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Research Article

SOCIO-ECONOMIC PROFILES AND CORRIDOR MAPPING OF TWO BOTTLENECK REGIONS LYING BETWEEN RAJAJI AND CORBETT NATIONAL PARKS, UTTARAKHAND, NOTHERN INDIA

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ABSTRACT
Uttarakhand hosts the majority of Asian elephant population of North- west region of India. Ten out of the total twelve elephant corridors are situated in Uttarakhand. In the past few years, alterations in feeding behaviour and higher frequency of attacks on humans have been reported. The reason for this is accelerated destruction and decimation of elephant habitats throughout the world. The once lush forests of Uttarakhand are fast turning into fragmented and greatly shrunk pockets of forest. This forces the animal to cover larger distances in search of food, water and shelter, away from the overcrowded pockets. As a result, the human- elephant conflict (HEC) levels rise because the animal tends to stumble over more number of settlements and raid crops or demolish buildings that fall in the path of their traditional migratory route. About 20% of the world human population is known to settle in and around sensitive Asian elephant habitats. The colossal threat looming on the species as a result is apparent.
Corridors are passageways that allow connectivity between two comparatively contiguous forest patches and are crucial for avoiding isolation and eventual inbreeding depression in species. In order to assess the status of HEC and utilization by elephants, two corridors: Barkot- Kansrau- Motichur and Rawasan- Sonanadi- Lansdowne corridor were studied. Two bottlenecks in these corridors were selected for understanding the level of conflict and major disturbances that impeded movement of elephants across the corridor. Socio-economic analysis of the surrounding villages was done with the help of semi- structured questionnaires to get an insight into the reasons behind the conflict and the perceptions and outlook of the people towards conservation. It was found that wheat was the most raided crop in both the bottlenecks. Heavy traffic plying through the Dehradun - Haridwar highway (in first study area) and Kotdwar- Lansdowne highway (in the second) were the biggest impedance for movement. Only bulls and sometimes herds were known to cross these highways. The highest level of conflict was found to be in Shyampur (maximum proportion of high and medium level damage) but was more often in Chandi. It is proposed that electric fences, if installed should be individually circling each household and field for better maintenance in first study area. In the second study area, stone walls with concrete/ electrified wire running on the top should considerably control elephant attacks.

Key Words: *Asian Elephant, Habitat, Corridors, Fragmentation, Human- Elephant Conflict*

INTRODUCTION
Human- elephant conflict is a battle that has been going on from decades and is one that the elephant is fast losing. Once considered the greatest symbol of royalty in the Mughal era, the majestic creature's state is dismal now. Reasons for this have been varied in the due course of time. In the 19th – 20th century, it was the value that was attached to ivory that proved to be the biggest blow. Game hunting, spread of firearms, introduction of cash crops and eventual expansion of agriculture and human settlements have brought the animal to the present looming threat of extinction. Presently, the biggest problem, which is threatening the animal's existence, is habitat loss, fragmentation and degradation.
With a cranial capacity, about 3-4 times bigger than Rhino, elephants have a very sharp memory and sense of hearing that picks noises from as far as 10 miles. However, the vision is compromised due to

peripheral view of the surroundings. The eyesight, improves in forest shade. The sharp memory indicates the reason behind elephant herds traversing the same migratory routes over generations. Also, forest shade is thus, important not only to escape the hot summer afternoons but also boosts their general vision. Males weigh up to 5 tones and grow more than 10 feet in height, whereas, females weigh around three tones and are a feet shorter. Since the pachyderm cannot sweat and regulate its body temperature, regular baths are a necessary component of their well being. Mud bath helps them to avoiding mosquito bites and other insects. Elephants are socially well organized creatures that live in matriarchal herds. The females live gregariously throughout their lives, however, males are found to live primarily solitary lives after the age of fourteen, thereafter defining their own home range, roughly following the female herds. The matriarch is the oldest female of the herd, who bestows all forms of knowledge onto the younger members and is an unquestioned elder, whom everyone follows (Sukumar, 2000). The ousted pubertal sons roam about solitary or in bachelor male packs of up to 10. At around the age of 20, the males find mates and reproduce to roam in pairs or as three. Unlike big cats, elephant herds that come across each other in a common home range do not fight for superiority/ territory but rather display warm family reunions. Elephants would rather prefer living in large herds as a better survival strategy for their offspring, who would be protected against predators (Gadgil and Nair, 1984) and also to be mutually guided by the various grandmothers of each clan about safe and lush foraging grounds and water sources in seasons of scarcity.

Distribution in the Past and Present

The Asian Elephants (*Elephas maximus*) are distributed today in a total of 13 countries in Sri Lanka, Mainland Asia and Sumatra (Shoshani and Jeheskel, 2005). The former distribution (about 6000 years ago) was widespread and contiguous from Iraq and Syria in the west, up till Central China in the east (Figure 1). The human population boom over the past few decades has simultaneously dwindled the survival of the other species. Presently, the total number of wild elephants is estimated to lie between 25,000 and 50,000 (Santiapillai and Jackson, 1990; Sukumar, 1990). This count is estimated to have been as high as a million, back in the 1900s across Asia. So, it can be comfortably deduced, how soaring human numbers on one hand are inversely proportional to the existence of the Asian elephant on the other.

The entire Indian subcontinent was once abounding with Asian elephants. They are now restricted to small pockets, constantly struggling to survive against all odds of disease, climate change, resource scarcity as well as poaching for ivory and persecution as crop raiders.

In India

India has 60% of the global population of wild Asian elephants, approximately 21,000-25,000 elephants and another 1600 are held captive, mostly in the range countries (Sukumar, 2006). The Asian elephant in India is at present confined only to four regions:

1) Southern India, 2) North- east along with North West Bengal, 3) Central Indian states of Orissa, South West Bengal and Jharkhand, 4) Northern India in the states of Uttarakhand and UP and in the North-western region, twelve elephant corridors have been identified in total. These are:

1. Barkot- Kansrau (Uttarakhand)
2. Chilla- Motichur (Uttarakhand)
3. Motichur- Gohri (Uttarakhand)
4. Rawasan- Sonanadi (via Lansdowne FD) (Uttarakhand)
5. Rawasan- Sonanadi (via Bijnor FD) (Uttarakhand and UP)
6. South Patlidun – Chilkiya (Uttarakhand)
7. Chilkiya – Kota (Uttarakhand)
8. Malani – Kota (Uttarakhand)
9. Fatehpur – Gadgadia (Uttarakhand)
10. Gola Rankhu and Gorai – Tanda (Uttarakhand)
11. Kilpura – Khatima – Surai (Uttarakhand)

12. Lagga – Bagga – Kishampur (UP)

Of the total, almost 1346 elephants are estimated to inhabit the forests of Uttarakhand across 14 administrative units. The elephant habitat is spread in an area of ~4,500-5,000 sq. km in Uttarakhand alone. Uttarakhand is a vital habitat for the Asian elephant and needs attention to restore the degradation caused, so as to stop the number of wild inhabitants to dwindle. According to a study carried out to assess habitat fragmentation throughout Asia, the Uttarakhand population was categorized to comprise of developed but small populations of less than 1000 elephants. Fragmentation and shrinkage has resulted in the breaking up of the Asian elephant populations in this region into six sub- populations (Johnsingh and Williams, 2005). These lie between:

1. Yamuna and Ganga River
2. Ganga and Khoh River
3. Khoh and Haldwani
4. Haldwani and Sharda
5. In and around Dudhwa Tiger Reserve
6. Katerniaghat Wildlife Sanctuary

Having a major stake in the World Asian Elephant population, the species needs to be focused upon so as to avoid further endangerment and eventual extinction (Figure 2). It is central to any conservation program targeted at improving the giant's dwindling numbers, to understand the causes of the problem of fragmentation that eventually raise serious repercussions like human- elephant conflict.

