

CROP RAIDING BY ELEPHANTS IN SINDHUDURG DISTRICT

TRENDS, PATTERNS AND PEOPLE'S PERCEPTIONS



Thesis submitted to

**COLLEGE OF FORESTRY, DR. BALASAHEB SAWANT KONKAN KRISHI
VIDYAPEETH (AGRICULTURAL UNIVERSITY), DAPOLI (M.S.)**

In partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE (FORESTRY)

in

NATURAL RESOURCE MANAGEMENT

by

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Under the guidance of

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May 2016



DECLARATION OF STUDENT

I hereby declare that the research work and its interpretation in the Thesis entitled “**Crop Raiding by Elephants in Sindhudurg District: Trends, Patterns and People’s Perceptions**” is an authentic record of the research done by me and that no part thereof has been presented for the award of any degree, diploma, associateship, fellowship or any other similar title.

The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

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This is to certify that, the thesis entitled “**Crop Raiding by Elephants in Sindhudurg District: Trends, Patterns and People’s Perceptions**” is a record of independent bonafide research work carried out by **Milind D. Patil** (FDPM-14-47) at this college during the academic period 2015 - 2016, under my guidance and supervision for the degree of M.Sc. (Forestry) of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

The said thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or any other similar title.

The source of materials used and all assistance received if any, during the course of investigation have been duly acknowledged.

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न जातु विषयाः केऽपि स्वयमं हर्षयन्त्यमी |

सत्तकीपत्तवप्रीतमीवेभं निम्बपत्तवाः ||३||

[No sense-objects ever please him who delights in the Self, even as the leaves of the Neem *Azadirachta indica* do not please an elephant, who delights in the Sallaki leaves *Boswellia serrata*]

Source: The True Knower, Chapter- 17.4, Ashtavakragita, pp.115.

It was an early morning in January 2010. I was walking alone along a small canal, parallel to a thickly wooded hillock in Oros village. Suddenly I came across the fresh foot prints of whole herd. The situation when all your dreads get overwhelmed by the moment and you could do nothing behalf of adsorbing the situation. Luckily the elephants were moved away just few hours ago.

The decade who had never seen wild elephants before, ‘*Hatti ilo re*’ (elephant is coming) could be an obvious excitement and the subject for long night discussions at village *katta*. People were worshipping the foot prints, served flowers and *prasad*. No doubt, it was a good omen if elephants walked through the agricultural field; you got more yield next year!?

But over a period of time earlier moments of excitement were aloft away since elephants started heavy raiding on agricultural fields, coconut orchards and falling earthen walls of houses and granaries. It was a swift shift of earlier minds regarding elephant as a ‘God’ to ‘a pest’ or ‘a killer’. Now, everyone in the area was under deep seated terror of being encountered by the wild tusker in the evening while returning through the jungles or the herd chewing soft core of banana next to the cowshed!

On this backdrop, and being hailed from the same region, it was a great opportunity for me to study crop raiding behaviour of elephants in Sindhudurg and do equally worthwhile to farmers. Fortunately I got this opportunity at Forestry College for Master’s thesis. Such studies were seldom conducted under the faculty of agriculture. No doubt it is also difficult here to meet with a robust ecologist as the advisory.

It is my proud privilege as Prof. Vinayak Patil (PhD), a profound academician, a keen ecologist and the lifelong naturalist attained as mentor for this research. I also express my gratitude to Prof. Satish Narkhede (PhD), the Associate Dean, College of Forestry; Prof. Ajay Rane (PhD) and Prof. Vinod Mhaiske, College of Forestry concurred as advisory peers. I

thank Mrs. Pathak, Mr. Koltharkar and other non-teaching staff at Forestry College for the genuine cooperation.

I thank Divisional Forest Officer Mr. Ramesh Kumar (IFS), Mr. Bagewadi (ACF), Mr. Kulkarni (RFO, Sawantwadi), Mr. Patil (RFO, Kadawal), Mr. Patil (RFO, Kankawali), Mr. Jere (RFO, Amboli) and Mr. Shinde (RFO, Dodamarg) for field support. I thank Mrs. Parab, Mr. Arun Sawant, Mr. Pramod Sawant and other official staff at Divisional Forest Office and the Range Forest offices for providing departmental records and other information.

I express my sincere gratitude to Prof. Nagesh Daptardar, Honorary Wildlife Warden of Sindhudurg District. He always accompanied my earlier field visits in elephant-prone area and offered a rare opportunity to study ‘elephant catching and domestication’ operations with the Forest Department in 2015. I express my gratitude to Mr. Ninad Mungi, Doctoral Scholar, Wildlife Institute of India, Dehra Dun, though of his busy schedule he prepared the excellent comprehensive thematic maps. I also wish to thank Mr. Gray Hodges, a renowned pencil artist of UK for using his famous sketches of Asian elephants in this document.

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I am also grateful to parents, Aai and Baba, younger sister Manali and my beloved uncle, Samant kaka for encouragements and moral support. I always be indebted my grandparents, Ajji and Ajoba, especially he, who always be adorned in the golden memories of my childhood.

Two rational thinkers – one of philosophy and another of nature – have always been guiding lights in my academic pursuits. I realized the true sense of their following words during the study that I present here.

