Can tigers survive in human-dominated landscapes?

Kolipaka, S.S.

Drawing of a bull. Humped cattle are common cattle breeds in the Indian subcontinent. This rock art was found near Udla village, buffer zone of Panna Tiger Reserve.

3 Factors Influencing Livestock Losses to Predators in the Multiple-use Buffer zone of Panna Tiger Reserve, India.

S.S. Kolipaka, W. Tamis, D.P. Srivastava, H.H. de Iongh, G.A. Persoon
(In Prep)

Abstract

Despite having seemingly excellent local knowledge on carnivores and using preventive strategies, livestock owners using the multiple-use buffer zone forests of Panna Tiger Reserve in India experienced high livestock losses to large carnivores. The underlying human factors behind such failure to control losses needed examination. Through informant interviews and observations we collected quantitative and qualitative data on local knowledge, livestock management strategies and resident livestock owner's perceptions on the factors creating barriers to lowering losses. We used Generalised Linear Models (GLM) and qualitative ethnography to analyse factors influencing livestock losses. Our findings do support our assumptions that proper knowledge of carnivores and use of preventive strategies lowered losses but did not prevent reoccurrence. Deep-rooted socio-political factors surrounding livestock and ineffective land use regulations in government forests compelled resident livestock owners to tolerate unproductive and free-roaming cattle and lenient herding practices. These external factors created barriers for resident livestock owners to manage their animals well and made livestock vulnerable to large carnivores. Further, the prevailing situation reduced cow and buffalo trade that once flourished in the area and removed the incentive to look after domestic animals. Importantly, the external influences prevented residents to take actions to improve the situation. We conclude that the ability of people to manage their livestock in a conservation area may be determined by the local socio-political factors as much as it depends on their own ability to safeguard their animals.

Keywords

Pastoralists; Livestock predation, Outside Protected Areas; Shared landscapes; India

3.1 Introduction

The pastoral Gond[10] tribes live in villages located inside the buffer zone of Panna Tiger Reserve (Panna TR), Madhya Pradesh State, India. Lakhan Gond and his people have

[10] Gond tribes are a majority, forest dwelling people of Central India. They commonly rear goats.

always grazed their domestic animals in these forests. Around 8 p.m. one December evening in 2013 a meeting was arranged to take place in Lakhan's hut and soon after dinner several herders gathered, some bringing their children. Some of the visitors sat by the open fire, while some stood. Customarily, Lakhan's family passed a sizeable plastic plate containing beetle nuts, cardamom, cloves, beedis (local cigarettes) and aniseed amongst the visitors. People picked from the assortment and by joining their palms together complimented the family by saying "Jai Mata"[11]. Soon a shepherd spoke up, and rest went quiet. He started to narrate the events of his day in the forest. *"The narha (stream) next to Siddh Baba (spirit site) is flowing fast and is still knee-deep, he continued. The stepping-stones are all high and allow easy crossing." "I also crossed a group of forest guards monitoring the radio-collared tigers near ganja pahadi (bald hill) with their tracking antenna. They said the Sher (tiger) was resting in the stream at the foot of the hill". "Any news of the thieves who stole the Yadav's[12] buffalo?"*, Asked another shepherd. A voice from the shadows said, *"The Yadav's suspect cattle rustlers from Katni". "According to them, this was the third incident this season in their village".* There was silence for a second, and someone asked, "*Did anyone see the bhigna (wolf)?"* Lakhan Gond and the two herders who accompanied him saw a pair of golden jackals and a group of six long-billed vultures on a cow carcass, two chinkara antelopes, a nilgai antelope and a pack of village dogs stalking an animal in the bushes. No one saw or heard the wolves that day. Soon the conversation turned to a pestering hoof rot that infected the commercially valuable village goats. After the quick exchange of news and information, the herders discussed grazing routes for the following day. There was a unanimous agreement to avoid using the waterhole below the *ganja pahadi* until the tiger moved away. Those who decided announced their routes, greeted others a good night and slowly walked away into the darkness towards their huts.

It is widely reported that in shared landscape effective livestock management practices lower vulnerability of stock to carnivore predation (Ogada *et al.*, 2003; Pimenta *et al.*, 2017; Tshering and Thinley, 2017; Tumenta *et al.*, 2013; Van Bommel *et al.*, 2007). In this article, we examine a case study from Panna Tiger Reserve (PTR), where Lakhan and his people experienced livestock predation from carnivores regardless of their seemingly solid local knowledge on carnivores and using precautionary measures. This case is compelling from the local people perspective for multiple reasons. Firstly, the resident livestock owners are economically deprived earning as little as 523 US $ or 31,389 Indian Rupee per annum (Bahuguna, 2000; NIC, 2017). They may be highly reliant on their livestock for their livelihoods and may not endure repeated losses. Secondly, in the absence of village grazing lands, government forest lands may be their only option for grazing livestock (Mathai, 1999). The social conflicts as a result of economic losses and a lack of alternative land for grazing are worrisome. From a wildlife conservation perspective, in Panna TR, Bengal tigers (*Panthera Tigris tigris*) became locally extinct in 2008 and were reintroduced in 2009 (Gopal *et al.*, 2010). Subsequent conservation efforts ensured that the numbers of tigers and other wildlife increased. The multiple use lands that Lakhan and his people

[11] "Jai maata" – To the glory of the divine feminine spirit (maata), is a common used good-wish phrase by Gond tribes.

[12] Yadav's are Hindu pastorals who rear cows and buffalos and consider the bovines their gods.

use are also critical for the future survival of the expanding wildlife. If left unaddressed, the current livestock predation by carnivores could trigger conflicts with local communities and pose a threat to the well-intended government efforts to secure tigers outside reserves. This precarious situation compels managers and conservation proponents to find solutions for the losses.