Objectives

1. To study the various corridors between the Rajaji National Park and Corbett National Park and select bottleneck regions of immediate concern due to expansion of human habitations in their midst and assessment of their use by elephants in it.
2. To collate secondary information regarding human-elephant conflict in the region. To carry out focus group discussions and household surveys using semi- structured questionnaires to assess the type and degree of conflict within villages adjoining the corridors.
3. To develop comprehensive maps with the collected data using ArcGIS-10 software and draw inferences from the Socio-economic survey towards understanding the issues of human- elephant conflict in the crucial connecting links within the landscape.

MATERIALS AND METHODS

Study Area

The Terai Arc Landscape extends from River Yamuna in west to River Bhagirathi in east (Figure 3). These two rivers only flank a stretch that brims with innumerable big streams as well as networks of small rivulets. The TAL has 3 basic features that run almost parallel to each other from the west to the east limit; these are- the Shivaliks, forming the Ridge area at the foot of the mighty Himalayas, the Bhabhar tract, which is the bottom of these ranges formed from the boulder, porous deposits, brought in from above and the Terai plains that run further. In the TAL region, two bottleneck regions flanked in the west by the Rajaji National Park and on the east by Corbett National Park were selected for the study. The entire tract between the two national parks has several crucial corridors for the movement of the Asian Elephant. One such corridor, in the plains adjacent to the Rajaji National park is the Barkot- Kansrau corridor (Figure 4, 5), lying in the Dehradun Forest Division. It connects the Kansrau range that lies in Rajaji National Park to Barkot range of Dehradun forest division on one arm and Motichur range of Rajaji to Rishikesh range on the other arm.

The second study area lies in the Lansdowne Forest Division, Dugadda range. It connects the Rajaji National Park to the Corbett National Park. Tootgadhera is well known for its frequent wild elephant sightings on the highway leading to Lansdowne (famous tourist destination and army cantonment area). About 10kms away from the town of Kotdwar lies the Duggada Forest Range (Figure 6, 7). At least 15kms of this forty km long highway connecting Kotdwar and Lansdowne falls in the main elephant

corridor area. As a result, several herds are often spotted crossing this road to reach the waters of the Khoh River underneath in late evenings or at night. The river lies below the road, flowing parallel to it continuously. The Khoh River is a very important source of water to both the wildlife and the human population, providing water to the thickly populated Kotdwar town as well as several villages that fall on the way to it. It is all the more vital in summers, being the only perennial water source in the region. Both solitary bulls as well as huge elephant herds are frequently spotted crossing by, between Jhawanu reserved forest and the Khoh reserved forest and going up to Pulinda and Naudi villages causing great damage to the agricultural fields there. Aamsod is the village that lies right in the middle of this route taken by the elephants and is thus, suspected to witness high conflict. Elephants are known to cross from here, further to the Sonanadi wildlife sanctuary in summers.

METHODS

Assessing the use of bottleneck regions by elephants

In order to assess the use of the bottleneck regions by elephants, I surveyed these sites by traversing existing forest trails with the help of information from the local people and the forest department. During the surveys these forest routes were walked on foot and all travel routes were recorded on a GPS unit. To quantify the use of the area by elephants all indirect signs were noted. These included dung, pad marks, trampling and feeding signs. The maps showing the study areas, evidence sites and drainage systems across the area, were developed with the help of Arc Map of ArcGIS 10 software (Tylor, 1993; 1999).

Assessing the socio-economic status of villages in and around the selected bottlenecks

To assess the socio-economic conditions of villagers in and around the selected bottlenecks, I administered a semi-structured questionnaire. The questionnaires were designed to assess the levels of literacy, extent of dependence on agriculture, land owned, crops grown, damage caused by elephants alone, deterrent methods adopted to safeguard crops and property, outlook towards conservation and aspirations from the Forest Department etc. Focus group discussions were carried out to get an insight into the cause and effect of their opinions and all the nuances they face from the animal and cause, in turn, in retaliation to it. I also attempted to elicit responses on the issue of compensation application and reception by asking villagers a series of open ended questions. The surveyed questionnaires were codified and tabulated in order to develop comprehensible bar graphs.

1. Collection of direct and indirect evidence of elephant presence in the patches of the reserved forest surrounding the surveyed villages was done with the help of a Garmin GPS device. Several forest trails were travelled on foot in search of these evidences. The surveyed villages encumber the free movement of the mega herbivore across several generation-old corridors this causing a narrow bottleneck in the Kansrau- Barkot and Motichur corridor and across Khoh River in the Rawasan- Sonanadi corridor. The discovery of these evidences pressed the importance of these bottlenecks to the animal's movement across the forest ranges. The routes were traced and also, signboards put up by the FD indicated the frequently used passages.
2. The Socio- Economic survey of the villages, prospering in the midst of the corridor area and thus, creating friction on a regular basis, was done with the help of an organized questionnaire.
3. The collected data was analysed and put on paper to draw conclusions.

RESULTS AND DISCUSSION

Socio- economic profiles:

Literacy

Literacy levels were the lowest in Chandi. Poverty in this village pushes men to contribute as bread winners and quit studies beyond middle or high school. All the respondents had dropped out after high school. Girls are married off early because of social as well as financial pressures. The Highest literacy can be inferred to be in Shyampur, where 80% of the sampled households were at least inter (12^{th} std.) pass, 30% of which graduated further. One reason could be that many men go away to big cities in search

of livelihood and are able to earn enough to support further studies and also get more aware about the importance of education. Chidderwala respondents quit before entering college and Pulinda and Aamsod showed a mix with at least 20% being graduates.

Dependence on Agriculture

In all the surveyed villages, at least 50% of the households depended on another source of income, apart from Agriculture (**Figure 8**). The reason behind this was the unpredictable nature of yield. Raids by elephants were a major reason for farmers to rely less on agriculture as a source of income beyond the level of subsistence and look for other options to sustain, in case the entire yield is destroyed by the famished elephants. The Maximum no. of households depending solely on agriculture as a source of income was found in Chidderwala- 35%. Further, Aamsod had 40% of households that had either given up agriculture or did not own any land and depended entirely on non- agricultural income sources. In Chandi, the individual land holdings had hugely constricted because of repeated partition of property over generations. This reduced the yield as well as multiplied the financial and psychological losses at personal level, in the situation of elephant raids.

Human-elephant conflict*:*

Human- elephant conflict is a pervasive issue and may lead to intolerance and anger among rural populations, if not dealt with promptly. Various aspects of a community like literacy, religious beliefs, financial status, crops grown etc. contribute in shaping the perceptions, retaliations, application for compensation against damage and outlook towards conservation. These are all vital elements for ensuring protection of the majestic creature and harmonious co- existence with humans. The conflict arises when either humans or elephants trespass into each other's territory and cause any form of physical, financial or psychological losses to the other. The tolerance levels of humans depend to varying degrees on the social, financial and religious set up of the community.

Type of* Fig. *Conflict

Physical damage is unacceptable to the people and was only recorded in Chandi, Chidderwala and Shyampur villages (5-10%). Maximum property damage (approx. 20%) was reported from Chidderwala and Shyampur (**Figure 9**). These two being comparatively bigger settlements had about 20% respondents with no conflict. The solar electric fences (installed in 2004-05) were maintained well by some households in Chidderwala and thus, kept these respondents safe till date. In Shyampur, although no such measures were taken by the government, these were mainly the respondents who did not reside at the immediate forest area frontage and were safer in the interior of the village.

No physical or property damage was recorded in Pulinda or Aamsod villages. In Pulinda, all the conflict was agricultural as the houses were away from the fields on the opposite hilltop. Additionally, the elephants usually foraged throughout the night and returned to the reserve forest in the morning, leaving behind agonized farmers.40% of households in Aamsod had no conflict, mainly because of the concrete wall that was built by the government several years back. In spite of being immensely degraded by erosion from River Khoh, it still protects many fields.

Cropping

Wheat is the major crop grown in both the study areas. Sugarcane was grown majorly in Chandi only and to some extent, in Chidderwala too. Other villages avoided growing it due to elephant raids. Shyampur respondents did not grow sugarcane at all. Rice is not grown in Chandi because of lack of water. Irrigation is possible only after paying for water supply for fixed number of hours. Shyampur and Chidderwala though, grow rice.

