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Detailed Spatial Analysis of Human–Elephant Conflict, with an Emphasis on Correlates of the Socio-Ecological Aspects in Southern Maharashtra, India

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Abstract: The extensive efforts of conservation do carry a cost of human-animal conflicts, especially to the human population residing in the close proximity of the wildlife. The Asiatic Elephant (*Elephas maximus*) populations are in a constant zone of conflict throughout their range of inhibition and such conflicts threaten and further weaken their survival aspects. The elephant migration in Maharashtra, India started two decades ago when the first documented herd entered the state through the forest passage south of the Kolhapur district. Since then it has resulted in a sudden spike in crop raids, human-elephant encounters and conflicts in the given area as the human communities exhibited no previous experience of tackling an elephant inhabited ecosystem. In this research, we evaluated the total crop damage by the elephants in the affected area for the years 2020-2022. On field surveys, interviews of the local communities, interaction with forest department and elephant tracking were performed for gathering data. The brief feeding behaviour by the elephant populations, the impact and correlation of the humans and elephants on different socio-ecological factors, the pervasive conflict created due to the constant encounters, the perception of this entire conflict by the local human communities and the holistic mitigation measures necessary to dissolve the conflict were inferred from the above study. These results further help in deploying environment centric policy for the conservation of these giants.

Keywords: Crop, Conflict, *Elephas maximus*, Elephant, Mitigation, Socio-ecological factors

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Introduction

The Asiatic Elephant (*Elephas maximus* Linnaeus, 1758), is a mega-herbivore, wide-spread umbrella species which occurs in 13 range (Perera, 2009; Riddle *et al.*, 2010; Baskaran, 2013). Around 60%

of the global population of Asian elephant is present in India (Riddle *et al.*, 2010). Even as the majority of the population inhabits the areas of the subcontinent, the decline in their natural habitat is

a case to worry about. Of the historical natural habitat of Asian elephants, only 55% was found to be remaining (Sarma and Easa, 2006). Nearly 80% of the Asian elephant population lives outside Protected Areas in close proximity to human habitations (Singh and Kumar, 2014). Such scenarios further result in the creation of overlapping habitats for human and elephant communities. These areas are the junctions and origin of conflicts which can lead to an unstable relationship between the local biota and the human existence in the area through crop raids, wild encounters and property loss (Kumar *et al.*, 2010)

Elephant crop raiding is largely influenced by the size and nearness of the cultivated area from the adjoining forest (Sarma and Easa, 2006; Zimmermann *et al.*, 2009; Wilson *et al.*, 2013; Patil, 2014; Nath *et al.*, 2015). Thus, forest borders, contiguous to the agricultural fields are the focal points for human-elephant conflict (Nyhus *et al.*, 2000). Ekanayaka *et al.* (2011) observed that less abundant crops are raided less frequently. Songhurst and Coulson (2014) highlighted that fields farther from elephant pathways were less likely to be raided by elephants, and fields that had been raided frequently in the past were more likely to be raided again.

Negative interactions between humans and elephants are a consistently rising conservation and social problem across the range of elephants in Asia (Gubbi *et al.*, 2014). Elephants are one of the least tolerated crop raiding wildlife species as the intensity of damage per conflict incident is much higher than with any other species (Naughton-Treves, 1998). Effects of human elephant conflict (HEC) such as crop damage, injury or death spread rapidly leading to fear among people (Ngure, 1995). This in turn has negatively influenced the local support for the elephant conservation which threatens the survival of elephants, especially outside the protected areas (Wilson *et al.*, 2015).

Since the fringe villagers do not know the ecosystem services directly obtained from

elephants, they have developed a negative attitude towards elephant that is hindering the conservation effort (Bhattacharya *et al.*, 2017). HEC mitigation is further complicated because it frequently affects communities that are already disenfranchised (Sampson *et al.*, 2021). One of the methods followed by several Governments to offset economic losses imposed by human-wildlife conflict is by providing monetary compensations to affected people. Nevertheless, this scheme has come under severe criticism as compensation payments are often too meagre, delayed and the procedures to avail of these compensations are time-consuming (Gubbi, 2012).

The present conservation challenge is to maintain viable elephant populations with minimum negative impact on humans (Kangwana 1995). For the long-term, landscape-scale strategies for habitat restoration and elephant conservation are essential, but these are conceptually and politically challenging to devise and take many years to implement (Zimmerman *et al.*, 2009). The survival of these species will depend not only on reducing proximate threats from illegal hunting and sufficient protection of extant range, but on preparing for possible range shifts and their associated challenges under scenarios of global change (De Silva *et al.*, 2020). Long-term resolution of human-elephant conflict requires a simultaneous focusing of management efforts on site-specific considerations as well as the formulation and application of strategic plans at the landscape level (Shaffer *et al.*, 2019).