“Freedom from the desire for an answer is essential to the understanding of a problem”
- J. Krishnamurti

“The true sign of intelligence is not knowledge but imagination”
- Albert Einstein

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ABSTRACT

For nearly 15 years, there is brewing a new and intense issue of human-wildlife conflict in Sindhudurg district of Maharashtra. Elephants had never been in this district for known history. But they came from neighbouring Karnataka and started expanding their range through this district. This problem was novel to the Forest Department as well as the people. One important aspect of this was crop raiding at a scale not known earlier. Several measures were taken to resolve the problem but almost all failed miserably. Brief studies especially on social issues were conducted but ecological aspects were mostly ignored. Present study was conducted to fill this gap.

Data on crop raiding incidences was available through the crop compensation registers maintained by the Forest Department. It was obtained for the period between 2002 and 2015 from corresponding Range Forest Offices. Information was available on 9148 crop raiding cases in all but one talukas of Sindhudurg district. The database revealed that 244 villages (33% of the total villages in Sindhudurg) were affected by crop-raiding by elephants. The worst affected talukas in terms of villages affected and no. of crop raiding cases were Kudal, Sawantwadi and Dodamarg. Thirty six different crops were damaged out of which coconut (44%), rice (22%), banana (20%) and areca

palm (8%) were the worst affected. Crop raiding records showed that in all 4598 farmers claimed compensation. Of which 64% claimed only once; 30% claimed between 2-5 times and 6% claimed more than five times during 2002 to 2015. The total compensation amount given by the forest department to the claimants was ₹ 11,33,70,904.

Over the years, the problem of crop raiding by elephants progressed from south-eastern Sindhudurg towards north. Pattern of this progression was studied and it was found that in the earlier years, elephant crop raiding was exploratory and widespread in nature. In the later years, however, it become more concentrated in Kudal taluka typically shows a high-intensity core zone.

To assess the spatial patterns and vulnerability of villages Crop Raiding Vulnerability Index (CRVI) was formulated and calculated for each village. It was useful to identify crop raiding hotspots. It was found to be performing well and providing more meaningful ecological information compared to Crop Raiding Frequency (CRF) and Relative Crop Raiding Intensity (RCRI) in the present study situation.

It was observed that crop raiding frequency was higher during winter season followed by monsoon and still lower in the summer. November and December months formed a peak of crop raiding. Rice is a recognized attractant for the elephants. And the raiding on coconut is collateral damage at least when the rice is in fields. But immediately after rice is harvested, the elephants are still attracted to paddies and not finding rice, they go on rampaging the coconut.

People's perception survey of 180 farmers from 12 different villages in high conflict zone revealed that around 40% of the respondents were not even applying for getting compensation for each raiding event. Moreover, more than 20% of the claims submitted were rejected by Forest Department for various reasons.

More than 95% of the respondents replied that elephants should be protected despite the higher level of crop raiding. They were also receptive to the potential changes in cropping pattern.

Date: 30 / 05 / 2016
Place: Dapoli

Milind D. Patil

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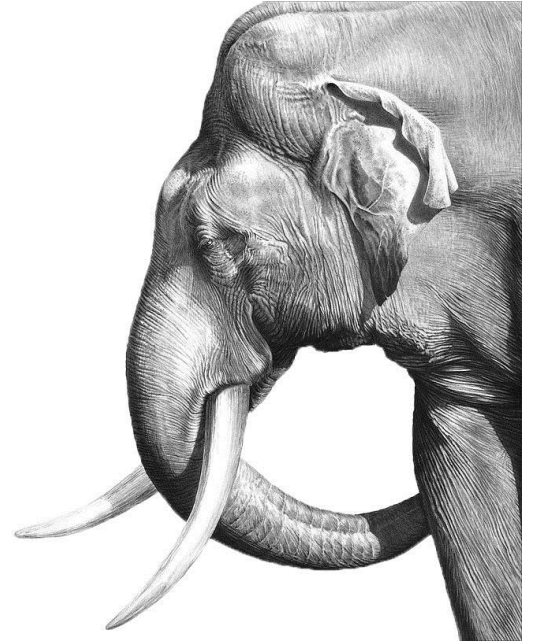


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INTRODUCTION



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1. INTRODUCTION

Asian Elephant *Elephas maximus* Linnaeus, 1758, a megaherbivore, wide-ranging umbrella species occurs in 13 range countries with population between 30,000 to 50,000 in wild and around 16,000 in captivity (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). Although these figures instil a feeling of pride, the worry lies in other related statistics. Of the historical natural habitat of Asian elephants, only 55% was found to be remaining (Sarma & Easa, 2006). Nearly 80% of the Asian elephant population lives outside Protected Areas in close proximity to human habitations (Singh & Kumar, 2014). Like its African counterpart which were found to spend most of their time outside park boundaries (Granados et al., 2012), unprotected habitat is highly important in the distribution and range of Asian elephant. However, this results into an intimate interface between elephants and humans which results into negative interactions. Present study investigates one such peculiar situation in Sindhudurg district of Maharashtra located on the junction of Maharashtra, Goa and Karnataka states.