The objective of this article is therefore to make the factors influencing livestock predation in the buffer zone of Panna Tiger Reserve explicit. Firstly, we quantified the extent of annual losses experienced by residents to understand the range of causes and scale of such losses. Second, we analysed possible factors influencing predation. Within this we specifically examined;

A. Since, several authors showed that lack of precautionary measures could increase predation rates of livestock by large carnivores (Abade *et al*., 2014; Pimenta et al., 2017; Tshering and Thinley 2017; Tumenta et al., 2013; Van Bommel et al., 2007). We examined the effectiveness of local preventive strategies to minimise losses. Here, we checked for variability in use of preventive strategies and their effects on different livestock species. Since the resident livestock owners have low incomes, we assumed that the higher their dependence on their stocks for revenue, the higher would be the likelihood of them using preventive measures. We hypothesised that the use of preventive strategies would decrease predation risk.
B. We questioned Lakhan and people's local knowledge of carnivores, another critical aspect affecting predation (Khorozyan *et al*., 2017; Logan *et al*., 2014). We examined their ability to accurately identify local carnivores and their knowledge on the habits, and risks from carnivores to different livestock types. We hypothesised that inadequate understanding of carnivores and their behaviour would increase predation risk.
C. We examined livestock owner's individual perceptions of factors influencing loss. Drawing from an earlier study of Kolipaka *et al*., (2015). We specifically re-examined livestock owner's views on the effect of income from livestock on their choice of using or not using preventive strategies. We also questioned the consequences of regional socio-cultural cultural practices such as the ban on selling cattle to abattoirs and the local cultural practice of abandoning untenable cattle to livestock owners living in the buffer zone. The sensitive nature of the examined topics means that people seldom discuss these topics but try to adapt and the influence of these issues on livestock losses are overlooked (EPW 2017; Santoshi, 2016; Ghosh, 2017). The discussion describes the factors affecting livestock predation and management options.

3.2 Methods

3.2.1 Study Area

This research work was conducted in the multiple-use buffer zone forests of Panna Tiger Reserve in India. The reserve is located in North-central Madhya Pradesh at longitude

79°556E to 80°273E and latitude 24°274N to 24°905N. The protected tiger reserve is approximately 1400 km² and has a core zone and a multiple-use buffer zone surrounding the core. Other government-controlled forest lands, agricultural lands and villages extend beyond the periphery of the tiger reserve (Kolipaka *et al.*, 2015).

3.2.2 People's Use Of Forest Land

People from 42 villages and practising traditional ways of life live inside the buffer zone. The resident villagers (43,125 people) have customary rights called Nistar to access forests and extract forest resources (Kolipaka *et al.*, 2015). Additionally, several tens of thousands of people also live on the periphery of the reserve and access the buffer zone forests. Residents and outsiders' use the forests on a daily basis. They graze livestock, collect fuelwood and extract forest products like tree raisin, wild gooseberries (*Amla*), wild mushrooms, and honey. They also visit religious sites located in the area.

3.2.3 Local People Groups and Their Livestock

People belonging to 30 different caste and ethnic groups, practising Hinduism, Islam and tribal religions, coexist in the study area (Kolipaka *et al.*, 2015). Local people have animistic beliefs and consider several domestic and wild animals including the cow, nilgai antelopes, peacocks, monkeys and snakes sacred. They restrain from harming, killing or eating them. Livestock keeping is standard in the area, and resident villagers commonly keep house cows, domestic water buffalo and goats (Mathai, 1999) The small milk yielding native varieties of cows provide mostly for sustenance. The fat rich buffalo milk, on the other hand, is sold. Milk from a single buffalo can earn the owner approximately 100 US $ (5000-7000 Indian Rupees) per month. Goats are sold for meat and make about 30 US$ (2000 Rupees) for a 10-kilogram male goat.

In the study area and the broader region around it, religious prohibitions on eating, culling or selling cows and buffalo to slaughterhouses exist (Ghosh 2017). Politically motivated vigilantes, thugs and community-enforced norms ensure that bans are in place (Dosanjh, 2017). Additionally, local cultural customs like *Anna Pratha*, where livestock owners choose to abandon scores of cattle during drought years into the forests, rather than see them die of thirst or hunger, prevail (Santhoshi 2016). Prohibitions on the sale of cows and buffalo to abattoirs have decreased their economic value, and livestock owners are compelled to let excess, unwanted and unproductive animals to roam free and feral (Kolipaka *et al.*, 2015). Thousands of such animals move inside the Panna Tiger Reserve and are available prey for local carnivores (Kolipaka *et al.*, 2017a).

3.2.4 Wildlife in Human-Use Areas

The presence of several large carnivore species including, the tiger (*Panthera tigris tigris*), leopard (*Panthera pardus fusca*), Indian wild dog or dhole (*Cuon alpinus*), wolf (*Canis lupus pallipes*), striped hyena (*Hyaena hyaena*), sloth bear (*Melursus ursinus*), and domestic dog

(*Canis lupus familiaris*) are reported outside PTR (Kolipaka *et al.*, 2015). Additionally, wild pig (*Sus scrofa*), nilgai antelope (*Boselaphus tragocamelus*), sambar deer (*Rusa unicolor*) and cheetal deer (*Axis axis*), are also recorded in the human-dominated landscapes of the PTR buffer zone (Mathai, 1999).

