population performance (fawn: female ratio) of chital (*Axis axis*) and steady increase in the population of tigers (Harihar et al., 2009, 2011).

The recent assessment of this priority tiger conservation landscape (Harihar and Pandav, 2012) reveals that the study region consists of a gradient of tiger occupancy (ψ) which we reclassify to represent three Tiger Occupancy Categories (TOCs). The ‘high’ TOC (ψ ranging from 0.91 to 1.0) was further characterized by evidences of breeding and spanned parts of the two protected areas (CTR and eastern RNP) and adjacent multiple-use forests, making them ‘core or critical tiger habitats’ within which, under current government policy, resettlement of Gujjars may constitute the favoured policy. The medium (0.51–0.9) and low (0–0.5, corresponding to encounter of no more than one tiger sign per cell) TOCs

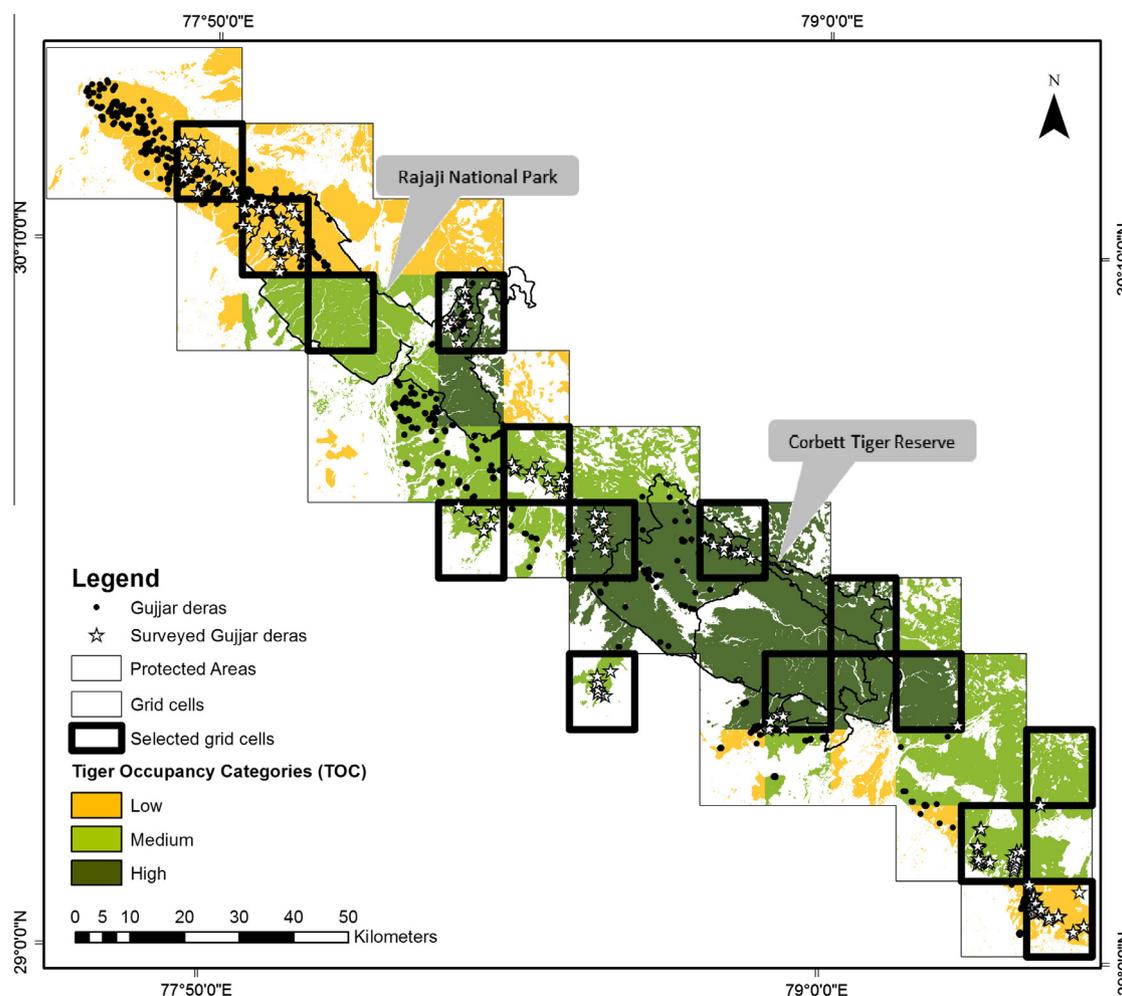


Fig. 1. A map of tiger occupancy across the western Terai Arc Landscape, with locations of the households interviewed during this study (November 2010–March 2011).

present areas where mechanisms of “co-existence” are required to be prioritized in the landscape (Fig. 1).