Western Ghats lost its forest cover by 40% during 1920 to 1990 (Menon & Bawa, 1997). And this region qualified Myers' criteria (Myers et al., 2000) of $\geq 70\%$ loss of primary vegetation to be identified as a biodiversity hotspot. This region harbours around 10,000 elephants, distributed in six different populations over four major landscapes (Baskaran, 2013). Uttara Kannada is the northernmost limit of elephants' distribution in the Western Ghats. 5,081 km² area of Uttara Kannada provides shelter to around 50 elephants (Baskaran et al., 2011). Sahoo (2015) Recently estimated the population and sex ratio of Asian elephants in Dandeli-Anshi Tiger Reserve (DATR), Uttara Kannada where he reported that there exists small isolated population of around 23 individuals with male:female ratio of 1:8. The northern most divisions of DATR viz. Yellapur and Haliyal have low elephant population densities due to loss and fragmentation of habitat (Gubbi et al., 2014).

Human-elephant conflict is a serious conservation and social problem and has been on increase throughout the range of elephants: both African and Asian (Gubbi et al.,

2014). The negative interactions between human and elephants can be taken for granted in the areas of human-elephant interface given its ancient origins (Sukumar 1994). However, when this interface develops in a previously unaffected area, this conflict assumes new dimensions. And it needs to be approached differently for study as well as solution.

The states of Maharashtra and Goa, including the Forest division of Belgaum, were not part of the traditional elephant range. However, an elephant herd from the Haliyal-Dandeli Forest division made a short foray into Belgaum Forest division in 2001 (Baskaran, 2013). Since November 2002, especially from Dandeli Wildlife Sanctuary, wild elephants started intruding the forests of Sindhudurg and Kolhapur districts of Maharashtra.

Initially a group of seven wild elephants entered Mangeli village of Sindhudurg district in Southern Maharashtra. After staying in the area for two weeks they went back to Karnataka. A herd of 11 returned in April 2003 by the same route. There were sporadic reports of 2, 5, 7 and 11 elephants making to and fro movements afterward (Mehta & Kulkarni, 2013). There appeared to be two different entry points for elephants in Kolhapur and Sindhudurg districts (Sarma & Easa, 2006).

In November 2004 the Forest Department of Maharashtra launched an operation wherein 16 elephants were driven back to Karnataka, but four elephants remained behind. Meanwhile, another group of seven elephants from Karnataka entered Chandgad Range of Kolhapur district in Maharashtra (Mehta & Kulkarni, 2013). Migrating elephant populations in Sindhudurg initially took shelter in the forests near Tiları Reservoir area especially in Konal Forest Round (Sarma & Easa, 2006). Since 2005, the influx had been continuous and elephants seemed to have become resident over the Dodamarg and Kudal taluka of Sindhudurg district.

In 2009, again, State Forest Department conducted elephant capture and translocation programme in Sindhudurg. Total four elephants were captured two of which died during the operation. The remaining two were released near Kankumbhi in Karnataka, which is about 100 km away from the place they were captured, but both elephants came back to the same region within a week (Mehta & Kulkarni, 2013). In February 2015, State Forest Department launched 'elephant capture and domestication' operation for the last remaining herd (Plate 1). Three males were successfully



Plate 1: Elephant' capture and domestication operations (2015) in Sindhudurg district

tranquilized and captured. Unfortunately two of them died during domestication training and one was handed over to the Karnataka State Forest Department. Although the department and the people have sighed relief, it seems that the problem remains unresolved and a herd of three has again entered in Dodamarg area in February 2016.

Against this backdrop of invasion and driving away of elephants in a previously unoccupied range, human-elephant conflict raised many a storms in the sociopolitical spheres of Sindhudurg district. Here the negative interactions largely due to crop raiding (CR) problem. Nevertheless, till date, Sindhudurg and Kolhapur districts have seen death of sixteen elephants and thirteen persons. By this time, the State government had already spent more than ₹9 crore as crop compensation (Mehta & Kulkarni 2013, in the original paper this figure is erroneously printed as ₹90,248 million).

Forest Department has constructed elephant proof trenches, solar fencing, Iron posts hurdles and stone wall fencings along the passage between Karnataka and Maharashtra. On the parallel, villagers have attempted to use various indirect measures like shouting, lighting fires, beating drums, cracking fireworks etc. to keep away intruding elephants from agricultural fields. Practicality of preventive measures like chilli-smear ropes, electric wire fencing, and burning chilli-mixed-dung had also been tested. But it is not quite surprising that elephants get habitual towards this humdrum (Zimmermann et al., 2009) and becoming conditioned to the human presence. Such dispersal of elephant herds into newer habitats has brought fresh challenges to management.