3.2.5 Data Collection

Data used in our study were collected as part of a broader effort aimed at understanding the survival of the endangered tiger species outside protected areas of India between 2009 and 2015. Table 1 presents the summary of data collection methods. Wherever possible, interviews have been recorded on a digital Dictaphone (Phillips Voice Tracer 600) and some of the respondent disclosures are quoted directly in the text of this article. We accompanied herders and while out in the field examined their knowledge of animal tracks, burrows and examined kills. We used explicit photographs of animals and using vernacular names tested respondent's ability to identify carnivores accurately. We also checked their local knowledge on the spatial and temporal aspects of animal movements and predation incidents and their preventive strategies. To assess the accuracy of the responses we crosschecked respondent's answers on predation with the data we collected independently on large carnivores (Kolipaka *et al*., 2017a).

Table 3.1: Summary of Methods

S. NO.	METHODS	TYPE OF INFORMATION	SOURCE	SAMPLE	PERIOD
1	Pre-structured Questionnaire Survey	• Socio-Economics • Livestock Husbandry Practices • Livestock Losses	Households owning livestock	255	2013-2014
2	Ethnomethodology	• Local cultural factors surrounding livestock, • Bans on sale of cows • Factors influencing the use of government land.	Households owning livestock (from within the 255)	82	2013-2014
3	Herder Observations	• Livestock herding techniques • Preventive measures against local carnivores	[1] Herders (from within the 255 interviewed households)	40[3]	2013-2014
4	Observations	• Corralling practices[13]	Households owning livestock	255	2013-2014

[1] Herders were accompanied to the forests on 78 occasions. [13] Corrals and enclosures are used synonymously in the article.

3.2.6 Data Analysis and Statistics

The wide range of enquiries allowed us to collect both qualitative and quantitative information. This information is analysed for each of the two research objectives and synthesised. The explanations are presented with the intent to provide a detailed, in-depth description of everyday life and practice, a "thick description", based on the idea of an interpretive theory of culture, used within the context of describing the factors affecting livestock losses.

Treatment of quantitative data: To test the effect of the "importance of income from livestock" on preventive strategies and predation rates, we used Generalised Linear Models (GLM) with "Importance of Cows, buffalos and goats to income" as a response variable. Independent variables included the use of dogs, herders, corrals, entire stock with each household, total loss per family in one year and loss from predation in one year. We also checked for two-way interactions between some of the presumably related independent variables. Then, following a systematic removal process, we removed all non-significant interactions and keeping only the significant variables in the final model. Next, we used predation as a response variable and used the same preventive measures as independent variables. The selected models are shown in the online supplement and Appendix 2.

Treatment of qualitative data: Perception data collected from the interviews with households were administered informally, and during the interviews, we asked respondents their opinions on three topics. These included 1. Local socio-cultural practices influencing livestock husbandry practices. 2. The effect of prohibitions on the sale of cows and 3. The influence of current land use regulations on livestock grazing in government lands. Here, our goal is to arrive at an understanding of a particular phenomenon from the perspective of those experiencing it. Only 82 of the 255 respondent households participated in the extended discussions. Time and their willingness to discuss the sensitive topics influenced respondents' participation. Since local culture is the focus of our enquiry, the philosophical background that traditional culture is inherent within respondents has not been overlooked.

Like a PRA (Participatory Rural Appraisal) exercise, we made a flowchart of respondents perceptions during the interviews and drew the trajectory of the influences to understand relations between the external forces and livestock losses. This allowed us to refine the specifics of each theme and the overall story that the analysis tells, generating clear definitions and names for each theme. Next, we identified themes relevant to the research objectives and re-questioned respondents. For example, one respondent household expressed *that the local cultural practice of dumping dead cattle carcasses near the village-forest fringes in the study area attracted carnivores close to villages* (Figure 1). Next, they expressed the advantages and unwanted impacts of the disposal practice (right-hand side of Figure 1). One of the commonly stated adverse effects was that dangerous wild carnivores came close to villages. When asked how to reduce this, they provided solutions and perceived barriers to change. Here, we considered both the latent and manifest content in the responses, which further allowed us to choose between manifest (developing categories) and latent contents (developing themes). We then included these incrementally in the next stage of questioning and similarly in the analysis that allowed us to construct vivid, compelling extracts.

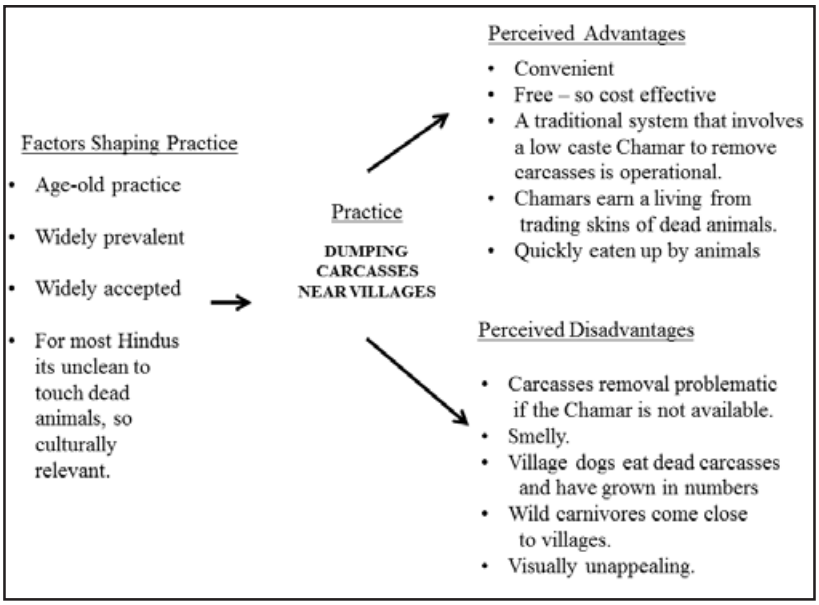

Figure 3.1 Factors shaping the local practice of dumping livestock carcasses near villages fringes and the resident livestock owners perceived advantages and disadvantages of the practice.