In Pulinda and Aamsod, the investment in field was negligible because farmers generally followed organic farming. Seeds and fertilizers were not bought unlike in first study area. Seeds from the earlier yield were saved for next and cow dung was used instead of fertilizers. Wider variety of crops was cultivated here including onions, potato, Napear and Ginni (two local fodder grasses that boost milk yield

in cattle). In Pulinda, pulses like arhar and masoor, garlic, ginger and various spices were grown along with the main crops wheat, rice and barley.

Crops raided

In Shyampur, only wheat is destroyed because sugarcane is not grown by the fringe farmers. Rice and maize are kharif crops that are sown with the first rains in July do not attract elephants. Although the young leaves that grow on the fields shortly after being sown attracted the young calves and their mothers in Chidderwala, no other village reported any damage to rice yield. One big reason is the abundance of fodder and grasses inside the jungle with the onset of monsoons. Another reason cited by the villagers in hilly areas of Pulinda and Aamsod was that the swampy soil could not hold the animal's weight and it became difficult for animals to raid the fields (**Figure10**). Sugarcane was grown extensively in Chandi and sent to the sugar mill nearby in Doiwala. Thus, in Chandi village, maize, sugarcane and Chari (cattle fodder) were also raided apart from wheat. A variety of crops are grown in Pulinda, - fruits, banana trees, kitchen vegetables, pulses, barley, apart from wheat and almost all of these are raided by elephants, those that are not eaten are damaged by trampling.

Time of visit

In the plain areas of first study area, maximum incidences of attack by elephants took place after dark (in late evenings or night). In many cases, it was observed that elephants would come at around 12:30 at midnight and would only leave the fields in the morning, around 4:00 A.M. Although elephants are not nocturnal creatures but were found to moderate their feeding habits in accordance with availability of food, in order to survive and avoid being caught and chased away. In Chandi, 100% of the cases occurred at night. Only about 30% of respondents reported also being raided in daytime in Chidderwala and Shyampur. In the hilly region (second study area), Pulinda showed the highest number of respondents claiming daytime attacks as well. This could be due to the step farms being very far from the houses (on the opposite hilltop) and not being guarded enough. In Aamsod however, all attacks happened at night only.

Months of elephant raids

Highest conflict was reported in the months of March- April (**Figure 11**) when wheat crop was ready and harvested. March- June were months of high forest fire and lack of water and shelter drove the animal to move towards greener pastures with water sources that could quench their thirst. The greater ranging movement, thus, allowed them to come across greater number of human habitations and agricultural fields (Sukumar, 2000). Wheat heaps that were kept aside after harvesting and others that matured in the fields, attracted the wandering elephants immensely. The conflict levels were minimum in July- September in first study area and completely absent in the second area. This was because in these months, with the onset of monsoon in North India, the forests flourished and had ample fodder for sustaining the animal. Their food requirements were thus, met within the forests and did not require them to gain nutrition from crop fields. Raiding pattern grew with winters as there was slight scarcity of fodder because of approaching autumn season.

Damage done

The majority of agricultural loss was borne by wheat cultivators. Granaries and houses storing bags of flour and wheat grain were often raided by elephants. Although the proportion of physical damage or death was very low, such incidences mostly happened when the animal was chased or instigated. In some cases, however, tuskers and cows escorting their calves turned violent and harmed the villagers. In Chandi, about 75% (Figure 12) of damage was medium level (2-6 bigha) and the rest (~25%) was less than 1 bigha (low). Large areas of sugarcane were particularly destroyed. High level of Conflict was absent because the patriarchal property (fields) were divided among brothers over generation and had left the farmers with only 2- 6 bigha of field under plough. Also, no property damage was recorded from this village. However, death of a villager occurred in April 2008 but the incident happened inside the forest and not in the village. Property damage of granaries or house walls were only majorly reported in Chidderwala and Shyampur villages. A few incidences of physical damage were also reported from these

two villages. 40% of households in Aamsod had no damage because they did not have any fields at all or because the fields were still considerably protected from the concrete wall built several years back. At places where the wall was broken, low and medium level of damage was recorded. In Pulinda, a herd of three often even entered the interior of the village for the banana trees grown there. Pulses and onions were trampled. No property or Physical damage was recorded. Although elephants did not eat all the crops grown in the field, they trampled and destroyed other crops grown along with wheat, barley and bananas. This raised the total loss borne by the farmer.

Herd size of elephants

Majority of raids (50%) in Chandi village, were by small herds (2-5) of elephants. About 42% of cases also showed attacks by herds of 7 and 12. This was probably out of fear of the villagers, who never left their crops unguarded. Only 8% of all the cases were those of attacks by tuskers. In Chidderwala about 30% of cases showed tusker attacks. Smaller herds were more common. In Shyampur, either tuskers (30%) or small herds (3-4 elephants) were seen (55%). Large herds of 10 elephants were seen only 12% of times. In Pulinda the same herd of 3 elephants and a *makhna* (tusk less) male used to raid the crops repeatedly. The distance from houses to the fields was long and the elephants could easily get attentive before any harm could be caused to them. Aamsod showed equal nos. of single, small and large herd attacks.

Deterrent methods adopted

Due to the ever increasing interface between humans and elephants, various intervention methods (**Figure 13**) have been tried, tested and adopted over centuries. These include:

1) Traditional methods, 2) Disturbance methods, 3) Killing methods, 4) Translocation
5) Repellent methods, 6) Physical barriers and 7) Compensation schemes

Out of all the intervention methods adopted to deter elephant attacks, Traditional methods of creating noise, fire and guarding crops were the most commonly used method in all the five villages. Buffer crops (like *aloe vera*- unpalatable and spiny) were used sometimes around fields in some villages but have not proved to be very effective. Cleared field boundaries were used as simple buffer zones in some areas. The most effective purpose of these clearings is for crop guards to see elephants before they enter the fields and get alert. Noise is made by beating utensils and drums or from tractors. Kerosene loops are used to chase away elephants and have been successful in few villages. However, tuskers are known to extinguish the fire loops under their foot sometimes. Guarding crops is inevitable during the period of standing crop and at the time of harvest. This indirectly leads to psychological stress due to lack of sleep and contributes to a tendency of dropping out of school because of lack of sleep (in need of more members to guard the property) and ultimately lack of employment opportunities (Hoare, 2000; Sukumar, 1990). Very simple techniques like single wire barriers with tin cans and bells to make noise were used in Aamsod. Traditional methods alleviate the problem of conflict only temporarily or shift it to a nearby area (Tchamba, 1995). The biggest problem with traditional methods of noise, fire etc. is that elephants are intelligent animals and after some time realise that there is no real threat and become habituated (O'Connell-Rodwell *et al.*, 2000).

Killing and disturbance methods were not reported from the study areas. Translocation of a problem tusker responsible for killing several people in and around the Barkot and Rishikesh range was translocated to the Chilla range. This technique can fail too because elephants tend to return to their original habitats. Olfactory repellents, although extensively reported from other Asian elephant areas were absent in these regions. Physical barriers were provided by the government and constructed by the locals but could only prove successful to a limited extent.

Trenches and moats were dug by FD and locals but were not very successful because the elephants were known to fill the trenches with soil and cross over. In monsoons, these trenches levelled and did not hinder the movement of elephants. If dug, their depth should be maintained regularly. Stone walls are expensive to construct in the absence of usable stones. They were constructed in Aamsod several years back and have showed limited results. It is proposed to be built around Pulinda village. Constructed along

the River Khoh behind Aamsod, the wall degraded as a result of erosion from the river. Also, the villagers broke it at places to pass through. Elephants are also able to break them with their chests. A new wall with a concrete top or an electric wire along its top are proposed now. The advantages of stone walls are their minimal environmental impact and their relatively low material costs if the stones are readily available and tractors do not have to be used (Nelson, *et al.* 2003).