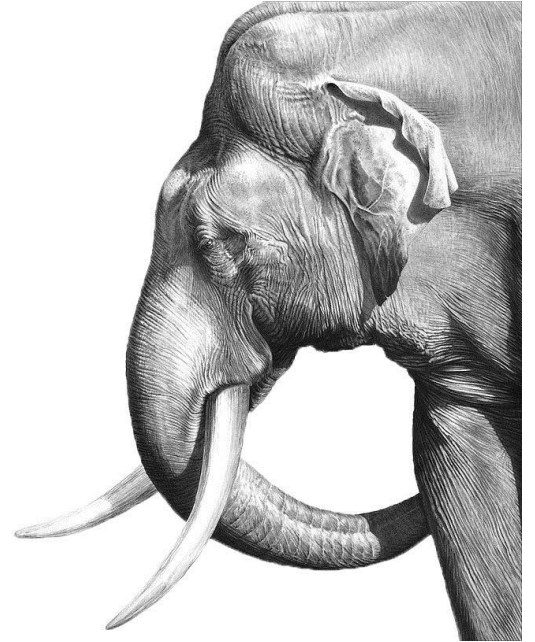
Traditional range of these elephants in Uttara Kannada is subjected to intensive biotic pressure and fragmentation. Kali hydro-electric project, open mining activities and increase in commercial plantations and monocultures in Uttara Kannada and adjoining areas are the major causes of range extension of elephants towards north into Belgaum and Maharashtra (Baskaran 2013, Mehta and Kulkarni 2013). Unable to sustain themselves within their traditional home, the elephants have moved further northward in search of new areas to settle down.

Because Forest Department of Maharashtra implements a compensation scheme for crop damage, there is a dataset of elephant crop damage available with forest department which can be analysed to derive insights into this now historical problem.

Similarly, for effective management of the problem in future, it is necessary to find out the perceptions of farmers. With this background, the present study on trends and patterns of crop raiding by elephants in Sindhudurg district was proposed with following two objectives.

Objective 1: To study spatiotemporal pattern of crop raiding and to identify crop raiding 'hot spots' in Sindhudurg district

Objective 2: To study the people's perception about human-elephant conflict in Sindhudurg district



REVIEW OF LITERATURE



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2. LITERATURE REVIEW

2.1 Elephant Habitat

Asian Elephants are highly selective towards habitats with higher numbers of woody plants (Datta, 2009) and with proximity to the water resources (Mohapatra et al., 2013). More specifically, they prefer moist and dry deciduous forests that contain substantial grass and bamboo forage (Sukumar, 2003). The presence of reeds (*Ochlandra*) along streams and in forest fragments also encourages elephants' use of natural habitats (Kumar et al., 2010). Natural habitats provide a diverse array of food plants across different seasons and are therefore preferred by elephants over monoculture forest plantations (Baskaran et al., 2013).

The social organization of elephants has been studied for long and there have been contradicting evidences for different aspects of social units. The major social units known include female clans, solitary bulls and male groups. Each of these units has large and more or less well-defined but overlapping home range. Territoriality may be absent or present. The size of home range typically depends on availability of water and habitat productivity (Sukumar, 1989). Elephants are non-territorial animals thus 5 - 6 males may share the same habitat (Fernando, 2010). They are known to explore newer areas and extend their range (Jasmine et al., 2015). However, their movement rates are based on a risk-minimization strategy (Kumar et al., 2010). It is not true that pubertal males are repelled by the adult females in a herd. Actually they drift away from the herd of their own volition at an early age and they may spend few years in the periphery of their natal herd. And with the increasing age they become independent to lead solitary life (Fernando, 2010).

Within home range of a social unit, there are seasonal ranges. Elephants are wide ranging animals and they are known to migrate from one part of their range to another. Like their African counterparts, they show seasonal movement pattern influenced by the availability of food and water (Osborn & Parker 2003, Campos-Arceiz et al. 2008). These movements, however, are usually much short-distance as compared to African elephants. Joshi and Singh (2007) observed that elephants in Rajaji National Park showed marked seasonal migrations influenced by availability of

water and fodder in northern and southern parts in wet and dry seasons respectively. Elephants are always in search of more productive areas (Sarma & Easa 2006, Hart et al. 2008). They possess an excellent memory to make toposheets of cross-country over which they roamed (Hart et al., 2008). Other reasons for migration of elephants can be annual fire, drought and absence of cool green shades in their respective areas (Joshi & Singh 2007, Samansiri & Weerakoon 2007).

2.2 Elephant Diet

Elephants are both grazers and browsers depending on the season. Their diet accounts for higher proportion of Family Poaceae and Fabaceae (Samansiri & Weerakoon, 2007). Browse generally offers higher levels and diversity of nutrients, but toxin and lignin levels are also higher (Datta, 2009). Immature plant parts like foliage and sprouts contain maximum digestible nutrients with minimum proportion of fibres, lignin, tannin and other toxic substances (Pretorius et al., 2011). In the case of grass, intake rates are higher when it is easier to harvest and handle, when it is lower in toxins and its nutrient content is high, and when its fibre content low (Lindsay, 1994). Grass species form the bulk (> 60%) of the annual diet of elephants (Baskaran, 2013). They switch from browsing to grazing from the dry to wet seasons (Kumar et al., 2010).

Seasonal variation and selection of specific plant parts in elephants' diet represents nutrient flux in plants (Jin et al. 2006, Mohapatra et al. 2013). In seasonal habitats, dry season forage availability is a limiting factor for most herbivores. In southern Sri Lanka, Asian elephants use shifting agriculture areas intensively during the dry season (Pastorini et al., 2013). Post-harvest shifting-cultivation fields provide significant food sources and enabled temporal partitioning of resources between farmers and elephants with little conflict.

African elephants would select the nutrient rich patches as feeding sites with higher nitrogen and phosphorus percentage. Uprooting of trees is observed on nitrogen deficient soils. Nutrient intake varies with the seasons (Barnes 1983, Pretorius et al. 2011). Pretorius et al. (2011) observed that elephants eat the bark and roots in winter when much of the quality food stuffs are not available representing nutrient stresses.