3.3 Results

The relationship between respondent's local knowledge and use of preventive measures and livestock losses were examined. Also, the influence of income from livestock on the use of preventive measures, and the impact of socio-political factors and land use regulations on local livestock practices were examined.

3.3.1 Livestock and Losses

According to the respondents, forty (40%) percent of households in the study area raised domestic animals (cows, buffalos and goats). Cows were the most commonly tended animals and 83% of the 255 interviewed households owned an average of 5.5 (SD 9.68) cows per household. People profited from the protein in the milk and from cow dung, which is the standard cooking fuel and used in-house maintenance. Buffalos and goats provided direct incomes through milk and meat respectively. Forty-two (42%) percent of the interviewed households kept buffalos and 65% goats with an average of 5.5 (SD 4.29) and 14.2 (SD 12.50) animals per household.

Livestock Losses: Sixty (60%) percent of the interviewed households reported livestock losses occurring from disease, predation, theft or accidents during a one-year period between 2013 and 2014 (Table. 2). Diseases caused the highest mortality amongst livestock and accounted for losses of 55% for cows, 52 % for buffalos and 55% for goats during the study period. Predation by carnivores ranked second followed by theft and

accidents (Table.2). Affected owners of buffalos and goats lost an average annual income of 250 US $ (15,000 Indian rupees) and 110 US $ (6500 Indian rupees) respectively to carnivores alone and valuable protein from cow milk.

Table 3.2. Livestock losses experienced by 255 interviewed households resulting from disease, predation, theft and accidents during a one-year period between 2013 and 2014 in Panna Tiger Reserve Buffer Zone.

LIVESTOCK	FAMILIES WITH COWS (n=Total livestock with households in 2013-14)	HOUSEHOLDS WHO REPORTED LOSSES (n=Livestock killed in 2013-14)	DISEASE (N)	PREDATION (N)	THEFT (N)	ACCIDENT (N)
Cow	212 (1422)	116 (385) (Mean = 2.75; SD = 1.96)	172 (Mean=2.75; SD=7.2) S	162 (Mean = 2.46; D = 0.72)	37 (Mean = 2; SD = 0.58)	14
Buffalo	106 (586)	41(83) (Mean = 1.6; SD=0.56)	43 (Mean = 1.5; SD= 0.4)	24 (Mean = 1.6; SD=0.28)	10 (Mean = 1.2; SD=0.21)	6
Goat	168 (2388)	144 (847) (Mean = 4.62; SD= 4.36)	462 (Mean = 2.60; SD= 0 .97)	286 (Mean = 3.3; SD= 1.5)	86 (Mean = 4.3; SD= 0.68)	13

3.3.2 Factors investigated for influencing livestock losses

Local Ecological Knowledge on Carnivores

Residents accurately identify most wildlife species and their awareness of the threats from various species was also high (see Figure. 3). The exception was on nocturnal species like honey badger (ratel) and Indian pangolin.

Location of Attacks:

According to the respondents, a significant proportion of cow, buffalo, and goat (71%, 92%, and 90%) predation incidents occurred when the animals were out in the forest. Only 7 incidents (3 cows and 4 goats) of predation while the animal was in an enclosure were reported during our study period. Overall, 94% of the goat owners knew the precise location of the predation incidents, but only 50% of cow and buffalo owners knew such details.

The Timing of Attack:

According to the respondents, 34% of cows were attacked or killed between dusk and dawn and only 10% during the daytime. Additionally, 56% percent of cow owners were not aware of the time of attacks or kills. In the case of domestic buffalo, 57% of predation incidents took place between dusk and dawn, 9% during the day and 34% were now aware of the time of the incident. In goats, 72 % of attacks or kills occurred during the day, 15% at night time and only 13% of goat owners did not know the time of the attack.

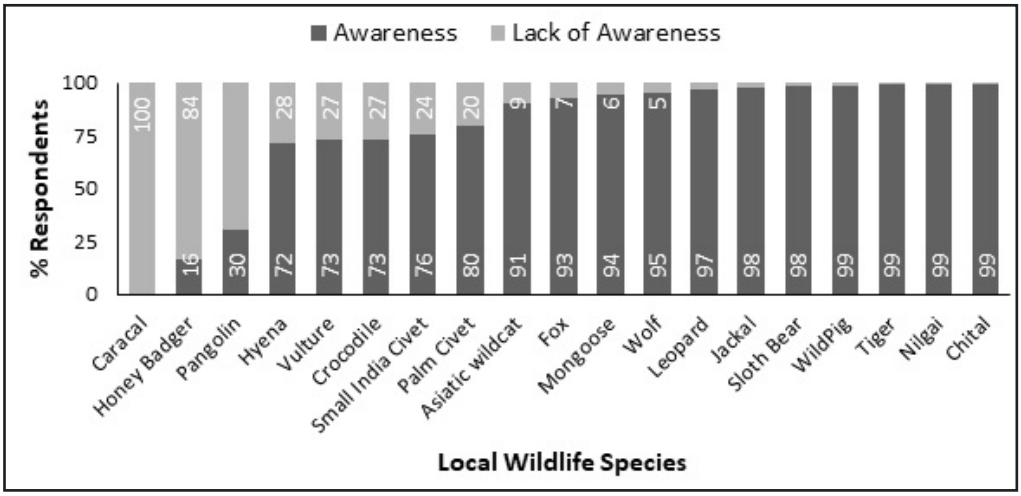

Figure 3.2 Awareness (dark grey) on the threats from carnivores was high amongst resident pastoralists.