2.2. Socio-economic surveys

To conduct questionnaire surveys among Gujjars in the landscape, the 57 geographic grid cells (166.5 km² each) were used as the basis of sampling (Harihar and Pandav, 2012). Using a multi-criteria approach, a sub-sample of these grids (i.e. 15 cells) was selected (Fig. 1). The selection was made from 46 cells (with >25% forest cover) using a combination of Wild Prey and Disturbance indices, the primary descriptors of tiger occupancy, to represent the three TOCs (Harihar and Pandav, 2012). Prior to initiating the surveys, the number and location of all Gujjar *deras* (settlements) for each of the selected grid cells were obtained from the local forest departments and supplemented by previous field surveys carried out by Harihar and Pandav (2012). Thereafter, we randomly selected 25% of the *deras* from each of the TOCs and conducted surveys from November 2010 to March 2011. Each Gujjar *dera* typically comprises of 2–6 households belonging to a father and his married sons, usually headed by the father/eldest son. Hence, we interviewed only the household of the eldest member in each *dera*.

We spoke to the head of the household, during which other members also participated, and administered each interview either in *Gujjari* (by Imam Hussein, a Gujjar field assistant) and/or Hindi by AH, which typically lasted 30–45 min. Audio-recordings were made at the site and later translated by Imam to Hindi and

transcribed by AH into datasheets. We based the interviews on a semi-structured questionnaire (available from AH) that consisted of three main sections. The first section assessed the socio-economic profiles of the households surveyed. We initiated each interview by noting the age and sex of the respondent. In addition, we noted the family composition, educational qualification of household members, modes of income, livestock ownership, quantum of production of milk and other dairy products and revenues generated from pastoralism and other sources of income. In the second section, we focused on livestock losses incurred due to diseases/depredation and their correlates within the past calendar year. Here, we obtained detailed information on the type, cause and nature of loss. In the case of a predation event, we also asked which predator was potentially responsible and questioned the respondents on compensation amounts received.

The content and format of the interview were based on our informational needs influenced by documented prior experiences of resettling Gujjars from RNP (Mishra et al., 2007). To introduce a more inductive element to our research, gain a better understanding of the issues from the Gujjar perspective, provide an opportunity for new issues to emerge and re-enforce the unbiased nature of our research, we included a series of open-ended questions to close the interview (MacMillan and Han, 2011). The following questions were asked: (a) Are they satisfied with their current living conditions inside the forests? (b) What changes do they desire to improve their well-being, if any? and (c) What factors determined the choice of suggested changes?

As the interview team had been working on the field for 6 years prior to conducting these interviews, they already had considerable understanding and personal experience of the local social context and had built up a degree of trust with the Gujjars. Hence, it was anticipated that the semi-structured approach would work well (Bernard, 2006). In line with good practices, a pilot study confirmed there were no significant biases arising associated with language or other topics being discussed.

2.3. Analytical methods

The variables related to socio-economic profiles and livestock losses were summarized using standard descriptive statistics. To test for differences in household-level characteristics and depredation-related attributes among the three TOCs, contingency χ^2 tests were employed. We summarized the livestock losses incurred to diseases and large carnivores and calculated the associated financial losses. The financial loss for each livestock lost to either diseases or depredation was calculated based on the average annual sale price of the different livestock types based on their age, sex and reproductive status, which were estimated independently from market sources (Table S1). All financial attributes (income, loss) were quantified in Indian rupees, which were then converted to USD (@ 1 \$ = 53.99 INR) to enable comparison with existing literature.