They also observed that tannin content in plant parts was significantly lower in fertilized areas. Elephants were observed stripping the leaves in fertilized areas than the non-fertilized areas. Stripping and uprooting of trees is remarkable observed outside the fertilized patches. Jin et al. (2006) found that the iron content in plant parts highly correlated with the plant species proportion to the diet. In addition, there is some difficulty in meeting the elephants' requirements for sodium. This may be the reason elephants often seek sodium from salt ponds.

Availability of attractive and nutrient rich food-items may influence foraging behaviour of elephants. Elephants often visit secondary forest habitats or forest gaps where pioneer plant species are more abundant (Jin et al., 2006). Availability of bamboo forage significantly influences their habitat utilization strategies (Sarma & Easa 2006, Patil 2014).

However, alien invasive species like *Lantana camara* and *Eupatorium odoratum* have taken over this precious resource from the elephant habitat. *Lantana* invaded more than 13 million hectare of land in India since last 200 years (Bhagwat et al., 2012). The two species have taken away most of the ground cover (space) available to the local grass species such as *Themeda cymbaria*, *T. triandra* and *Cymbopogon flexuosus* and other native herbs and shrubs including regeneration classes of native tree species (Sundaram et al. 2012, Baskaran 2013, Ramaswami & Sukumar 2013). For example in BRT Wildlife Sanctuary, Karnataka there are no young trees now, rather than old ones and herbivores are suffering due to *Lantana* invasion because it is largely unpalatable to wild herbivores. Since there is very little grass and bamboo left in BRT now, many animals are in an unhealthy condition and resort to crop-raiding to augment their diet (Sundaram et al., 2012).

Hiremath & Sundaram (2005) found that in South India, the initial spread of *Lantana* in these dry forests coincided with the last mass-flowering and die-back of bamboo, which was followed by widespread fires. Babu et al. (2009) state that as villages were relocated from the park to the elsewhere, large tracks of lands once cultivated were rapidly invaded by *Lantana* and other invasive weeds.

The vacant space created along the streams due to natural mortality of old bamboo clumps after flowering has been occupied by *Eupatorium* first, and subsequently *Lantana* invaded to replace the *Eupatorium*. Baskaran (2013) found that *Lantana*

thickets along the dry streams during low rainfall/drought years also catch fire and take the ground fire up to canopy level, burning mature trees. Climbing stems of *Lantana* can reach up to > 20 metres, getting into the forest canopy and resulting in devastating crown fires when they burn (Hiremath & Sundaram 2005, Babu et al. 2009). Increasing forest fires in Indian reserves have reduced some of the favoured food species of elephants like *Kydia calycina* and *Bosewellia serrata* (Baskaran, 2013). A strong allelopathic effect and the resultant proliferation of these two species has affected significantly the biomass of grass and browse available to elephants (Baskaran, 2013). Thus *Lantana* invasions inside the protected area landscapes impoverished quality of wildlife habitat and enhanced the frequency of crop raiding by herbivores in nearby villages (Babu et al., 2009). Taylor et al. (2012) were found that Global climate change will assist spreading of *Lantana* to persist along the Western Ghats.

Besides *Lantana* and *Eupatorium*, decline in biomass of palatable forage due to overgrazing by livestock inside the protected areas could be one of the reasons to lower carrying capacity of the area for elephants (Madhusudan, 2003). Madhusudan (2004) found that livestock-mediated resource limitation if left unchecked could trigger declines of wild herbivores, particularly grazing ruminants and bulk feeders. Elephant showed a sharp declining relationship with increasing livestock density in South Indian reserves.

2.3 Elephant Movement

According to Milroy (2002), “*Wild elephant...feeds chiefly at night, rests during the day after retiring in to heavy cover until sun sets*”. Human density and close proximity of humans had negative effect on resting and movement of elephants (Mavatur & Singh 2010, Crosmar et al. 2015). Mavatur & Singh (2010) found that vigilance behaviour of elephants was lowest in forest fragments and riverine vegetation. They also state that protection and non-conversion of canopy habitats, restoration of river beds with native food species, and maintaining distance from elephants would foster normal activities of elephants and help promote human- elephant co-existence. Social trauma experienced early in life may have significant effects on physiological development and adult behaviour patterns (Shannon et al.,

2013). Extremely disruptive events, including culling, poaching and translocation to new areas or capture for captivity can ultimately lead to serious disruption of the intricate social networks that underpin social structure in elephants, with severe impacts on each individual's close social bonds and opportunities for learning from older group members (Shannon et al., 2013). These in turn would affect the behaviour of these mega-travellers.

2.4 Elephants Range Extension

Range extension i.e. invasion of elephants in an area previously unoccupied by elephants, also, is a known phenomenon and has been reported from different parts of India. Elephants were not known to occur in Andhra Pradesh for the last 300 years. In 1984, a group of 7 elephants migrated to the forests of Kuppam and Palamaner area of Chittoor district from adjoining Tamil Nadu forests, followed by the herd of 22 animals in 1986 (Sarma & Easa, 2006). Gubbi et al. (2014) have reported similar range extension of elephants into Tumkur division in 1998 and Kolar division in 2012 within Karnataka. Elephants ranging further south in the Karnataka-Tamil Nadu border (the Nilgiri-Eastern Ghats) also follow a similar pattern. There have been incidences of elephant herds straying out due to degradation and fragmentation of traditional areas of Hosur-Dharmapuri forest division, Tamil Nadu, bordering Bannerghatta National Park, Karnataka, and colonizing the habitats in neighbouring Andhra Pradesh causing extensive damage *en route* (Baskaran, 2013).