Maharashtra state in western India did not have resident wild Asiatic elephant populations in the recent past, though there are records of their dispersed presence (Mehta and Kulkarni, 2013). Yet, the traditional elephant range did not include the states of Maharashtra, Goa, and northern parts of Karnataka state (Kulkarni and Mehta, 2011). The historical range of elephants in the Western Ghats is suggested to have extended farther north than the present range (Patil *et al.*, 2021). Since November 2002, elephants from Dandeli Wildlife Sanctuary were reported further north in the

forest-plantation mosaic of Sindhudurg and Kolhapur districts of Maharashtra (Patil and Patil, 2017). This range extension or emigration of elephants into a previously unoccupied range and the consequent human-elephant conflict (HEC) drew a lot of attention in the socio-political spheres of Sindhudurg and Kolhapur districts (Patil and Patil, 2019).

In this study, we evaluated the crop damage pattern and impact for the period of two years (2020-22) for the elephant inhabited districts of Kolhapur and Sindhudurga. The crop selectivity and preferences by the elephants, the crop damage statistics, the impact created due to the crop damage, the mitigation measures undertaken by the local forest department and the necessary precautionary steps to be implemented for the conservation of the elephants are also devised in this study. The research work also mention about the spatiotemporal and seasonal variation in crop damage cases along the area of survey. Spatial analysis of the conflict patterns is essential for understanding the underlying processes of conflict, and to develop mitigation management plans which prioritize high-risk regions. In general, there is a certain notable relationship between the spatial phenomenon of the human elephant conflict and the geography of that area (Tripathy *et al.*, 2021). The study also emphasized on site selection by elephants for crop raiding and the perception of the local people in context of the negative impact on their yield as well as present scenario of conservation discussions. Thus to summarize, this research work will analyse the causes of conflicts and will suggest imperative steps required to dilute the same.

Materials and Methods

Area of survey:

The area of survey comprises of two districts situated in the southern part of Maharashtra namely Kolhapur and southern Sindhudurga. The concerned talukas for the above study include the Ajra, Chandgad and Bhudargad taluka from Kolhapur while Sawantwadi and Dodamarg taluka from Sindhudurga. The total area of the two

districts of Kolhapur and Sindhudurga is 7692 km² and 5207 km², respectively. The area of survey in Kolhapur is home to 3 east flowing perennial rivers namely Hiranyakeshi, Tamiraparani and Adnala and two annual rivers namely Ghatprabha and Wedganga. The area of survey in Sindhudurga comprises of two west flowing annual rivers namely Tilara and Terekhol.

The climate in Kolhapur is a blend of pleasant atmosphere and inland elements common to the state. The annual temperatures range from around 10 to 35°C. The district receives abundant rainfall from June to September due to its proximity to the Western Ghats with the average annual precipitation being 1035 mm. The topography of the area mainly exhibits plains and plateaus in the east with partially hilly terrain in the west.

The forest type in Kolhapur is primarily semi evergreen in the central regions to moist deciduous in the western parts. The primary mosaic consists of forest patches blended in with farmlands, plateaus and plantation habitats.

Sindhudurga district is a part of Konkan region, a narrow coastal plain in western Maharashtra which lies between the Western Ghats and the Arabian sea. The district exhibits a semi-tropical climate and remains warm and humid most part of the year. The annual temperatures vary from 16 to 32°C with the average precipitation being 3287 mm.

The topography of the area comprises of hilly terrain in the east which categorizes the Western Ghats, the coastal plains in the west and the cultivated plateaus in the central region. The forest ecosystem mainly exhibits semi evergreen, evergreen and moist deciduous forests of the Sahyadri. Figure 1 describes the detailed map of the area of survey.

Data collection:

The basic literature survey was undertaken in order to understand and map the historic range of the wild elephant populations in the two discussed districts. Further the data for crop and property damage was retrieved from forest departments

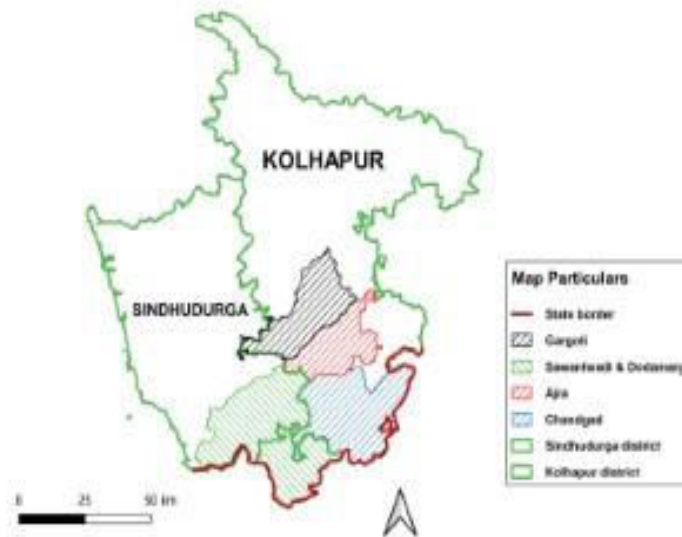


Fig. 1: Map of talukas inhabited by elephants in the districts of Kolhapur and Sindhudurga. (Area of survey).