To evaluate the influence of potential determinants on the number of livestock lost to depredation, we fitted generalized linear regression models using Poisson distribution. We tested the following predictions: number of livestock lost to depredation is expected to be (1) higher in areas with higher tiger occupancy (TOC-low, medium and high; Harihar and Pandav 2012), (2) correlated to the number of livestock owned by the respondent (livestock units), and (3) lower in areas with high wild prey density, since higher wild prey availability is expected to buffer livestock against depredation (Mizutani, 1999). We used three wild prey density categories (low, high and medium), which were classified using quartile distribution of mean wild prey density per 166.5 km² grid cell (A. Harihar, B. Pandav and D.C. MacMillan, unpublished data). For each response variable, the set of candidate models included all additive combinations of the response variables. Since the overdispersion parameter was estimated to be 1, we ranked the models using AIC and models within 2 Δ AIC units were considered to have sufficient relative support to be included in the final set of explanatory models (Burnham and Anderson, 2002). Furthermore, we calculated the cumulative Akaike weight for each variable by adding the model weights for all models containing that variable to evaluate the relative importance of covariates. All statistical analyses were performed using the software R (version 2.15: <http://www.r-project.org>).

3. Results

3.1. Livelihood of Gujjars inside the forests

The 158 Gujjar households interviewed comprised 2237 individuals with an overall literacy rate of 9.2%. Of these 96 heads of households were male and 62 were females (mostly spouse of the head) with an average age of 45 years (range 22–75 years). Production and selling of milk was the primary source of income (89% of total income). During our survey, we enumerated a total 7615 heads of livestock. The average number of livestock owned by the households was over 4 times higher (TOCs: low-4.14 times, medium-4.03 times and high-4.43 times) than the number of livestock permits issued to these households by the forest department. Of these holdings 91.5% were buffaloes, 6.6% were cattle, 1.3% were goats and 0.6% were sheep/horses/mules. The proportion of the households that owned less than 4.5 livestock units per capita were 67%, 82% and 92.7% in low, medium and high TOCs, respectively. Moreover, livestock units per capita differed significantly across the three TOCs (Table 1).

Daily milk yield was similar across the three TOCs (Table 1). The average rate at which the respondents sold their milk differed significantly across the three TOCs, with respondents from medium TOC selling milk at the highest rates (Table 1). The estimated monthly net income varied from USD 11 to 3333, ~89% of which came from milk production. Also, the total monthly income was significantly correlated to number of livestock heads owned by the respondents ($r_s = 0.67$, $N = 158$, $P = 0.0001$). When these figures were calculated in terms of income per capita per day, 65.5%, 78.6% and 68.3% of the households fall below USD 1.25 (international poverty threshold, Ravallion, 2009) in the low, medium and high TOCs, respectively. Included in this figure is the revenue generated from producing and selling milk, wage earnings from both informal and formal employment, remittances from relatives and families, and income from other business revenues such as selling firewood.

3.2. Livestock losses

A total of 597 livestock losses were reported to have occurred in the last one year. A majority (72.7%) could be attributed to diseases, while depredation accounted for 154 livestock losses (25.1%) in the same year and affected 91 households (Fig. 2a). A small number of losses (2.1%) occurred owing to theft, falling off cliffs and train accidents. The number of livestock lost to diseases did not differ significantly across the three categories ($\chi^2 = 4.01$, $df = 2$, $P = 0.13$). However, the number of livestock lost to depredation differed significantly with most cases being reported in the high TOC ($\chi^2 = 38.86$, $df = 2$, $P < 0.0001$). Buffaloes were the most affected species under both categories constituting 91.7% of the

Table 1
Household level characteristics of the respondents (Gujjars) from the western Terai Arc Landscape, India, 2010–11.