Sometimes they venture into the man-modified habitats like plantations and agricultural fields to fulfil their dietary requirements (Samansiri & Weerakoon, 2007). Thus in small home ranges with fragmented landscape, elephants may use specific parts of their ranges more intensely than in large home ranges and therefore the resource consumption impact may be more intense (Rood et al. 2008, Datta 2009).

Today protected areas are increasingly becoming islands of habitat surrounded by seas of cultivation and development (Madden, 2004). Elephant populations should persist in areas where human settlement occurs within a matrix of untransformed elephant habitat, but when the total area of transformed land exceeds a critical point, the system flips into a new state in which patches of elephant habitat now occur

within a matrix of human settlement (Hoare & Toit, 1999). Chartier et al. (2011) computed the critical habitat threshold of wild elephant populations in Assam. They observed that human–elephant conflict may exist at 30–40% forest cover. Below this level, conflict expanded across the landscape in Assam.

2.5 Crop Raiding

Increasing agricultural land use has substantially reduced the area once available to wildlife. Throughout the elephant range, situation has changed from one in which man lived in small settlements in areas surrounded by elephants to one in which elephants are forced to inhabit small patches of forest surrounded by a landscape dominated by man (Santiapillai, 1994). This has resulted into crop raiding which is often associated with overlapping resources of food and water, and/or elephant movement routes (Nelson et al. 2003, Datta-roy et al. 2009). Songhurst & 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. They also state that elephants are returning to fields they remember having raided successfully in the past, which were either close to these traditional movement paths, or movement paths have been altered to travel close to these foraging sites.

Elephant crop raiding is largely influenced by the size and nearness of the cultivated area from the adjoining forest (Sarma & 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). “frontline farms” (farming area < 1 km from park boundaries) generally suffered more compared to the area farther away from park boundaries (Sitompul et al., 2010). Such area also provides ‘secure refuge’ to the intruders (Hoare 1999b, Sugumar & Jayaparvathy 2013, Wilson et al. 2013). Graham et al. (2010) defied the ‘daytime elephant refuge’ as the natural habitat where elephants could hide by day and keep themselves undisturbed by human activities. They found that distance from daytime elephant refuge was the only predictor of crop-raiding occurrence. Elephants may feel less secure outside and so may be too frightened to move very far from the park boundaries (Sitompul et al., 2010). They wait for the cover of darkness to enter fields and were often seen lining up across the border at sunset (Nyhus et al., 2000).

Ekanayaka et al. (2011) observed that less abundant crops are raided less frequently. Thus raiding frequency of a particular crop seemed to be related to its abundance. Elephants do not destroy crops solely by eating them, but can also cause considerable damage by trampling crops while in transit (Sutton, 1998). Elephants tend to spend less time in forest reserves at night than by day (Graham et al., 2009). Similarly, crop raiding is almost exclusively a nocturnal activity suggesting that offenders seek to minimize the associated risks (Hoare 1999b, Debata et al. 2013).

'Problem elephants' are animals that extend their range into human settlement, commonly to feed on a wide variety of cultivated food and cash crops but also sometimes damaging food stores, water installations or fences and barriers and/or houses, and occasionally injuring or killing people (Hoare 1999b, Fernando 2010). The degree of overlap between the food choice of elephants and people is very high (Ekanayaka et al., 2011). Human cultivated food crops are more palatable, more nutritious, and have lower secondary defences than wild browse plants (Nelson et al., 2003). Irrigated and rain-fed crops if available to them in close proximity throughout the year, food conditioning will be more rapid (Donaldson et al. 2012, Kamweya et al. 2012). Crop-raiding in Assam occurs from June to February, with peaks from October to December, coinciding with the harvesting of paddy (Zimmermann et al., 2009). However, crop damage severity is considered to be site specific (Sitompul et al., 2010).

In agricultural land, however, they get substantial quantity of nutritious food over a smaller area with minimal effort (Roy & Sah 2012, Wilson et al. 2013). Elephants mostly target mature crops under cultivation (Datta-roy et al. 2009, Monney et al. 2010, Gubbi 2012). Ekanayaka et al. (2011) have found that in Sri Lanka 75% of raiding incidents were associated with mature crops. The reason might be the crude protein content of cultivated grasses (range 5.3 to 10% of dry weight) during October-December which is much higher than that of the basal portion of the wild grasses (2-3.8%) consumed by elephants at this time (Sukumar & Gadgil, 1988). Here villagers often harvest their crops at prematurity e.g. rice. This reduces the value of the harvest even if elephants do not eat it (Santra, Samanta, & Pan, 2007).