of the two districts. Thus, using this data the intruded villages' list was obtained and shortlisted for further examination. The registered data with the local forest departments of Ajra, Chandgad, Patne, Dodamarg and Amboli from November 2019 to January 2022 was collected. This data mainly comprises of a sectioned information regarding:

- The village in which the crop raid took place
- The date
- The crop damaged
- The area under damage in case of cultivated crops and number of trees damaged in case of plantations
- The name of the farmland owner
- Property number
- Total area under the property
- The reimbursement rate of the damaged crop in the said taluka
- The total reimbursement given.

The primary data was collected through ad hoc method which comprised of questionnaire surveys

in the villages, tracking down the wild elephants through signs, markings and local information, and through site visits. The surveys and visits which were carried out were mainly performed diurnally and some nocturnal stays were arranged in the farmlands of hotspot regions. The majority of the elephant tracking was done through secondary forest patches, farmlands and degraded forest lands and did not involve any visits through reserve forest areas, especially in Kolhapur district.

The questionnaires were mainly targeted at the perception of the local villagers and communities regarding the elephants and their local mitigation measures for the same. The interviews of the locals as well as the forest officials often lasted around 10 min each with substantial information gathered through informal chats and discussions. The questionnaire mainly focused on the social structure of the areas, the crop culture of the areas, the expectations of the local communities from the forest sources and the department, their perception regarding the forest areas and nature, their knowledge regarding the elephant behaviour, some of their important

experiences and their understanding of the need for elephant conservation.

The raided farmlands were inspected for elephant foot marks, droppings, scratch marks, and many of such signs. Fresh raids also helped in understanding and evaluating the approximate movement pattern of the elephants. The visits also focused on understanding the crop variety and agricultural diversity of the area of survey. A small emphasis was also given on understanding the relations between the locals and the forest department so as to draft the future conservation plans and directives accordingly. The GPS locations of all the areas with elephant markings and crop damages were noted. Different water reservoirs, water bodies and rivers were visited and tracked for elephant activity.

Data analysis:

All the obtained data regarding the crop damage cases was entered in Microsoft Excel and segregated into columns and rows with proper disjunction. The acquired raw data was analysed for seasonal variation, spatial variation, crop wise variation and monthly crop damage patterns by using different statistical tests. The variation along the talukas was derived using One Way ANOVA in which the test was performed to conclude any significant difference in the p values. The crop preference by elephants was calculated and derived using the Jacob's selectivity index.

The given formula of $S = R - P / (R + P - 2RP)$ was used for the selectivity index, where, R is the ratio of the damage cases of the particular crop to the total cases and P is the proportion of the area under cultivation by the crop to the total area under cultivation. The final resultant values range from -1 to 1 where, -1 indicates total avoidance of that crop by the elephants while 1 indicates most preferred crop. The data for the area under cultivation was obtained from the agriculture department of the respective regions.

The test results were formulated and presented diagrammatically using graphs and charts. The graphs were prepared in Graphpad

Prism 9.0 and Microsoft Excel. The statistical tests were also performed using the above two software. The GPS locations taken at the different crop damage sites and farms were plotted using QGIS and maps of the area of survey and crop damage locations was plotted using the same software. The answers from the questionnaires were sorted and registered in the Microsoft Excel in the same format. This data was further analysed to devise mitigation measures as well as to formulate the strategies necessary for local involvement in the conservation process.

Results and Discussion

The present survey and project work was carried out for a time span of a year from June 2021 to May 2022, while the data acquired regarding the crop damage was collected for a time period of 27 months. A total of 132 villages from 5 talukas of 2 districts were visited and surveyed during this process and the data was collected from the same. Figure 2 explains the localities from the area of survey which faced crop damage during the period of survey. Local interviews were conducted in 30 hotspot villages out of those 132 where the crop damage cases were in the above threshold region. Around 45 farmers and 4 sarpancha were interviewed in this process. A total of 7 range forest offices (RFO) were visited for interviews of the forest department and collection of local data of crop damage. Apart from the affected villages, 3 reserve forests of Amboli, Tilari and Chaloba, 7 rivers, 7 water reservoirs, a forest route adjacent to the old gas pipeline from Bambarde to Patne which the elephants use for movement across the ghats, the myristica swamps of Hewale, the pristine migration patches of Talkat and the tributaries of Otavane were also surveyed. A total of 18 affected farms were examined for crop damage analysis and tracking elephant markings. During the above time period of the survey, 20 crop types were raided on and damaged out of which 10 were harvested crops while 10 were plantation trees. Figure 3 illustrates the variation in crops damaged throughout the area of survey. The span of the project comprised of three seasons