Carnivores Responsible for Livestock Predation:

According to respondents, wolf, village dog, leopard, tiger and occasionally dhole were the leading killers of livestock. According to the respondents, tigers were responsible for 20% of the cows and 30% of the buffalos killed during the study period. Leopards were held responsible for killing 50% of the cows, 33% of the buffalos (mostly calves) and 21% of the goats. Wolves and village dogs were help responsible for losses of 30% of cows, and 79% of goats in the buffer zone of PTR. Overall, respondents could not identify the predator in 21% of cow and buffalo attacks and 3% of goat kills

Respondent's views and choice of preventive measures:

According to the respondents, all herders (100%) conducted grazing only between dawn and dusk, and avoided forests during low light. In the evenings, following their return from grazing, all herders gathered and discussed daily events and consciously made decisions on future grazing routes. They felt that this practice reduced predation considerably. Fifty percent (50%) of herders did not view that further increase in herding efforts could decrease predation rates. Herders believed that local dog breeds were good for the warning but not to frighten carnivores. They also felt that dogs attracted carnivores like leopard and wolves. While these were the reasons for the low usage of dogs for protection, 47% of interviewed herders also believed that having good guard dogs could reduce predation. Making loud noises and calling livestock while grazing was a commonly used deterrent to warn carnivores of human presence. 31%, 35% and 43% of the interviewed cow, buffalo and goat owners expressed satisfaction with the effectiveness of this method of deterrence. Use of sticks and stones was also common deterrent to scare off carnivores. However, only a small percentage of herders (12%) got convinced of its effectiveness. The materials used to build enclosures for animals and fencing fields varied between respondents. Goat enclosures located in the open forests or near the fringe of villages comprised of hardy thorns and thorny shrubs all mixed and piled to

form an impenetrable barrier. These structures were roughly two meters in height, and the majority of the inspected goat enclosures were of proper construction capable of preventing predators and thieves from entering the corral. When the stock size was small goats were also enclosed within the house compound. Buffalos and valuable cows were also confined within the complex of the owner's house. According to the respondents, confining animals at night time also prevented theft of animals (Appendix 1). Overall, only a tiny percentage (<3%) of predation incidents occurred near the corrals and respondents did not see a need for improvement in corral construction and expressed satisfaction with the effectiveness of their existing structures. Protection of forest spirits is another commonly sought measure to reduce losses of domestic animals, but less than 20% felt that this could further reduce real predation. Overall, 30% of herders did not respond when asked to "think of other new ways to prevent losses from predation".

Reasons For Low Retaliating On Carnivores:
According to the respondents, a majority (91%) of the interviewed respondents mentioned "Fear of getting into trouble with forest department personnel" for tolerating carnivores. A small percentage (7% and 2%) also expressed that "It was wrong to kill animals" and that "The spirits would be annoyed", as reasons for not retaliating (Appendix 1, Tab.5).

3.3.3 Use of Preventive Measures
The most common preventive measures used to safeguard domestic animals from carnivores were herders accompanying herds, use of guard dogs and use of corrals. The preventive measures used by owners to protect cows, buffalo and goats varied. For instance, use of enclosures to secure buffalo and goats after grazing was common. Cows, on the other hand, stayed outside the enclosures. Likewise, herders accompanied 79% of buffalos and 97% of goats while grazing in comparison to 64% of cows. The use of dogs to protect animals was observed in only 34% of respondents.

Income from livestock increased use of preventive measures. Generalised Linear Model (GLM) showed an interaction between the stock size and presence of herders influencing income. The size of stock significantly impacts the importance of livestock for income (for all three domestic animal species; $P = 0.0018$) and deployment of herders (only cows ($P=0.0013$) and buffalos ($P<0.001$)). The larger the size of the stock, the more valuable livestock became for income. Additionally, if herders accompanied cows and buffalo while grazing such stock contributed more to income. (Here, the effect of the presence of the shepherds on income is two-directional.)

Preventive measures decreased predation rates. There was a significant interaction between the size of the stock and presence of herders influencing predation rates. The number of predated livestock increased significantly with the size of stock for all cows, buffalo and goats (Cows: $P<0.001$, Buffalo: $P=0.00192$, Goat: $P=0.0362$). Predation rates were significantly lower in cows (not for buffalos and goats) when herders were present ($P<0.001$). Further, distance from the village to the forest also showed a significant relationship with predation $P<0.001$). The numbers of cows predated were higher at closer distances to the forest and the further away from the village from the forest edge the

lesser cows predated. For instance, with every 1000 m increase in distance from the forest to the village, there is statistically speaking, half a cow less predated. Predation of buffalo and goats, on the other hand, was not significantly related to distance. The presence of dogs and total losses (from disease, theft, accidents) did not significantly relate to predation rates (Chapter 3, Appendix 2).

3.3.4. Perceived factors shaping predation

Respondent disclosure revealed significant influence of local cultural practices, politically backed prohibitions on cattle and lack of preferential land use rights to residents as the three major indirect factors affecting respondents ability to control livestock losses in the study area.