Elephants have an acute spatial awareness and it is likely they are able to recognize the transition between 'safe' forest and 'dangerous'. Few elephants will take risk of

going deep into the farming area, farm land whereas some reside at periphery (Roy & Sah, 2012). Crop raiding elephants, especially males, are always willing to savour extra-nutrition. They are more destructive than females since 'high risk-high gain' strategy influenced their reproductive success through better nutrition. Pubertal and adult males above 15 years incur greater risks than female led family herds by foraging on cultivated crops (Sukumar & Gadgil, 1988). Radio-collared male African elephants were found significantly closer to human settlements, suggesting a degree of male tolerance (Nelson et al. 2003, Thaufeek et al. 2014). Fernando (2010) found that in Sri Lanka, majority of crop raiding incidences are due to adult males. Crop raiding by female herds is uncommon. He also found that few males are very aggressive and respond to attempts at chasing them by counter-attacking those who confront them. Haturusinghe & Weerakoon (2012) found that more than 80% of elephants causing crop damage and houses damage are bulls in north-western region of Sri Lanka. Nyhus et al. (2000) found that 50% of the raids by solitary males at the park boundary of Way Kambas NP, Sumatra, Indonesia. Such inherent risk-taking abilities adversely influenced human-elephants interrelationship (Sukumar 1991, Chiyo et al. 2011, Ekanayaka et al. 2011). Older males were more likely to be raiders than younger males. However younger males are more likely to be raiders when their closest associates were also raiders, especially older than them (Chiyo et al., 2012)

Continuous disturbance to elephants might result in loss of fear of humans and sore human-elephant relationships (Mavatur & Singh, 2010). exposure of young males to conflict situations is likely to play a major role in the genesis of 'problem elephants' e.g. conflict mitigation activities such as the indiscriminate use of 'elephant fire crackers' and 'elephant drives' are likely to promote the creation of problem elephants. In some of the conflict interactions with elephants he found that it was an outcome of carrying multiple gun shots on their body. Wounded elephants generally become more aggressive and are prone to attacks on humans. They often die from infected wounds (Nelson et al., 2003).

Elephants have the capacity to acquire novel foraging behaviours in part through social learning. They are known to be 'food-conditioned'. Thus social learning can facilitate the acquisition of undesirable and maladaptive behaviours from human perspective (Donaldson et al., 2012). Elephants normally attacked houses to consume stored food and beverage prepared from Mahua flower (*Madhuca indica*) (Palei et al.,

2013). African elephants too break houses to drink locally brewed beer which appear to smell like fermenting fruits of amarula (*Sclerocarya caffra*) which they are fond of (Chomba et al., 2012). Talukdar & Barman (2003) reported habituation in elephants in some parts of Assam stopping trucks carrying sugarcane and pulling out the canes on road.

The correlation with proximity to the current road network reflects the fact that killing of people by elephants usually occurred at night when people were travelling to or from home along main roads (Haturusinghe & Weerakoon 2012). Such incidences represent unfortunate spatial coincidences when elephants have ventured out of forest refuges and crossed roads just as people were passing by. Sitati et al. (2003) found that around one-third of cases the human victim had been drinking and was returning home from a local bar.

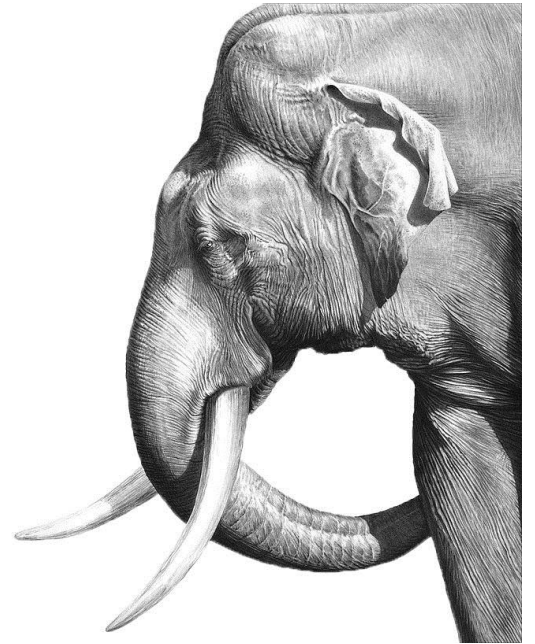
There are certain other aspects of human-elephant conflict when human is killed by an elephant e.g. a sudden state of financial instability, negative impact of school pupils (Jayewardene 2010, Sitati et al. 2012). Jadhav & Barua (2012) and Barua et al. (2013) discussed mental health and psychosocial consequences of conflict between people and elephants.

2.6 Human-Elephant Conflict Studies

Nyhus et al. (2000) conducted rapid village and field assessment of human-elephant conflict using focus groups, semi-structured questions, field visits to the areas of elephant damage at Way Kambas National Park, Sumatra, Indonesia. Santiapillai et al. (2010) studied human-elephant conflict in Sri Lanka through questionnaire survey. They randomly selected 100 villages from the five provinces within the elephant range. Baskaran et al. (2013) conducted rapid questionnaire survey and used secondary data on elephant crop raiding from forest department records in the Anamalai elephant landscape, South India. Mehta & Kulkarni (2013) proposed the first systematic study of human-elephant conflict in Maharashtra. They studied entry points of elephants from Karnataka to Maharashtra and movement of elephants between Kolhapur and Sindhudurg districts. Crop damage patterns and compensation

schemes given by forest department were examined. They used Jacob's selectivity index to study the crop preferences by crop raiding elephants.