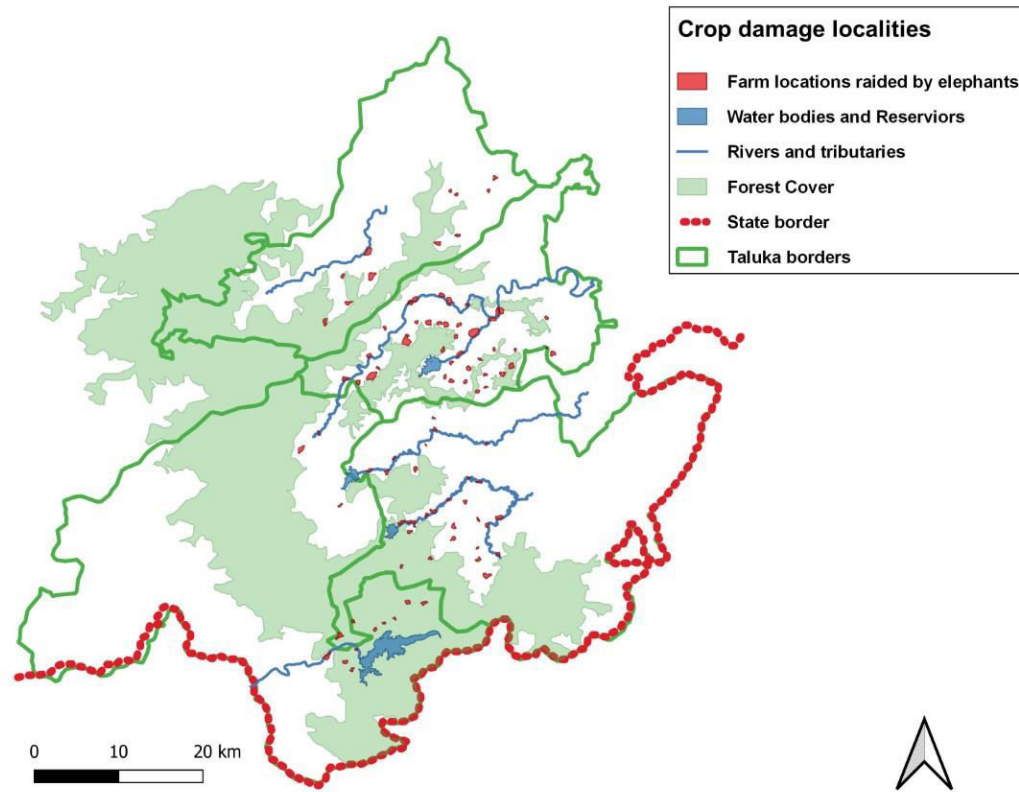


Fig. 2: Map of elephant habitat and crop damage cases in the area of survey.

Relative spatial variation in crop damage cases

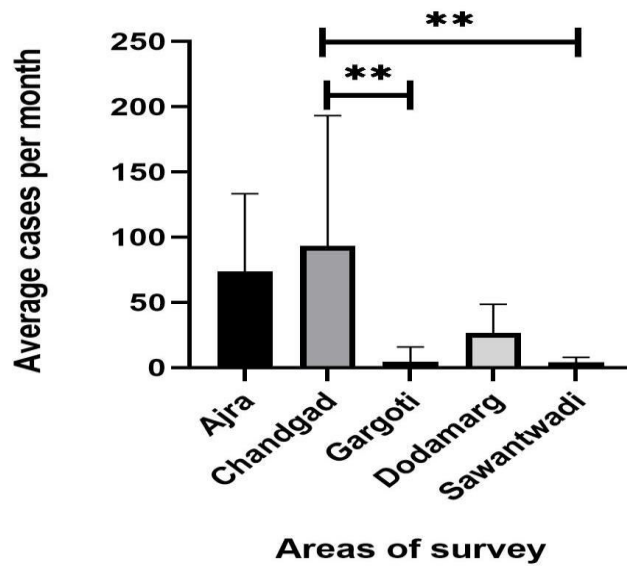


Fig. 3: Spatial variation in crop damage cases using ANOVA.

of monsoons, winter and the summers and thus apart from the data received from the forest department, an actual on field variation in number of cases were also observed. The data was also collected by discussions with the local wildlife warden and retired forest guards. Overall the survey was carried out on a larger scale in order to understand and evaluate the feeding biology of the elephants and the conflicts they face.

In the given time period of the survey, a total of 2430 cases of crop damage were extracted from the data shared by the forest department. Out of these, 870 cases were from Ajra, 1122 cases from Chandgad, 54 cases from Gargoti, 319 cases from Dodamarg and 65 cases from Sawantwadi. Some distinct vagrant cases were also recorded from Gadhinglaj and Patgaon but they were very inconsequential to be considered for statistical analysis. The total damage noted through these cases was around 346.6 ha (hectare) of cultivation crops and 3423 plantation crops and trees. Figure 4 depicts the number of cases of each crop and the variation from the complete area of survey. The asterisk highlights a significant difference between the two talukas. The most abundant crop or plant was often raided the most with sugarcane being the staple food crop for the elephants in the Kolhapur district while the coconut being the majorly preferred crop in Sindhudurga. Apart from crops, other material like bullock carts, water tanks, oil cans, scarecrows, watch towers, tree houses and wild trees in the farmlands were also damaged.