Local cultural practices:

According to the respondents, *Anna Pratha* is an old and familiar local practice. The local Hindu groups revere the cow as a sacred animal but when they are challenged by calamities such as droughts and sickness in animals and cannot tend to their stocks they prefer to abandon cows and bulls into the forests rather than see them die. As a result, thousands of abandoned cows and bulls roam feral in the study area. "*The villagers from Ajaygadh pushed 2000 unwanted cows and bulls this summer into the forests*", said one respondent. "*With periodic droughts in this region, the practice of Anna Pratha has become more common and widespread in the Bundelkhand area*", he said. "*These abandoned animals will compete with our valuable cows for grazing and water*," According to the respondent's, large carnivores killed the surplus feral cows and bulls in the forests, and when their valuable animals use the same areas, they too become vulnerable to the

Figure 3.3 Lenient herding makes cows vulnerable to predation by large carnivores like a tiger in multiple-use lands. Photo Source: Anshuman Kumar

carnivores. Responding to a question on "*Can you round up and remove such unwanted cows from the forests?*" A Yadav caste respondent explained, "*We belong to the family of Krishna[14], and the cow is our mother. I would rather prefer to see it die in peace in the forests than seeing it die in front of my eyes*."

Politically backed prohibitions:

Hindus in the study area believe that the cow is sacred and consider it a sin to eat beef. The ruling right-wing Hindu party is in power for nearly two decades in the state of Madhya Pradesh. Their stay in power allowed them to impose an informal ban on cow slaughter and prohibition on the sale of cows to abattoirs. In 2015, the same Hindu right-wing party became a majority government in India. Respondents viewed that since the new government came into power, the informal prohibitions on cows also extended to buffalos. Further, the enforcement of prohibitions by local vigilante groups has become more stringent. In response to one of our questions, "*Would you sell us a buffalo calf for use in our tiger research?*" A Yadav buffalo herder said, "*The community will kill me if I sell you a buffalo calf to bait tigers*". "*The villages will also target my family and may expel them from the village*". Respondents expressed that prohibitions on selling cattle have disturbed the normal functioning in communities. "*the Yadavs threatened the Chamar family in our village, and they left. Currently, we do not have help to remove dead animals. Sometimes carcases of animals killed in road accidents stay untouched and stinking for days. Villagers bear the stench but do not touch them*," said one respondent. "Animal attacks on cattle increased since the tigers have been reintroduced", said one respondent. "T*here are so many unproductive cattle in the forest, and the tigers are taking advantage of them. At the same time how could you blame the tiger, it is not its fault that the cattle are there. I wish these feral animals were removed and sent away to a ghosala[15]*", he concluded. Respondents expressed that because of the prohibitions, there are currently more cows in the villages and in the forests then there were 20 years ago. All respondents failed to visualise a solution to reducing the number of cows or taking the matter into their hands. The fear of the cow-vigilantes and the increased community retaliation was reasoned for their inability to make decisions. They expected the park authorities to make decisions both on cattle and wildlife issues. "*It is their park and their animals*", said one respondent.

Ineffective land use regulations and preferential rights

All respondents were aware that the core zone of the Panna Tiger Reserve was a prohibited area for grazing and that the buffer zone forests was for multiple-uses. All respondents believed that the park authorities had full legal control to restrict their use of the multiple-use buffer zone. None of the interviewed respondents was knowledgeable on their legal right to access the government forests as described in Forest Rights Act 2006[16]. According to the respondents, poor regulations are restricting the systematic use of buffer zone forests. "*Anybody can come, aap ajo (you come), nobody will stop you. People from*

[14] Krishna the Indian god is believed to be the king of Yadavs pastoralist. The cow is therefore sacred to them.

[15] Ghosala is a care centre for abandoned cows. Several ghosalas accommodating hundreds of cows are situated around the study area.

[16] Forest Rights Act 2006 gives solemn right to all forest dwelling communities to access forests for meeting their natural resource requirements. The act does not distinguish between protected and non-protected forests.

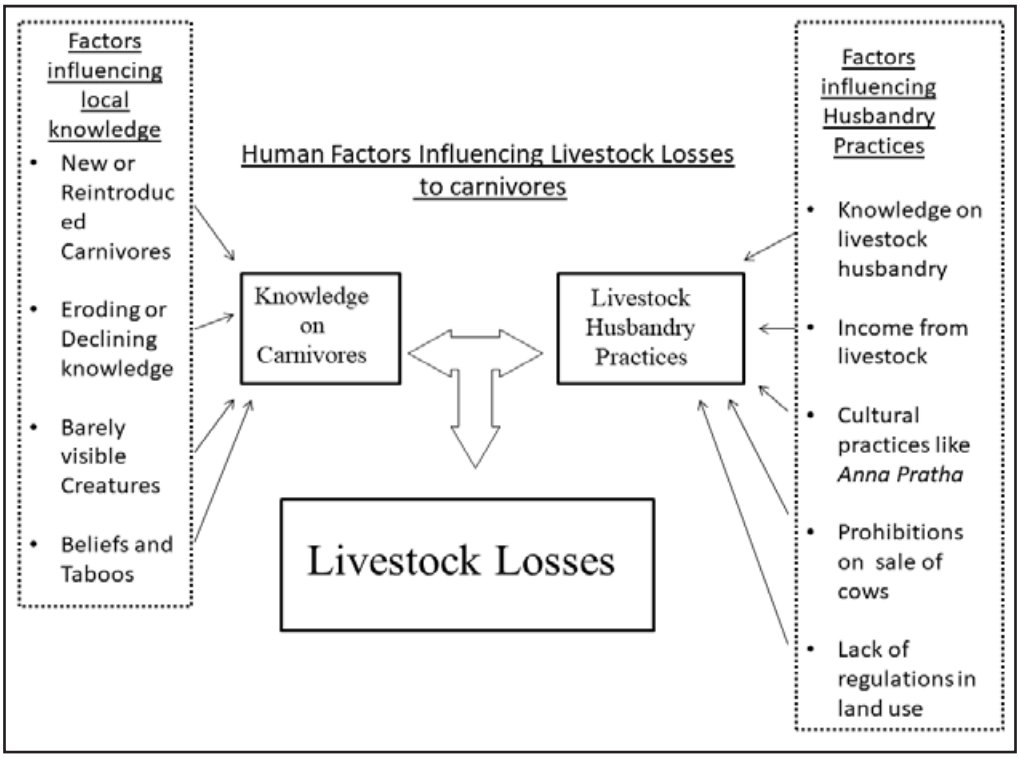

Figure 3.4 Schematic diagram showing the external factors that could affect people's local knowledge and livestock husbandry practices in the buffer zone of Panna Tiger Reserve, India.