Attribute	Statistic	Tiger occupancy			χ^2	p
		Low	Medium	High		
Family size	Median	12	12	12	0.75	0.68
	Range	4–63	2–36	5–45		
Livestock holdings	Median	40.00	31.00	30.00	5.7	0.06
	Range	4–200	2–152	4–120		
Daily milk yield (litres)	Average	34.61	25.98	30.20	1.01	0.60
	Range	3–84	3–200	3–150		
Price of a litre of milk (USD)	Average	0.38	0.46	0.42	66.12	<0.0001
	Range	0.33–0.56	0.37–0.56	0.37–0.56		
Monthly income from milk (USD)	Average	396.80	374.12	379.42	0.12	0.94
	Range	33.33–933.51	33.33–3333.95	36.67–2083.72		
Monthly income from other sources (USD)	Average	107.70	96.86	126.88	2.48	0.29
	Range	46.3–250.05	0–222.26	0–222.26		

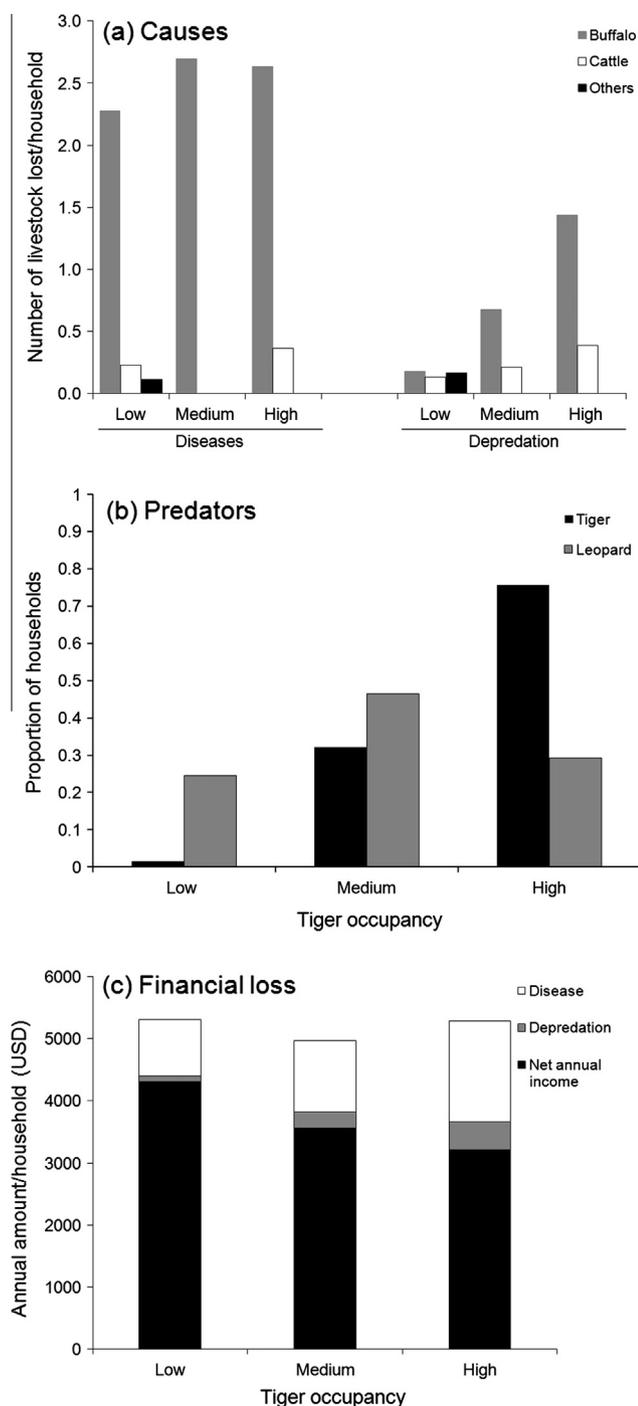


Fig. 2. Statistics on livestock losses across the three tiger occupancy categories. (a) Reported number of livestock losses per household to diseases and depredation categorized by livestock type. (b) Proportion of households who perceived either tiger or leopard to be responsible for reported depredation. (c) Financial losses per household caused due to diseases and depredation in relation to the average annual income per household. Net income represents the difference between average annual household income and market value of livestock lost.

losses attributed to disease and 70% of the depredated livestock heads (Fig. 2a). The proportion of livestock types depredated varied significantly across the three TOCs ($\chi^2 = 108.47$, $df = 4$, $P < 0.00001$), with buffaloes being killed more in proportion to their relative abundance in high TOC (Fig. 2a).