The crop and cultivation culture of both the districts differed a lot. The area of survey from Kolhapur district showed a high plantation of sugarcane crops. In fact, the survey highlighted the over production of sugarcane as a cash crop. This overproduction led to over consumption of sugarcane by the elephants, resulting in major shift of their feeding culture on crops and plantations rather than natural options.

The plain plateaus and ideal precipitation conditions further directed the farming culture of

the Kolhapur district towards cultivable crops. These crops helped them in cultivating multiple cycles throughout the year which further resulted in distributing the dependency over one crop. Also the elephant population in this area is dispersed and is never found in herds. The approximate count of 4 elephants from Kolhapur is fragmented into pockets across the area of survey. The cultivable land across the area of survey too is huge and comprises of almost three talukas. Hence even though the crop damage cases and the total damage in this district is more, it is distributed over a larger canvas, which leads to less loss of crops and property per farmer.

On the contrary, the Sindhudurga district comprises of a complete hilly and uneven terrain with humid, moist and tropical climate. This leads in creating unfavourable conditions for most of cultivation crops like sugarcane, cotton, corn, chilly and much more. The leading crop options in this district are the plantation crops which includes the orchards of mango, coconut, banana, jackfruit, pineapple and cashew. Thus the food culture of the elephant populations in this district comprises of coconut and rice as the staple food. Table 1 illustrates about the selectivity of crops across the complete area of survey by the elephants through selectivity index.

The elephant population of the southern Sindhudurga district is approximately of 6 individuals with a herd of 5 living together. The cropping pattern of the district is also restricted to mostly one cycles per annum. This does affect the overall productivity and the impact of crop damage on the same. Also the area covered by the elephants in this district is comparatively less, leading to more damage per cultivated land. This leads to more loss for the human communities in this district than that of Kolhapur and thus is creating farther more impact on the local people. Thus, the overall crop damage and cropping culture is directly proportional to each other in both the districts.

The crop damage patterns in both the districts

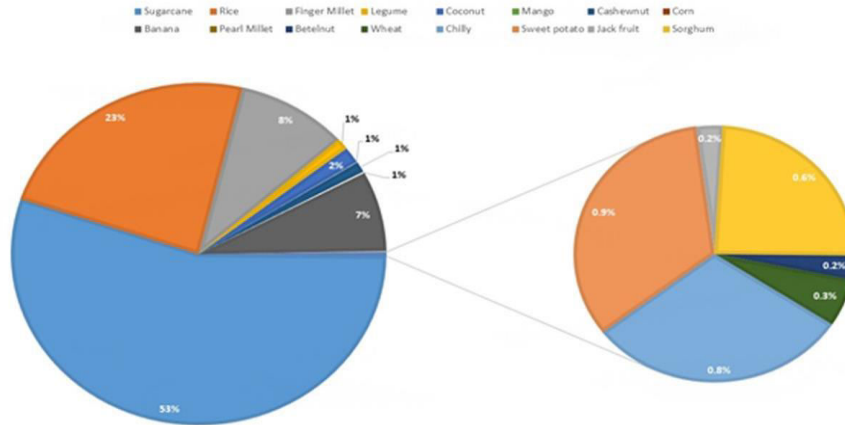


Fig. 4: Per cent of crop damage cases for each crop.

Table 1: Crop selectivity by elephants derived using Jacob’s selectivity index

S. No.	Crops	Area under cultivation in regions of survey	Total cases	Selectivity index
1	Sugarcane	24380	935	0.398193
2	Rice	1065	607	0.946014
3	Coconut	574	103	0.782958
4	Banana	450	94	0.810058
5	Finger Millet	530	206	0.899425

exhibited a monthly variation from January to December. This variation was also in connection with the seasonal cropping patterns adhered by the local communities. In the Kolhapur district, the majority of damage cases were seen in the winter season during the months of October to January. This spike was mainly seen due to the season being the cultivation, growth and harvesting period of majority of crops like sugarcane, rice, finger millet and banana. The monsoons show moderate damage cases as a stable production of rice, juvenile sugarcane, corn, coconut and betel-nut is seen in the district. The months of March to June show little to no damage cases as the cultivation period of majority crops is either over or in the initial stage. Also a lot of natural fruit diversity is available in the same period. Thus a

decline in cases can be seen in the summer season. Figures 5 and 6 demonstrate the seasonal variation in the crop damage cases along the area of survey.