as far as Khajuraho town come to fish in the river" said one respondent. Respondents expressed that outsiders allow cattle to graze freely without herders and enabled them to stay in the forests for prolonged periods. Because they had no exclusive land use rights, they could not stop or regulate their use while in government forests. They felt that as residents in the buffer zone they should be given preference over non-residents to access buffer zone forests. When asked, why do you choose to be part of the buffer zone? The most common responses suggested that respondents expected increased monitory benefits from being part of the buffer zone. "*We are going to get a good price on our land when the park authorities propose relocation of villages*," said one respondent.

3.4 Discussion

3.4.1 Local socio-political factors influencing livestock losses

Our findings revealed that resident livestock owners had good local ecological knowledge on large carnivores in their areas. They changed preventive measures for various livestock stages and for different livestock species. Significantly higher efforts were made to

safeguard buffalos and goats but not cows. Those owners who used preventive measures lost significantly lesser animals than those who did not. This findings supported the well-established understanding that preventive measures and excellent local knowledge on carnivores enable livestock owners to reduces the loss of livestock to predators (Ogada *et al*., 2003; Timenta *et al*., 2017; Tshering and Thinley 2017; Tumenta *et al.*, 2013; Van Bommel 2007). However, we found that several obscured factors reduced the ability of owners to manage their stock well and kept losses relatively high than in other comparable parts of India. For example, despite high awareness of the threats from carnivores some owners were selective in their use of preventive measures. Income from livestock influenced such differential treatment. Likewise, local socio-political factors increased the presence of unwanted and feral animals in multiple use forests and also compelled respondents to stock more livestock than they needed. Also, lack of exclusive land-use rights for resident livestock owners in the buffer zone forced them to tolerate the lenient herding practices of non-residents. Based on our empirical findings we agree with Eklund et al., (2017) that preventive measures and knowledge may reduce predation rates but may not stop all predation incidents. As our study shows, factors like income from livestock, age old cultural practices, political influence that deterred people to take actions and ineffective land use regulations, in an interlinked manner may influenced local livestock husbandry practices and people's own ability to control losses.

Absence of income from cows

Cows did not earn income to resident owners, but goats and buffalo did. The lack of revenue reduced people's use of preventive measures for cows. Our findings support the results of Banerjee *et al*., (2013) from Gir forests in the Gujarat State of India that economic incentives motivate herding practices. In Gir forests the local pastoralists tolerated lions killing their buffalos because they earned more money from the local park management's compensation scheme. A majority of cows owned in our study area were little milk yielding native varieties. Most people kept these cows for milk and used their dung as fuel. They did not earn incomes. The native cow types were hardy animals and could withstand the harsh local conditions and did not need tending. So residents continued keeping them and benefited, even in a small way, without having to spend time or effort in their upkeep.

We found a relationship between stock size and preventive methods used. Owners who depended on their cows for income also kept more cows than those who did not depend on animals for income. Further, owners with larger stocks also benefited (economically) if they used preventive measures such as deploying shepherds. Finally, those who did not use precautionary measures lost more animals to predators than those who did. These findings show how income from cows influenced the stock size, use of preventive measures and losses. The segment of people who lost more animals were those who earned their income from labour work. They kept cows for sustenance use, to supplement their weak earnings. This group of residents did not earn enough income to hire shepherds. The effect of the stock size on the owner's ability to employ shepherds, as predicted by our GLM model in two-directional. This is interpreted as, people could afford shepherds because the livestock they owned generated enough

money to afford the services of shepherds. Unfortunately, people holding large stocks (they also earned income) and those who used preventive measured also suffered high losses from predation. Such undiscerning losses are because; since all residents grazed their livestock in the same forests and the differential treatment by some affected all. This relationship shows that in multiple use landscapes that are also used by large carnivores, when a portion of the stock is secured, and rest is allowed to graze free, the portion that is secured is also likely to become vulnerable to predation. The next discussion is on interconnected effects of socio-political influence on livestock husbandry practices.

Socio-political influences

The disclosures of the livestock owners suggest that the external socio-political factors are essential stimuli and create barriers for livestock owners. For example, cultural practices such as Anna Pratha encouraged people to abandon untenable cows into the forests. Similarly, the lack of land use regulations in government forests encouraged resident and non-resident villagers to pursue lenient cow herding practices such as, not using herders and allowing cows to graze unguarded and not using night time enclosures. In our study area, people do not eat beef. Further, the ban on selling cows to abattoirs and the low milk yielding cows, all these factors have lowered the commercial value of native varieties of cows. Our findings in Panna are dissimilar to those reported by Bhatia *et al.*, (2017) who studied the influence of religious beliefs of Muslim and Buddhist pastoralists towards snow leopard in Ladhak, Kashmir. In Ladhak, they found that income from livestock was a stronger influencer on attitudes of people towards snow leopards than religion (Bhatia *et al*., 2017). We found the opposite to be true in Hindu respondents in Central India, who despite their weak economic status are unable to exploit the surplus cows in their areas because of local religious norms towards cows and the political support for such views. This situation created an excess of unwanted native varieties of cows and bulls that did not have any commercial value in villages. As a result, large numbers of livestock were allowed to move freely in the forests, and such animals became ready prey for large carnivores (Kolipaka *et al*., 2015). In Panna, the complex interactions between the social (beliefs, religion and cow protection) and natural systems (multiple-use forests, predators), like observed in several other contexts in the world, are of significance (Adhikari 2016; Abade et al., 2016; Madden, 2004).