The two carnivores perceived to be responsible for all the cases of depredation events were tiger and leopard (Fig. 2b). Leopards and tigers were implicated in depredation events by 53.7% and

46.3% of the respondents, respectively, and the number of respondents holding either carnivores responsible differed across the three TOCs ($\chi^2 = 23.6$, $df = 2$, $P < 0.0001$). The number of depredation events attributed to tigers increased in high TOCs (Fig. 2b). The culpability of species involved was deduced from signs such as pugmarks, scrapes, scats near the kill in majority of the cases (86%), while the remaining offered no support to their inference. A vast majority of households reported that livestock were killed while unguarded (low = 100%, medium = 87%, high = 89%).

3.3. Correlates of livestock depredation

The best model explaining the observed pattern of livestock depredation included only TOC (high, medium, low); while the second best model (within 2 Δ AIC) also included livestock numbers as an additive term (Table 2). TOC (summed Akaike weight: 1) and livestock numbers (summed Akaike weight: 0.50) were the more influential terms, followed by prey density category (summed Akaike weight: 0.29). Based on predictions of the best model, the expected number of livestock losses was ~ 4.5 times higher per household in high as compared to the low TOC (Table S2).

3.4. Financial losses and compensation

The total value of livestock losses reported for the past one year was USD 231,197. Most of the losses (USD 185, 894) could be attributed to diseases, while the losses incurred to livestock depredation amounted to USD 45,303. The amount lost to both diseases ($\chi^2 = 19.2$, $df = 2$, $P < 0.0001$) and depredation ($\chi^2 = 42.85$, $df = 2$, $P < 0.0001$) differed significantly across the three tiger occupancy categories, with maximum losses being reported among households residing within high TOCs (Fig. 2c). On average, the financial losses due to depredation per household represent 2.2%, 5.2% and 8.5% of the average annual income per household in low, medium and high TOCs, respectively. However, when averaged over only those respondents who lost livestock, the losses amount to 8.8% (in low), 8% (in medium) and 11.8% (in high) of the average annual income per household.

Livestock depredation events were reported to the forest department by 40.6% of the households (Table 3). Among the rest (59.3%), households either did not report deliberately foreseeing bureaucratic hassles (42.8%) or were unaware they were eligible to receive compensation (16.4%). The proportion of households reporting such events increased considerably from low to high TOC. Only 11% (~ 10 households) finally received the compensation, eight of which were residing in high TOCs (Table 3). The compensation amount totalled USD 1422, and fell far below the market value estimated to be USD 5970.

3.5. Attitude towards living inside forests

In total, 156 out of 158 respondents were not satisfied with their current living conditions inside forests. Subsequently, the respondents were asked to suggest potential changes that could enhance current living conditions. Of the 158 households surveyed, 156 respondents (Low-100%, Medium-98.2% and High-97.6%) suggested that they would prefer to be resettled outside forests following the state-sponsored resettlement scheme implemented by the Uttarakhand forest department resettle Gujjars from RNP (Mishra et al., 2007). All 156 respondents also insisted that monetary compensation was not acceptable in lieu of the elements of the existing resettlement package, when asked to clarify what they meant by the existing scheme. When asked about the reasons determining their choice to resettle outside, most households (>60%) claimed that the “forests are no longer productive enough to graze and raise livestock for milk” (Table 4). In addition, they

Table 2

Generalized linear models used to identify the variables influencing the number of livestock killed by predators, with associated number of parameters, Akaike Information Criteria (AIC) values, Δ AIC and model weights. TOC refers to tiger occupancy category (low, medium, high), PDC denotes wild prey density category (low, medium, high) and 'Livestock' represents the number of livestock heads per household.

Models	Number of parameters	AIC	Δ AIC	Akaike weight
TOC	3	391.10	0.00	0.59
TOC + Livestock	4	392.90	1.81	0.24
TOC + PDC	5	394.31	3.22	0.12
TOC + Livestock + PDC	6	395.90	4.80	0.05
Livestock + PDC	4	436.28	45.18	0.00
PDC	3	436.45	45.36	0.00
Livestock	2	436.74	45.64	0.00
Null	1	437.24	46.14	0.00

Table 3

Percentage of interviewed households categorized based on reporting a livestock depredation event across the three tiger occupancy categories.