The seasonal variation can also be seen in the Sindhudurga district but the change is gradual with a slight dip seen during the monsoons. The majority of the cuisine options for elephants in this district comprises of the plantation crops and fruiting trees and thus the availability of these alternatives is seen throughout the winters and the summers. Also the moist climate and abundant rainfalls in the region compels the elephant populations to spend majority of their time in the forest areas. There is a decline in the crop raiding cases from June to August in the Dodamarg taluka

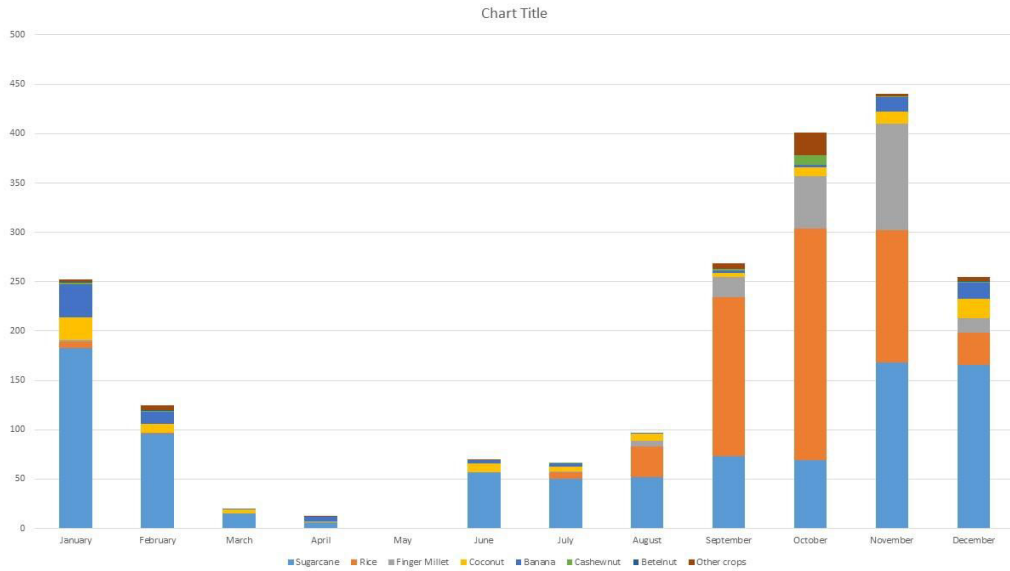


Fig. 5: Seasonal variation in crop damage cases in Kolhapur district.

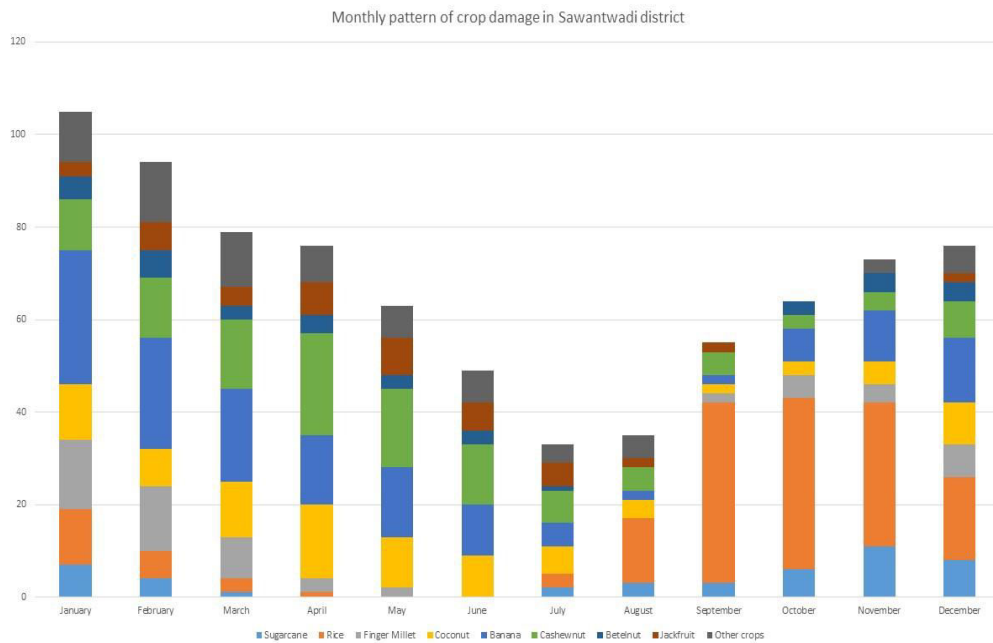


Fig. 6: Graph of seasonal variation in crop damage cases in Sindhudurga district.

while May to July in Sawantwadi taluka.