Solar electrified wires were extensively put up in Chidderwala and to some extent in Shyampur village but had failed completely to control attacks by elephants. Apart from a small section of Chidderwala (Nawabwala), no electric fences were left to stop elephants from raiding crop fields or attacking houses or granaries. Failure of electrified fences is known related to maintain the regime strongly (Hoare, 1995). The main problems that were observed in these villages was battery and wire theft, low voltage and eventual breaking by elephants, vegetation growth leading to power leakage and breaking by villagers to pass cattle or tractors over the wires. It is important to maintain constant high voltages as low voltage render the fence ineffective. It may only become an irritant to elephants provoking them to destroy sections of fence (Hoare, 2001a).

In Chandi, the people are poor and do not buy crackers, they use them only if provided by the FD. Thus, only 13% use it to chase away elephants. Villagers gather and beat utensils (48%) and throw kerosene loops (~38%), 2% also use torchlight as a disturbance method (see Figure 20) at stubborn herds and bulls. In Chidderwala, crackers are bought by certain people (21%) or saved up after Diwali. Approximately 40% beat utensils and make noise with tractors without silencers. Car headlights and torchlights are also used by few (8%). Kerosene loops (32%) are common methods to deter elephants. In Shyampur, crackers are burnt (~35%) most of the times. Kerosene loops are thrown (20%). Battery run torches are shown sometimes (2%). The FD beat office is right next to the village and often (20%) helps chase them back into the forest.

In Pulinda, it becomes very difficult, owing to the terrain, to chase away elephant herds, so, often (15%) the FD is called to rescue. 31% cases showed use of Crackers (distributed by the FD). Beating utensils remained the most common way (45%).

Aamsod uses Crackers (32%), beating utensils (33%), kerosene loops (20%) and spotlights (11%) to drive them away. A unique method was also used in this village for driving away all wildlife by noise. A no. of tin canisters were hung at different locations in the entire field and connected by a metal wire up till the house. Before entering the field, the farmer would ring the tin cans to chase away any wildlife in the field (Figure 14).

Compensation schemes were widely introduced in both the study areas. This method of intervention has failed to address the root cause and only tends to the effects. There are several drawbacks that were evident in all the villages.

The demands for compensation almost invariably grew and indicated bogus or inflated reporting.

These schemes also reduce the tendency of farmers to guard their crops, which invariably raises the frequency of raids (Taylor, 1999).

Since, the animals are owned by the government, there is a general tendency to threaten the FD about killing the animal, if not pacified with compensation in return. The major problem that was faced was of inflation and inability to check the actual damage caused, if any. In Pulinda particularly, certain people who hadn't lost any crops were quoting damage that was impossible to be yielded from the land they owned. Unequal disbursement of compensation raised the social enmity and resentment against the wildlife authorities. Disproportionate and low funding because of lack of central funding was also common. The bureaucracy, long application procedure and delayed administration lead the genuine victims to suffer. Many respondents (in Chidderwala) even pointed out corruption in the system leading to non- payment of granted compensations. Several people quit applying for compensation because others in the village did not receive it. The only positive aspect was that cases of conflict were reported and allowed demarcating the high conflict zones. The inefficacies are many and there is no end to granting compensation. This is not a solution to the problem of HEC as it does not change the relationship between

the wildlife authorities and locals and no awareness about the importance of elephants and the need to conserve them was spread. In a few cases, of granaries being attacked (Chidderwala) and entire fields being destroyed (Shyampur), there was reasonable ground for compensation payments because the damage was almost life threatening in that there was no food left to sustain the household. It has been shown though, that elephant damage only seriously affects very few people in a community (Hoare, 1999b).

Major Utilisation in First Bottleneck

The Barkot- Kansrau corridor is important for avoiding genetic isolation between populations of Rajaji National Park and Dehradun FD. The narrowing area is a looming threat and has almost cut the remnant veins of life connecting the reserve forest to the national park. Various settlements are gradually blooming and encroaching further into forest land, scraping off the fringes year by year. The pressure of these villages apart from spatial encroachment is also immense. Daily fuel wood and fodder demands are huge. The major threat, however, is the illegal felling of trees for wood and sand and boulder mining from Song River. The Dehradun- Haridwar highway (National Highway- 7) with its heavy traffic is the biggest source of disturbance for the wildlife. Only bulls are known to cross over to get to water and food sources in the adjoining forest patch. In spite of just being a linear obstacle, it greatly restricts the movement of female elephants and herds and is the major reason causing the gradual death of the corridor. About 14000 vehicles in 2007-09 pass across about a 14 km stretch of forest, hindering the movement of Asian elephants (Joshi R. et al, 2010).

Illegal felling and mining was not prevalent here. The major hindrance to movement of elephants to and from River Khoh was the heavy traffic on the Kotdwar- Lansdowne highway (NH-119). This is a high ecological priority corridor (Johnsingh and Williams, 2005) and needs to be protected. The expanded Kotdwar town and pressure of villages like Aamsod, Naudi and Pulinda on the forest is also high.

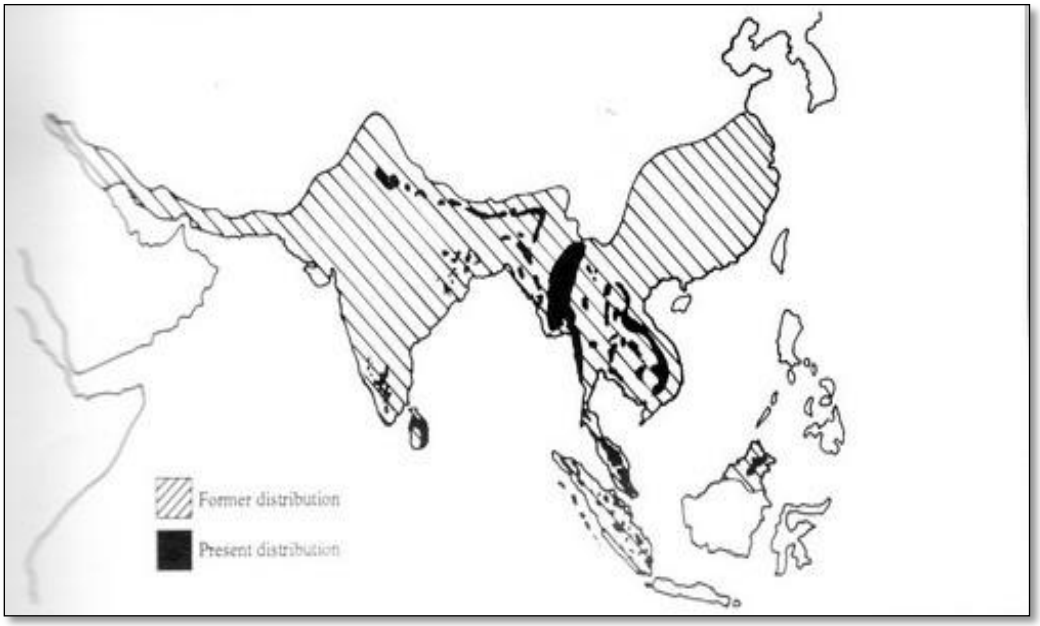

Figure 1: A comparison of the former and present distribution of Asian elephants in the world