Category	Low	Medium	High
Did not know compensation could be received	18.75	2.56	19.44
Did not report conflict event	68.75	61.54	2.78
Reported, but not received compensation	12.50	30.77	55.56
Received compensation	–	5.13	22.22
N	16	39	36

also stated that in the forests they had “no access to education and health facilities” and were illiterate. Livestock depredation emerged as one of the major explanations only among respondents in high TOC (Table 4). The two respondents who were satisfied with their current living conditions cited close proximity to nearby towns (Rishikesh and Kotdwar, respectively), which allowed them to access the market, education and health facilities, as their reason for preferring *status quo*.

4. Discussion

4.1. Socio-economic characteristics

This study revealed that the forest-dwelling Gujjars in the western TAL rely primarily on selling milk from their livestock holdings as their source of income, with additional livelihood options (manual labour, forest department wages, agriculture) contributing a very small proportion of income (<11%), which makes them almost 'pure pastoralists' unlike most other traditional pastoralists (McCabe et al., 2010). Currently, the number of livestock units owned by the respondents, mostly buffaloes, is over four times the number permitted by the forest department, primarily owing to non-renewal of grazing permits for years (Nusrat, 2011). This increased livestock population is negatively impacting forests (Johnsingh et al., 2004), wild prey (Harihar et al., 2009, A. Harihar, B. Pandav and D.C. MacMillan, unpublished data) and tiger (Harihar et al., 2009; Harihar and Pandav, 2012). However, given the large family sizes, the average number of livestock units per capita falls below 4.5 units (~1125 kg biomass for buffaloes) in over 65% of households. This represents the threshold livestock holding

Table 4

Explanations given by 156 Gujjar households when asked why they wish to resettle outside the forest, following the model of existing resettlement packages in the state. The values represent percentages of the respondents who give a certain explanation.

Reasons given for this preference	Low	Medium	High
Forests are no longer productive enough to graze and raise livestock for milk	59.02	62.50	60.98
Lack of access to school education and health facilities	21.31	33.93	43.90
Elephant raids	–	7.14	4.88
Livestock depredation	–	3.57	34.15
N	61	56	41

below which households are unlikely to be able to sustain their pastoralist lifestyle following stock losses (Lybbert et al., 2004). Moreover, households living inside high TOC possessed far fewer livestock units than low and medium TOC categories (Table 1), and an overwhelming majority (92.7%) owned fewer units than the minimum subsistence threshold suggesting increased vulnerability to livestock losses.

In general, the average monthly income per household was USD 395.72 and did not vary across the three TOCs despite respondents in high TOC owning significantly fewer livestock units per household. However, these respondents reported higher milk yield per livestock unit indicating possible adaptations to ensure adequate incomes, which may be achieved through better fodder quality in high TOC or keeping better quality livestock. Respondents from medium and high TOC also sold their milk at higher prices, which ensured almost similar income levels across categories although the mechanisms remain unclear. Overall, a majority (>65%) earned less than the international poverty threshold of USD 1.25 per capita per day (Ravallion, 2009), establishing that Gujjars represent a largely impoverished community.

4.2. Characteristics and determinants of livestock losses

Nearly three-fourths of livestock losses suffered by the Gujjars could be attributed to diseases, with depredation by two large carnivores (tiger and leopard) accounting for the rest (Fig. 2b). This finding agrees with recent studies which are helping dispel the notion that large predators are the principal agent of livestock losses in pastoralist communities (Dar et al., 2009; Mizutani et al., 2005; Rasmussen, 1999). In general, 5.7% and 2% of the total livestock holdings of the community were lost to diseases and depredation, respectively. The percentage lost to large carnivores is comparable to the 2.3% loss reported from Jigme Singye Wangchuck National Park in Bhutan (Wang and Macdonald, 2006) but higher than the 0.9% reported in Pakistan (Dar et al., 2009). These losses impose considerable costs to the milk-based economy of this community and the costs (per household) attributed to diseases and depredations constitute 23.6% and 5.2% of the annual mean household income (Fig. 2c). Losses to depredation are lower than those reported in Nepal (25% of household income, Oli et al., 1994) and Serengeti

(20%, Holmern et al., 2007), and diseases represent the most serious economic concern to the Gujjars.