The crop damage assessment not only helped in understanding the causes of conflicts but also helped in studying the overall feeding behaviour of the elephants. They followed some very peculiar patterns and habits while showcasing their feeding interests. The majority of raids took place at night between 8 pm to 5 am. The solo elephants

spent around 2 hours in the farms for feeding if not chased away, while the herd from Dodamarg spent around 4 hours in the farms. The hotspots for the crop raids were always either near a forest corridor and reserved forest area or near a particular water body. If the spot is near both like the farms in Haloli, Masoli, Parle, Hewale and Khamdale, the density of farm raids is at the peak

and even beyond the threshold. Majority of the damaged farms were near the rivers which originated from some water reservoir. The elephants visited the water bodies twice, at the dawn and the dusk each.

When in herds, the adult male elephant uses its trunk to remove the fruits like jackfruit from the trees while the mother elephant crushes it under her weight so as to provide a mashed fruit to the juveniles in the herd. Also a higher density of crop raids occurred near isolated farms which were situated a bit far from the main village or the human settlements. Even after use of different techniques by the locals to keep the elephants away, these individuals have now lost the fear to the human presence. The crop raids in the cultivation or plantation zones present on a hilly terrain were less compared to the farmlands on the plateaus as they preferred plain lands to devour their food. Crop damages were not always due to feeding by elephants. Many times even their movement through the crop fields resulted in such damages. Such damage due to movement and feeding cannot be appropriately segregated. Young elephants or juveniles even exhibited the behaviour of mud bath in the water logged rice fields which too led to a lot of damage in the area.

During the dry seasons of summer, the dependency on the cultivated cuisine became less due to less availability. But during the same period, the majority of natural floral species exhibited fruiting season which accounted for dietary benefits of the elephants. Their natural diet mainly comprised of *Ficus racemose*, *Mangifera india*, fishtail palms, *Mallotus philippensis*, ran korfad, *Ziziphus jujube*, *Syzygium* species, natural bamboo, jackfruit, *Madhuca longifolia*, *Phyllanthus acidus* and so on. All of these trees show fruiting period in the months of February to May. These are high nutrition fruit plants which are available in good numbers along the forest trails.

The government in collaboration with the forest department started the damage

compensation to the farmers in order to reduce the loss due to wildlife. The local forest office checks for the actual damage by the elephants. The actual damage is then reported to the department which further sends the total compensation amount to the centre. This amount is then directly transferred to the bank account of the farm owner through bank transfer. Now even though this process seems to be simple, the actual transfer of compensation money takes around 4 to 6 months of time. In many cases the damage done to the juvenile crops or saplings is not considered as a whole. The destruction of any juvenile field may also result the whole season being wasted. Also the compensation rate is almost 1/10th of the market price for the same crop. This huge difference leads to the loss of property of the local farmers and thus creates a negative impact in the society.

The overall perception of the local villagers and communities was also evaluated using questionnaires which were asked during the interviews. The interviews were of two types which consisted of personal interviews taken during affected farm surveys and group discussions. The idea of these two types was to collect as much authentic information as possible. Group discussions usually helped us in understanding the behavioural patterns of the elephants, their experiences related to the elephants, the strategies which the whole village has implied for preventing crop damage and mainly a lot of positive things related to the mega herbivore. Personal interviews helped us in understanding the real problems and issues faced by the farm owners and their needs in order to mitigate the same. The interview lasted for around 20-30 min depending on the involvement and interest shown by the person in question.

As these elephants first migrated during the earlier phases of the 2000's, the villagers adored this mammal from south due to its mythological connections with the Hindu god Ganpati. The curiosity to see an elephant in the wild took over

as the sole sighting of this animal was a centre of discussion all over the southern talukas of Kolhapur. But as the frequency of these elephant migrations started rising, their dependency on the local crop diversity increased and the crop raiding activities began. Slowly the conflict arose in the village fragments of Kolhapur and Sindhudurga as the crop damage and wild encounters transformed the curiosity into fear and worry. Even though the forest department compensated the damage, a continuous threat due to the moving elephant herds was a bigger problem for the local communities. They planned out and prosecuted different damage preventing strategies in order to keep the elephants away, but none of them proved to be an assertive solution on a longer run. The villagers also feel that apart from the compensation, it is the responsibility of the forest department to prevent and avoid the crop raids in the first place itself.

But in spite of the crop damage and loss experienced by the local communities, there still prevails a sense of belonging towards the elephants as many of these mega herbivores have spent much of their life years in the vicinity of these villages. Villagers even narrated some light faced incidences regarding the timid yet playful relationships of the elephants with the domestic fauna. As majority of the elephant populations in Kolhapur are single stranded individuals, these elephants face the need to socialize and interact with other mammalian groups in order to survive. Thus, cases have been noted where the elephant individuals have been seen grazing or browsing along with a herd of buffalos or group of sheep.