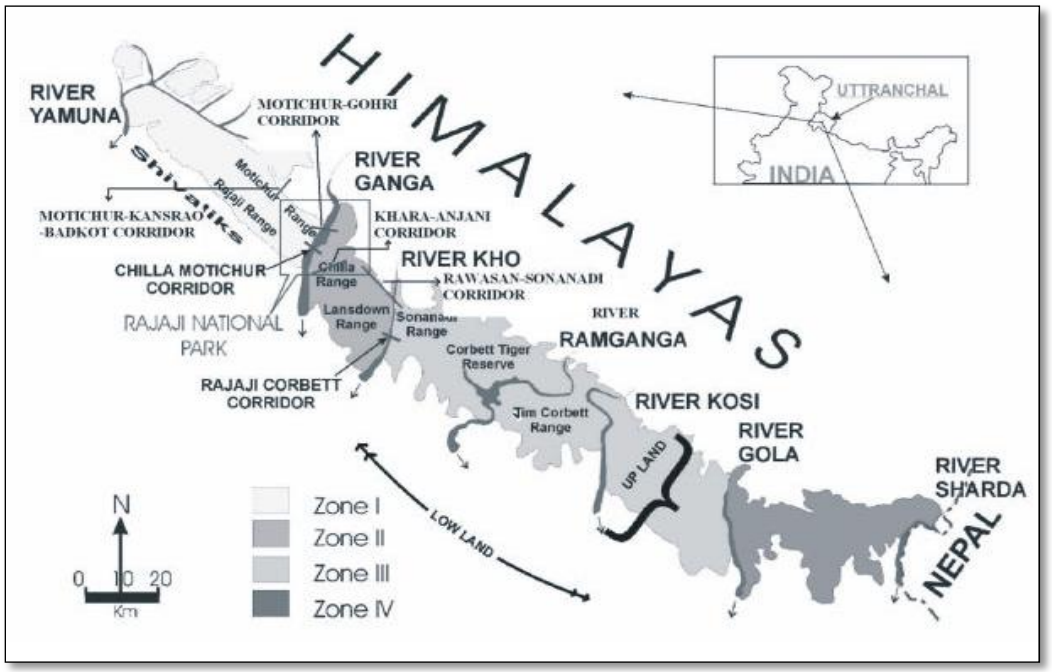

Figure 2: The main elephant corridors in Uttarakhand (Source: Joshi R. et al, 2010)

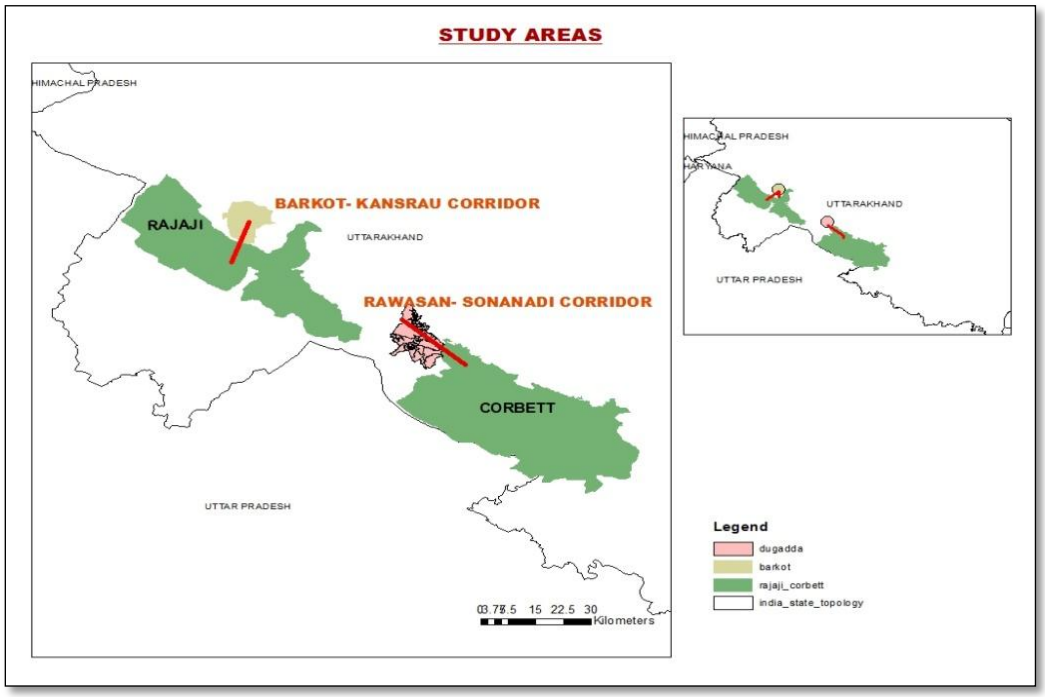

Figure 3: The corridors studied in Uttarakhand: Barkot- Kansrau and Rawasan- Sonanadi corridors

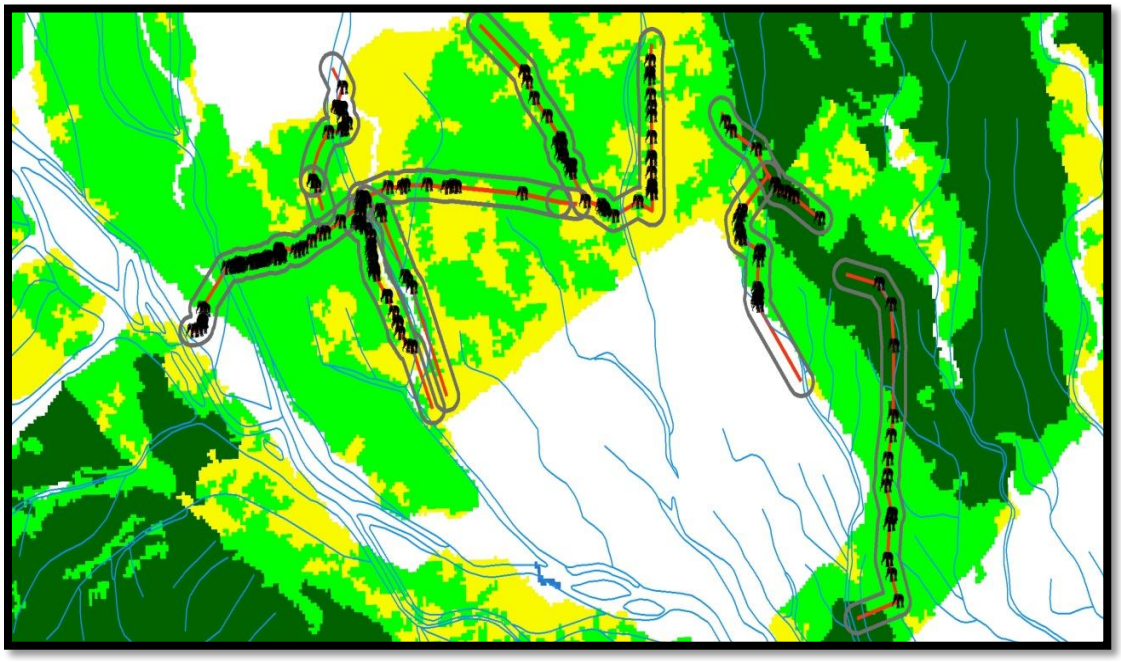

Figure 4: In first study area: Barkot- Kansrau corridor, whereas the direct and indirect evidences recorded.
Yellow: open forest, blue: water, light green: moderately dense forest, white: non- forest, dark green: very dense forest

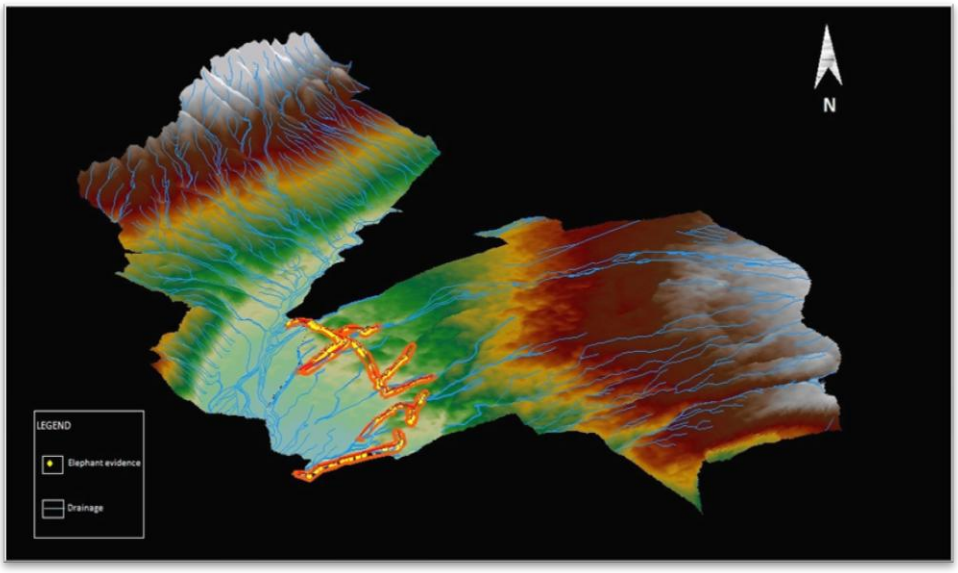

Figure 5: Barkot- Kansrau range with transects covered and evidences of elephant presence