As in previous studies on livestock depredation (Dar et al., 2009; Sangay and Vernes, 2008; Wang and Macdonald, 2006), we found leopard to be the principal predator (Fig. 2b). However, the reported number of livestock killed increased by more than four times moving from low to high TOCs. Respondents held leopards responsible for killings more often in low and medium TOCs (Fig. 2b) which is expected given that increased tiger density is known to depress the density of leopards in this landscape (Harihar et al., 2011). Furthermore, costs due to depredation by tigers were 1.4 times those due to leopards, since most livestock killed by tigers were adult buffaloes which are more valued (Table S1). In contrast to the expected buffering effect of wild prey density (Mizutani, 1999), wild prey density had no significant influence on livestock depredation.

Lack of adequate compensation appeared to be a serious concern with only 10% of households receiving compensation for livestock depredation. While schemes providing compensation and interim relief exist in the landscape (Uttarakhand Forest Department, WWF-India), it is evident that most Gujjars are not benefiting from these. Failure to report livestock loss was identified as a primary issue (Table 3) with only 40.6% of the affected households reporting livestock depredation, a little higher than the 34% reported from Kanha Tiger Reserve (Karanth et al., 2012), with the majority citing bureaucratic hassles including filling out the paperwork (literacy rates are around 9%) and previous unsuccessful claims to be the major deterrents. Reporting of, and successfully receiving compensation were higher in the high TOC surrounding the CTR since here both state and conservation agencies are more active in providing compensation and interim relief, respectively (Bose et al., 2011). While active persecution of predators is seldom reported as seen in Africa (Thorn et al., 2012) or Bangladesh (Inskip et al., 2012), it is suspected that higher depredation rates coupled with low compensation has resulted in repeated incidences of retaliatory poisoning of tiger kills and involvement of community members with organized poachers (A. Harihar and B. Pandav, pers. obs. 2011–2013). Such incidents have been largely confined to the high TOCs where households own fewer livestock heads and therefore, losses to predators may be particularly devastating.

4.3. Promoting Co-Existence

Our findings suggest that livestock losses can be substantially reduced through husbandry interventions which include providing access to veterinary care (for diagnosis and treatment of diseases) and by promoting better herding and guarding practices among the Gujjars. Currently, Gujjars almost entirely practice free range grazing while supplementary feed is provided in stalls during the dry season (November–March). Since most livestock were killed while they were unguarded, adopting practices such as guarding the grazing herd and using protective physical structure, which have proved to be effective against depredation (Banerjee et al., 2013; Karanth et al., 2012), may be beneficial. In the current scenario, the margin of loss is aggravated not only due to the low government-sponsored compensation amount, but furthermore due to the lost opportunity cost, transaction cost and health impacts (not considered here), which can impose substantial costs to the well-being of poor communities (Banerjee et al., 2013; Barua et al., 2012). Hence, to prevent retaliatory killing of tigers there is an urgent need for conservation agencies (governmental and non-governmental) to actively target this community and provide more streamlined compensation reporting procedure tailored to this largely illiterate constituency. Finally, losses need to be compensated in a more time-bound manner following re-evaluation of the

compensation amount incorporating market prices of livestock and associated hidden costs (Barua et al., 2012).

Finally, in terms of priority, concentrating on providing veterinary care would be more productive in reducing the economic losses to this impoverished community given that three-fourths of livestock losses are attributable to diseases. Moreover, by marketing this as an exclusive “payment for encouraging coexistence” for “residents of tiger forests” it can possibly aid in building a constituency for long-term conservation of tigers in the landscape.