Apart from the interaction with the locals and the farm owners, a questionnaire survey was also conducted with forest personals. The forest department has designed the damage compensation scheme way back in order to reduce the loss as well as the impact of the conflict. The department also organizes workshops and meetups during their annual meetings and events which aims at spreading awareness for overall

fauna that resides around the society. The department feels that even though the elephant populations have been stabilizing in this part of the state for some years now, the required or essential habitat for the sustenance of these herbivores is not present in Maharashtra. The ease of fulfilling their dietary needs through crop raids and availability of ample water as well as forest resources are the main reasons of their range extension into the state. The overall interaction with these local authorities helped us gain another perspective regarding this study, one which assisted in understanding the role of the conflict litigator. Also the approach of these officials was a lot positive in regards to the future of the elephant populations in the area and the probability of increase in their numbers, thus hinting to a legitimate management of the upcoming conflict.

Thus the overall survey pointed out the need to draft a plan of action in order to not only prevent the crop damage but also to avoid the conflict bubble to inflate further. Also apart from the anthropogenic perspective, the ethnic perspective of the elephants also needs to be taken into consideration. The local communities, though not totally against the herbivore, are definitely not living in harmony with them. Local prevention practices are undertaken by the villagers in order to alleviate the conflict to some extent. Defence mechanisms include use of fire crackers, creating hustle by gathering together, playing loud noise and even charging on the elephant to chase it away in some cases.

As the case study of the human elephant conflict in the southern parts of Maharashtra progresses, the further rise in crop damage and encounters is inevitable unless the people and the authorities try to find measures and solutions in order to mitigate this situation. The present survey project is a genuine effort to understand the different parameters of the ongoing conflict and the way it could be resolved in order to establish sustenance for all. Even though the local communities seem receptive regarding any

changes in the crop culture or land use to be inculcated from their side, they were ready to accept the presence of the elephants in their area, given that the forest department proposes a way of restricting the elephants in their natural habitat. Also they are persistent in creating a better natural habitat for the elephants with ample natural food options available to them. Thus, an affirmative approach is seen from the local side, which can further aid in devising strategies and collaborating with them. As this project arrived towards its business end, a sense of hope did reign in spite of so many negatives being inflicted upon the society. This hope will be a substantial card of ace as we move further to see the future of these herbivores.

Conclusion

Present study was conducted in the Kolhapur and southern Sindhudurg districts of Maharashtra, India with the objective to analyse recent elephant crop-raiding patterns, the conflict created due to it and to devise different mitigation measures for the same. Total 2430 elephant crop raiding records in both the districts for the years 2020-22 were analysed. The database revealed that the problem under study was spread over an area of nearly 3700 km² of study area. A total of 132 villages from 5 talukas of 2 districts were impacted by elephant crop raiding. The worst affected talukas in terms of villages affected were (i) Chandgad, (ii) Ajra and (iii) Dodamarg. Of all the 36 different crops damaged, sugarcane (53%), rice (23%), finger millet (8%) and banana (7%) were the worst affected crops and the former two were the most preferred crops by elephants. Crop raiding records exhibited that in all 1383 farmers claimed compensation during the survey period of 2020-22. The total compensation amount given by the forest department to the claimants was Rs. 12,313,221 (amount retrieved from the secondary data collected from the department for the above period).

Different mitigation measures were either drafted along the research project or incurred

from the locals and the forest officials. The positive approach by the local communities regarding the presence of the elephants in the adjacent areas can be said as the biggest takeaway from the project. Awareness campaigns, presentations in schools, conflict management training programs to the locals can be inculcated in the mitigation measures in order to involve mass junk of the local society in this process. Forest departments should also undergo training programs in order to handle human elephant conflicts more efficiently.

Elephant task forces should be assigned and managed by the forest department in order to track the movements of the elephants as well as prevent unnecessary conflict situations. These task forces are the group of trained forest personal which are assigned to a specific wild species and who undertake rigorous mitigation efforts. Production and distribution of elephant torches can also be devised in order to keep the intruding populations away from the farms especially at night. The elephants avoid well lit crop lands as they tend to hide in the dark for crop raiding. Isolated farmlands or houses can be protected by this method very efficiently. Elephants also exhibited avoidance of farms which had foul smelling material. Studies can be conducted in order to understand this olfactory barrier to the elephants and further provisions should be made to use it as a method to prevent crop damages. Many farm owners used solar powered electric fencing in order to keep these herbivores away. Such electric fencing might result in injuries or even prove fatal at times. Instead of such challenging methods the locals can reside to creating buffer zones for the elephants in their farmlands by planting spices like chilly and turmeric which act as natural repellents for the elephants.

Thus inculcating such various mitigation measures can help in providing the natural herbivores a habitable environment to thrive in. Not only will the conflict reduction help in providing a better life genre to both the clients of

the conflict cause but will also prove to be a pioneer project in establishing a successful framework for human animal conflict mitigation endeavour around the subcontinent. Today, even as the socio-political, socio-economic and socio-ecological structures of the discussed region tend to fluctuate regularly, the regulation of such impact making strategies will benefit one for all. The peaceful atmosphere and environment in the daily sustenance of the local communities due to conflict mitigation will result in long term effects on not only the wildlife and nature conservation but also the other sectors of the daily human life.

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