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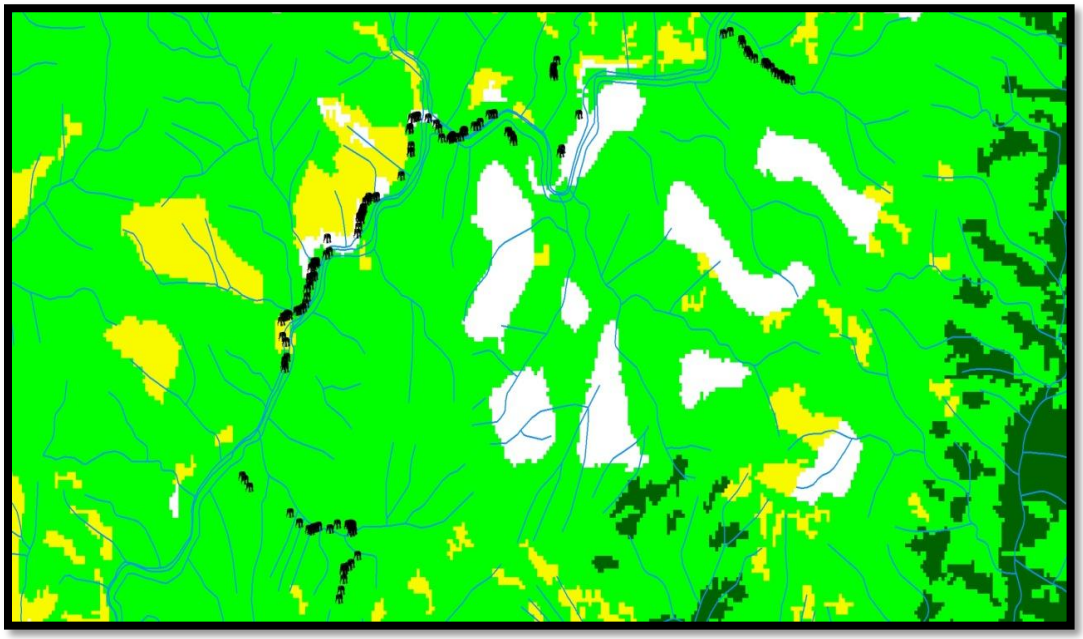

Figure 6: Second study area: Rawasan- Sonanadi corridor (Dugadda), whereas the direct and indirect evidences recorded
Yellow: open forest, Blue: water, light green: moderately dense forest, White: non- forest, Dark green: very dense forest

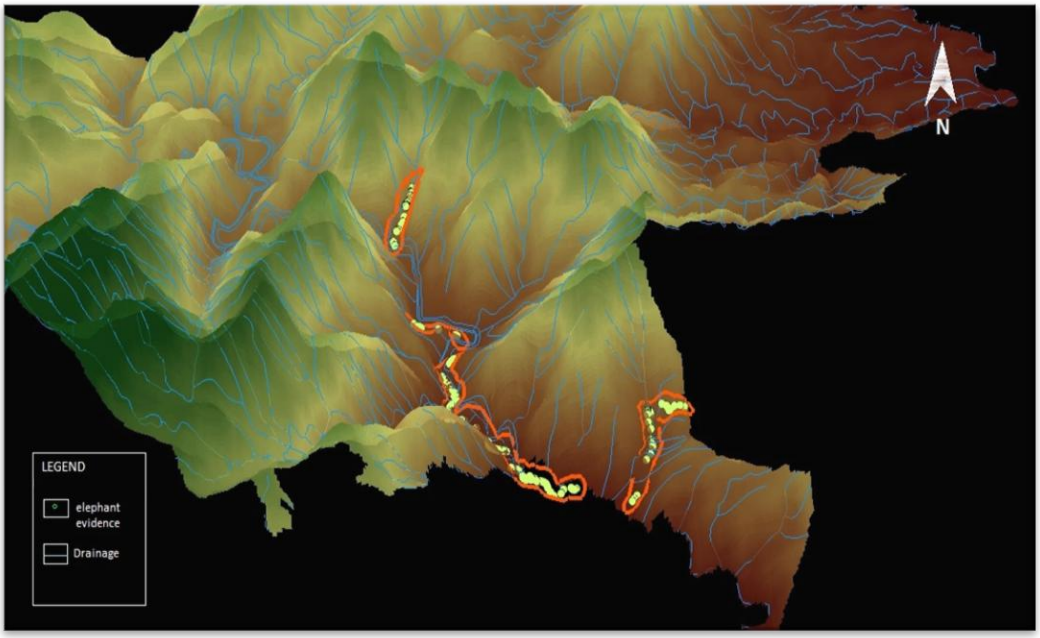

Figure 7: The Dugadda range, where the Khoh riverbed is used in the form of a corridor showing the transect covered and the evidences noted