4.4. Resettlement

Resettling forest-dwelling communities to achieve biodiversity conservation targets has been a contentious issue worldwide (reviewed in Agrawal and Redford, 2009). However, based on our assessment 156 out of 158 respondents suggested ‘resettling outside forests’ was the most preferred intervention in terms of improving their well-being, based on the existing government-sponsored resettlement package which promotes a more agro-pastoralist lifestyle (Mishra et al., 2007). The reasons cited to explain this choice were particularly revealing with a majority (>60%) concerned that the forest was no longer productive enough to profitably practice pure pastoralism due to the cessation of transhumance and excessive fodder extraction. This represents a rare instance where excessive extraction of natural resources, which has been recognized to be detrimental for biodiversity (Edg-aonkar, 1995; Johnsingh et al., 2004; Harihar and Pandav, 2012), is also perceived to adversely impact the community’s livelihood (by members of community) and has created a desire for resettlement.

The community’s desire to resettle outside to a more agro-pastoralist lifestyle also indicates a desire to diversify their livelihood options in response to lower returns from their milk-based economy and unsustainable livestock losses, in the face of increasing human population. Similar reasons have prompted the Maasai in East Africa to rapidly diversify their livelihood to include more agriculture (McCabe, 2003; McCabe et al., 2010), and is being increasingly documented among pastoralist communities across other African and Mongolian rangelands (Fratkin and Mearns, 2003; La Rovere et al., 2005; Marin, 2008). Given that Gujjars possess only grazing rights within forests which cannot be converted (Forest Conservation Act, 1980) and lack of financial means to procure agricultural land, a government-sponsored resettlement scheme is currently viewed as the only way to make this transition.

Lack of access to education for children and health facilities formed the second most frequently cited concern about living inside the forest (Table 4). Being a largely illiterate community, Gujjars are increasingly realizing how the lack of education is hindering their ability to adapt to an increasingly monetary economy, and is not allowing them to diversify their livelihood options (Gooch, 2009). Livestock depredation did not constitute a major explanation for wanting to resettle among residents of low and medium TOCs, but emerged as an important concern in the high TOC given their fewer livestock units (Table 1) and more incidences of depredation (Fig. 2a).

In general, while local tiger occupancy determined the number of livestock losses, it did not directly influence the desire to resettle which remained uniformly strong across the TOCs. However, examining the socio-economic characteristics and attitudes against a gradient of tiger occupancy was particularly insightful towards prioritizing areas for resettlement. In this case, given the heightened vulnerability of households and risks of retaliatory killing of tigers in high TOC, we recommend that government and non-governmental organizations should prioritize funding for resettling households from this category as co-occurrence with tiger seems most infeasible here.

These priority areas within both protected (parts of eastern RNP and CTR) and multiple-use forests (parts of Lansdowne, Ramnagar and Terai west Forest Division) represent ‘core tiger habitat’ with evidence of breeding (Harihar and Pandav, 2012), which need to be free of anthropogenic disturbances for continued persistence of tiger in the landscape. While adequate land and finances have been allocated to resettle people from the protected areas, financial and logistic assistance from both federal and state agencies (e.g. National Tiger Conservation Authority and Compensatory Afforestation Fund Management and Planning Authority) can be sought to resettle Gujjars from critical habitats in multiple-use forests. Given the availability of ~2250 ha of appropriate land near Pathri (isolated exotic monoculture plantations with low biodiversity value) available to resettle >2800 families, ensuring successful resettlement is only contingent on political will to do so. Finally, although resettlement is the preferred option for the Gujjars, it is important to recognize that it may not always be possible or desirable. Where coexistence is the preferred or most realistic option, it is essential this is supported and promoted by providing livelihood and development options to local communities.

5. Conclusions

In the context of tiger conservation, while the need for securing inviolate habitats is well-recognized, the possibility of coexistence between tiger and humans has been a subject of considerable debate (e.g. Carter et al., 2012; Goswami et al., 2013; Harihar et al., 2013; Karanth et al., 2013). This case study demonstrates a spatially integrated and interdisciplinary approach, which integrates a comprehensive social assessment with ecological data, in prioritizing these alternatives for large carnivore conservation in a human-dominated landscape. In the light of global commitment to double tiger numbers and recent legislations (FRA, 2006 and the amended WPA of 2006) in India, our study presents a timely framework for demarcating cores which are to be kept “inviolate”, and areas where mechanisms to promote “co-existence” are required for incentivizing communities to engage with the notion of ‘co-responsibility’ for tiger conservation.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.biocon.2013.11.012>. These data include Google maps of the most important areas described in this article.

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