While the above mentioned complex interactions were at play, residents in the buffer zone villages expressed helplessness to control the external socio-political influences and poor land use regulations that affected them. On-one-hand they experienced livestock losses, and on-the-other-hand, they could not respond to the overwhelming forces fuelling such losses. This situation is explained by Cutter (2003) through his vulnerability science framework as those circumstances that put people and places at risk and *those conditions that reduce the ability of people and places to respond to environmental threats*. Ghate et al.(2013b) also support our findings., and they demonstrated through their field experiments that people become vulnerable to external threats when they lacked the power to control their natural resources.

3.4.2 Management Option

Livestock is integral to people's welfare and well-being in most rural areas of the world including India (Herero *et al.*, 2010). Therefore, livestock's presence in rural landscapes and government-controlled forests will carry on, typifying such lands. To conserve carnivores in areas that are also used by livestock, it is essential to find ways to decrease livestock losses or risk losing people's support for carnivore conservation. With the current Hindu conservative government in power, the existing socio-political situation surrounding sacred animals in India are likely to continue (Teltumbde, 2015). Next, its influence on people and their livestock practices in the study area will likely remain. While this situation may advantage carnivores in multiple use areas through readily available domestic prey animals (Kolipaka *et al.*, 2017a), it is liable to exert economic burden on those residents who depend on livestock for livelihoods (Teltumbde, 2015). Under these circumstances, soliciting local people's support for carnivore conservation will be difficult.

Fortunately, the high local knowledge and good familiarity on wildlife amongst resident livestock owners will not require the need for costly and hard-to-execute awareness and educational campaigns. Further, local knowledge may be a reliable source of information to refocus local conservation efforts. For example, during our interactions with livestock owners, we became knowledgeable about the predatory nature of the wolf and free-roaming village dogs, which caused more livestock losses than the tiger, leopard and the dhole combined in the study area. This finding is significant for tiger conservation in multiple use forests because wolf and village dogs caused more losses of commercially valuable goats, unlike tigers or leopards that killed more commercially low-value cows (Appendix 1-Table 3). Next, the residents are satisfied with the usefulness of their preventive strategies against predators. They do not see the current predation resulting from their lack of knowledge of carnivores or their inability to use preventive methods. They feel helpless to tackle the interlinked socio-political and lack of rights in government-controlled forests, which exposed them to vulnerability. Since the support of the local people is critical for large carnivore survival in multiple use forests and outside protected areas, the reserve management may have to address the local concerns. For example, issuing exclusive user rights to residents who live inside the buffer zone, will empower and encourage the 43,125 people of 42 resident villages to come together and stand up against the non-residents. Issuing preferential user rights may stimulate residents defining their grazing lands and impose stricter grazing regulations that check undesired livestock grazing practices. Empowering local communities as Ghate *et al.*, (2013b) showed through their field experiments will allow better natural resource management by the communities when such communities have the power over their resources. Further, conservation advocates, through their networks and contacts, must find platforms to address the currently paralysed discussion on excess and unwanted livestock bothering rural people. I use the metaphor of an entangled knot. By addressing the issues the reserve managers will help loosen up some of the strands from the entangled knot[17], knot being the complex interlinked effects of the socio-political situation, which create barriers for residents. By

[17] Knot is a metaphor.

loosening the knot, the highly knowledgeable and adaptable residents will be in a position to better protect their livestock from predators.

3.5 Conclusion

Our study provides novel insights into various external factors that can influence livestock husbandry practices and keep livestock losses high. This is despite livestock owners having excellent local knowledge and using preventive strategies to safeguard their animals. Reserve managers and tiger conservation groups cannot overlook the interlinked effects of income, socio-political factors and ineffective land use regulations on livestock husbandry practices in a shared landscape. We feel that the external forces exerting pressure on resident owners may be too complicated for them to solve on their own and they may need the reserve management's help. We conclude that the ability of people to manage their livestock in a conservation area may be determined by the external factors as much as it depends on their ability to safeguard livestock.

Acknowledgement

We thank the Madhya Pradesh Forest Department and particularly Panna Tiger Reserve for granting permits and supporting Shekhar Kolipaka's work in the buffer zone and territorial forests around Panna. We are highly indebted to the local livestock owners who shared their way of life and allowed us to make observations that made this study possible. We thank para-ecologists Sushil Kumar, Shabbir Bhai, Sunil Yadav and Gulab Singh for their role in setting up interviews and introducing us to the local culture. We are thankful to the volunteers whose cheerful and energetic presence made tedious tasks like walking long days with herders in the heat and rain, pleasurable. We thank Linda Harding and Sushmita Krovi for their editorial help. We finally thank Leiden University, Louwes Fund for Research on Water and Food and De Fries-Bajpai Foundation for financially supporting the research work of Shekhar Kolipaka.

Author Contributions

Conceptualization: SSK.
Data curation: SSK.
Formal analysis: SSK WLMT.
Funding acquisition: SSK HHI GAP.
Investigation: SSK DP.
Methodology: SSK WLMT GAP HHI.
Project administration: SSK HHI.
Resources: SSK GAP HHI
Supervision: SSK GAP HHI.
Validation: SSK WLMT HHI GAP.
Visualization: SSK.
Writing- original draft: SSK.
Writing- review and editing: SSK GAP HHI.