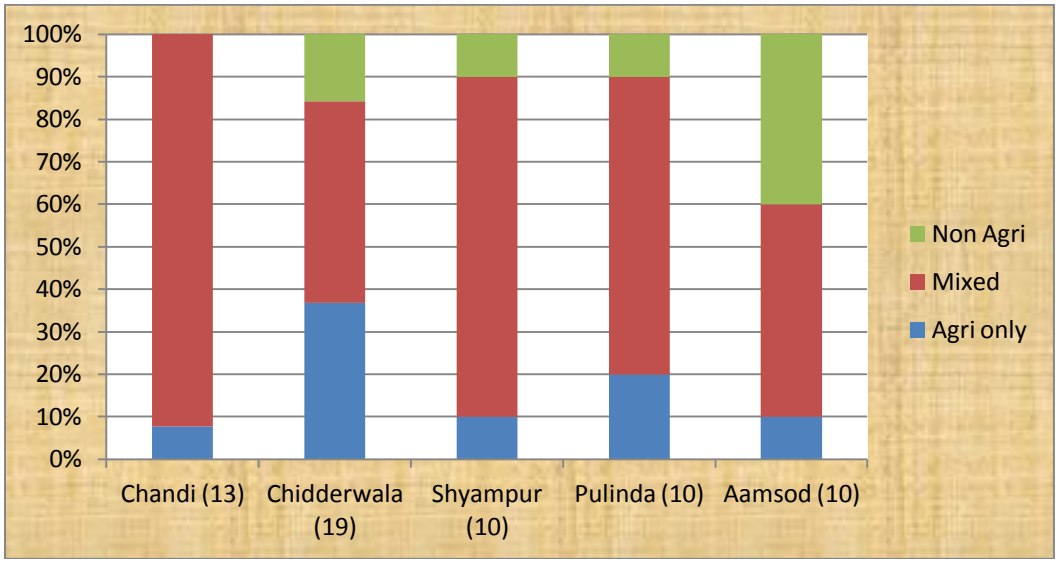

Figure 8: Comparison of occupation in different villages

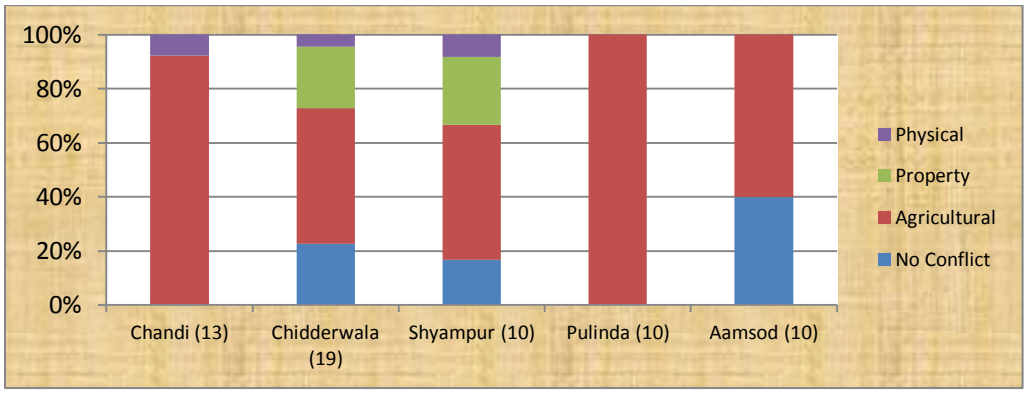

Figure 9: Comparison of type of damage by Elephants in different villages

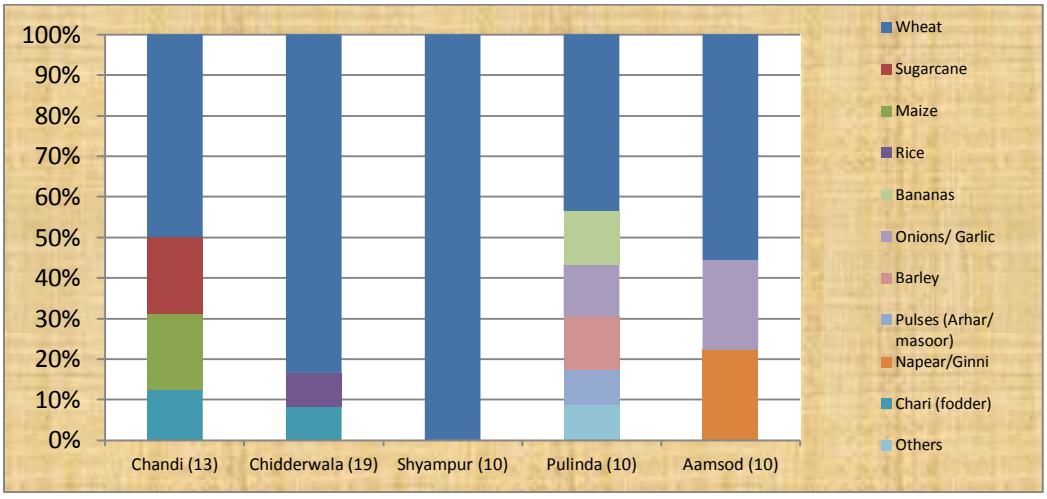

Figure 10: Proportion of various crops that were raided by elephants

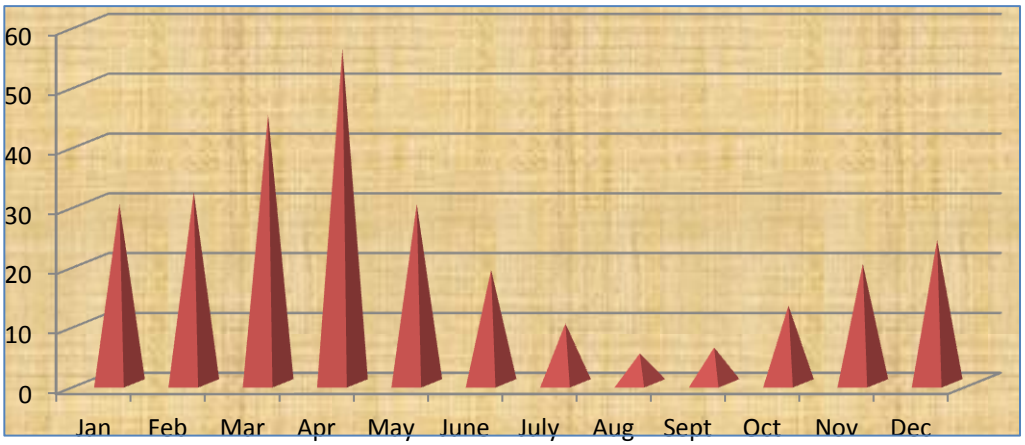

Figure 11: Total number of raids reported/ year

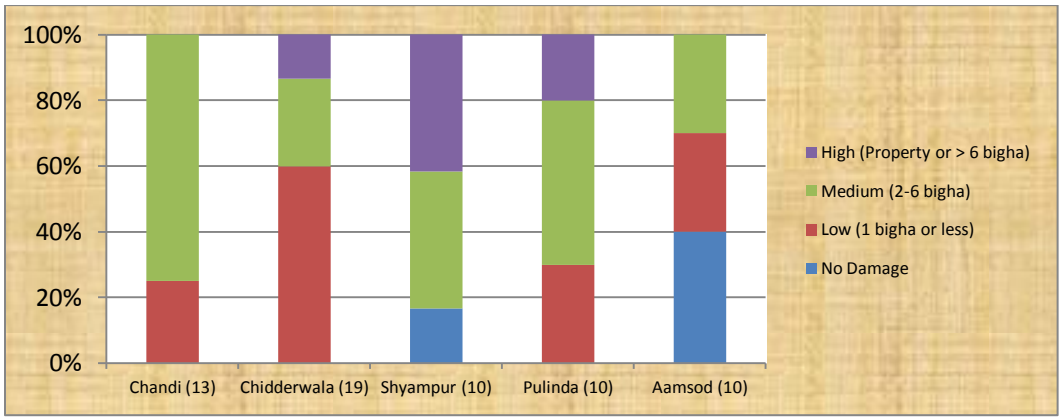

Figure 12: Degree of damage caused in different villages

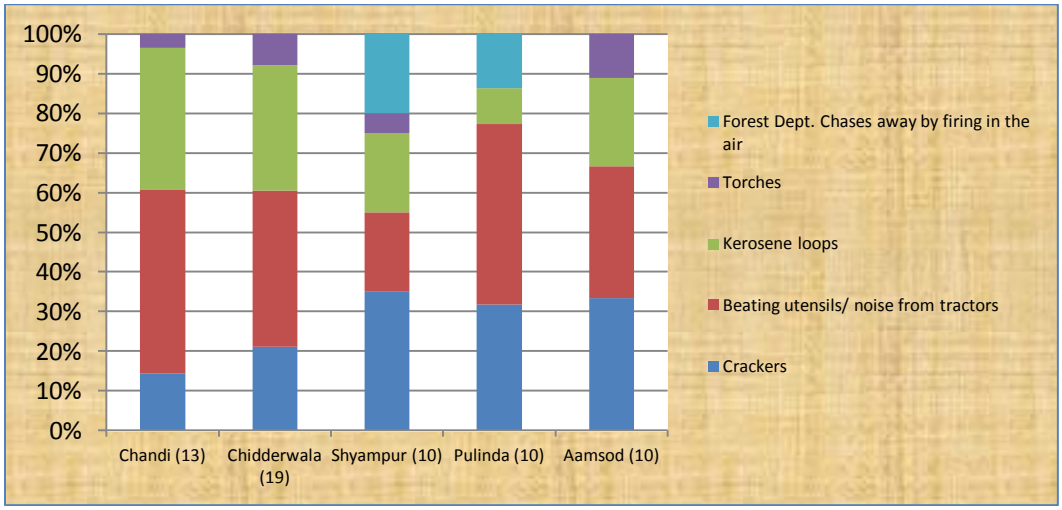

Figure 13: Different deterrent methods used by villagers

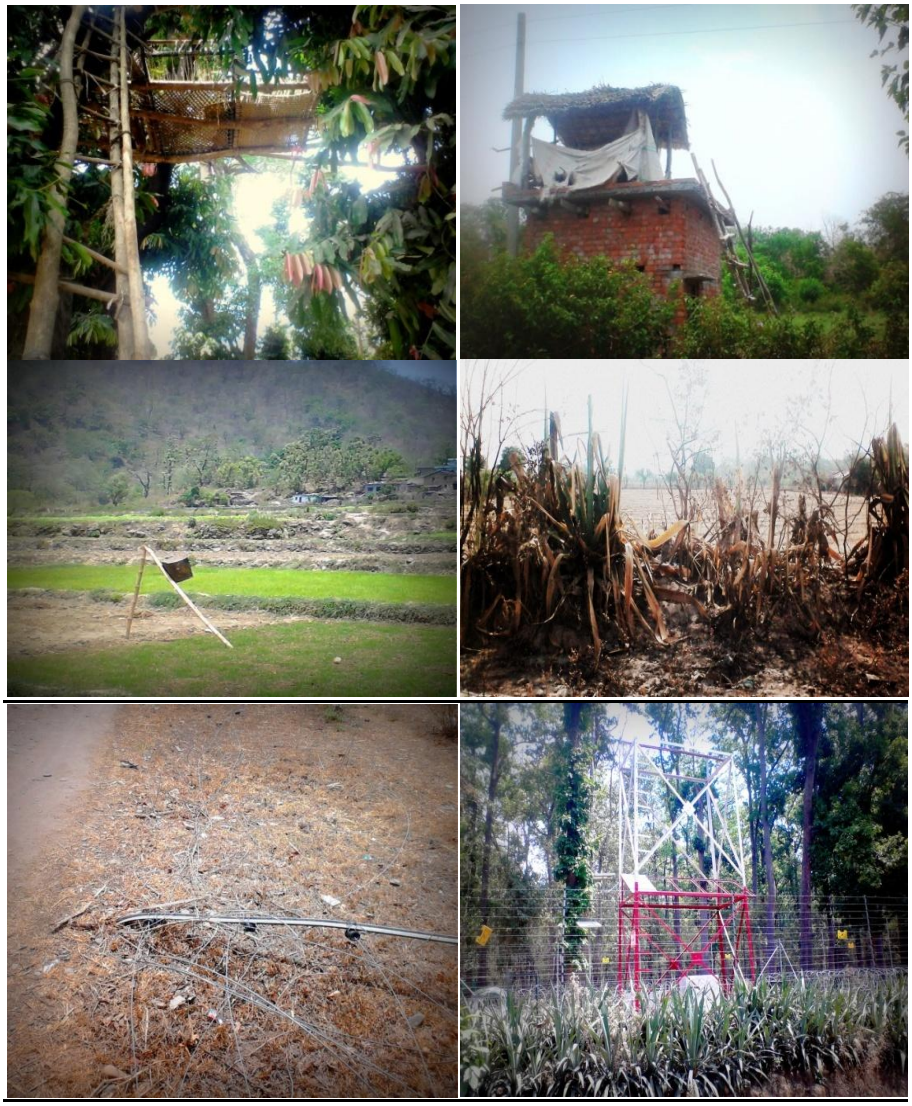

Figure 14: Clockwise from top left: A machan in Chandi to climb when elephants come, a machan to guard crops in Chidderwala, buffer crops like *aloe vera* planted outside the fields, electric fences along with buffer plants, trenches and electric fences and a damaged electric fence in Chidderwala, tin cans to create noise in Aamsod

CONCLUSION

As compared to the other herbivores, elephants are the most dangerous, owing to their large size, heavy weight and tusks, thereby causing more human deaths and injuries (Sitati, 2003). It is because of this reason that elephants often elicit fear more than sympathy on causing damage to people in rural communities (Parker et al, 2007). The damage that these giant creatures can cost a villager can be immense at a personal level (Parker *et al*. 2007; Osei-Owusu and Bakker 2008). There may be emotional and symbolical value attached to many assets that cannot be compensated for. Loss of life is intolerable. The rural communities live in constant fear and bear the brunt of these elephants on a daily basis. Over time, they retaliate by electrocuting, poisoning or shooting any giant that approaches. They may also turn

a blind eye towards poaching in retaliation. Human elephant conflict undermines the support and sympathy imperative for conserving this endangered species. Direct threats to the Forest division have been given to the FD in Chandi, Shyampur and Pulinda. In this scenario, it is very important to protect this majestic animal by mitigation of the conflict. There are several studies that have been done and concluded that mitigation is the best solution for conservation of elephants (Fernando et al, 2008 and Zimmerman et al, 2009).

In the villages around the first bottleneck, the pressure on the adjoining forest is immense. Apart from fuel wood and fodder, many villagers are known to be involved in illegal activities like felling of trees, mining in Song River and brewing of country liquor using Sal tree bark inside the dense forest. This greatly disturbs the docile creature's movement along the corridor and contributes to food scarcity and habitat degradation. In the second bottleneck, the forest cover is more and disturbance is lower as compared to the first. The highway is the major impediment. This corridor is of high priority as it is very commonly used by elephant herds that can be easily spotted in morning or late evening hours at the Khoh River or crossing the highway. The tourists and travelers often stop by to click photos and tend to tease the majestic creature. Such incidences must be checked and halted.

Highest level of conflict was found to be in Shyampur village, in terms of damage caused (40% high and 41% medium degree damage). However, the frequency of attacks was high in Chandi. Chidderwala and Shyampur had the highest percentage of property damage (~20%). The reason for highest conflict in Shyampur could be many: 80% of the households were inter pass (12th std.) and above. These lead to better job opportunities with 90% of the respondents either depending on extra sources of income, other than agriculture or entirely quitting agriculture (10%). Because of higher literacy, the villagers reported damage and filed for compensation extensively either directly to the ranger or the pradhan of the village. The highest number of applications (80%) was filed in this region and prompt reporting could be one reason for higher conflict appearing in this village. About 40% of the men went to big cities like Hyderabad and Mumbai in search of jobs. This directly lowered the guarding of crops and raised the incidences of raiding by elephants.

In the second bottleneck region, conflict in Pulinda was completely agricultural but higher than Aamsod. In Aamsod, many fields were saved due to the remnants of concrete wall built along River Khoh. Only at certain points, where the wall was completely degraded, elephants entered the village and destroyed wheat (55%), fodder grass (20%) and onions (25%). The major conflict was in Pulinda, where 70% of the damage was medium or high degree damage. There were several probable reasons for this:

The agricultural fields were on the opposite hillside, away from the houses. The elephants climbed up a "naala" (or small rivulet leading to River Khoh) to reach the fields and chasing them away was difficult. 70% of respondents reported that elephants visited both in the day and night time. The damage was high (20%) and medium degree (50%) because it multiplied, as several crops were grown together (for household purposes as well). When elephants came to eat wheat, barley or bananas, onions, garlic, ginger, pulses and spices were also trampled. There was no intervention methods like electric fences or walls put up by the government till date. Lastly, inflation of damage for compensation was a big problem in this village.

Deterrent Methods Proposed

Since, the method of solar run electric fences failed in Chidderwala because of lack of maintenance, alternatives should be contemplated. A big reason for failure was that villagers living in the interior, who did not face conflict, were insensitive to it and cut across to make way for cattle or tractors. Stealing of wires and batteries was another reason. Electric fences thus, should be installed separately around each household and field of the victims, so that better maintenance can be done. Watchmen can be hired in worst cases by a few households to take care of the vital components. Along with the traditional intervention methods, several other methods (like olfactory and auditory repellents) that are widely used elsewhere should be introduced to these people. A combination of various deterrent methods like chilli powder with grease, smeared on fences; unpalatable cash crops that act as buffers and also bring profit

with trenches and electric fences, should solve the problem. In the second area, electric fences would not be successful, owing to the terrain and thus, stone walls with concrete top or electrified fence running all over it would be effective.

The villagers need to be made aware and sensitive towards the cause of protecting Asian elephants and recognizing the animal's importance. Their educational and job requirements must be met so as to make them financially secure. Such awareness programmes would make them responsible and supportive and they would stop degrading the habitat of elephants. Only when their anger and animosity for the giant as well as the FD subsided, would they stop supporting anti- social elements like poachers and help the FD to combat fire, poaching, illegal felling and brewing inside the forest. It should be reminded that these communities are a closer knit part of this forest ecosystem than any outsider. No conservation programme can be a success without involving the local communities. Further long term research has needed in this region to provide the sustainable managements of wild elephants and their long term run.

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