(Gubbi et al., 2014) have studied distribution of human-elephant conflict, severity and explanatory factors over the entire state of Karnataka. They use forest departmental records, records of ex-gratia payments made by the government, elephant densities and forest cover. Their study highlights use of compensation data as a proxy for primary data at large scales where collection of primary data is highly time and resource consuming. (Jasmine et al., 2015) studied frequency of crop raids, crop preferences along with group size of elephants during crop-raids. They conducted questionnaire survey (a door-to-door approach) and several group discussions among the villagers of Mankanthpur village of Nainital district in Uttarakhand. They used a standardized questionnaire comprising with open ended and closed questions, and included both quantitative and qualitative questions.



MATERIAL AND METHODS



Gray Hodges

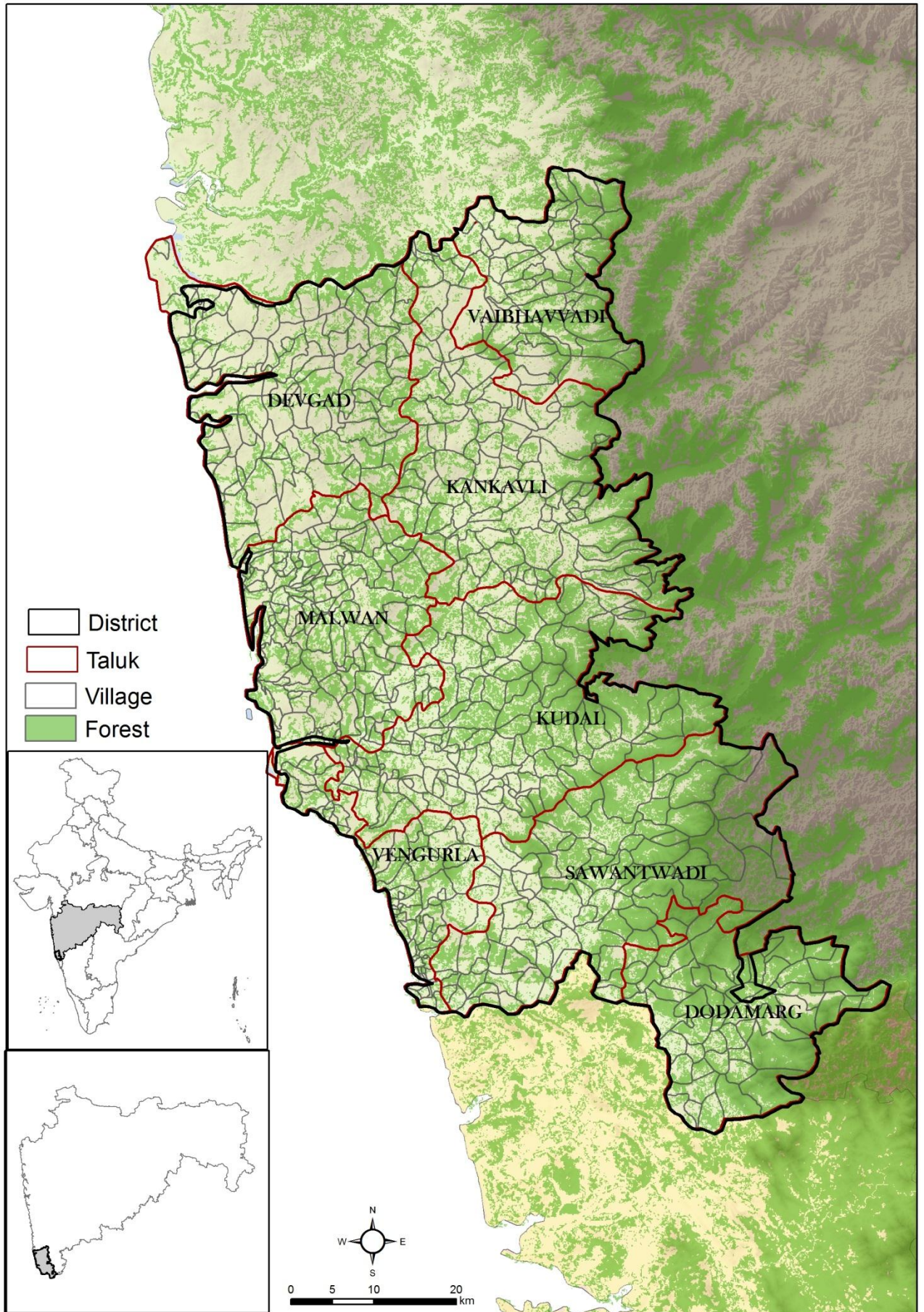
3. MATERIAL AND METHODS

3.1 Study Area

Sindhudurg District (15°37' to 16°40'N and 73°19' to 74°18'E) is the southern coastal district in western Maharashtra having 121 km of coast-line (Map 1). It has borders with Kolhapur and Ratnagiri district of Maharashtra on the eastern and northern side respectively, while state of Goa flanks it on the south. Total geographical area of the district is 508,523 ha. The terrain is hilly with coastal lowlands. Topographically the district can be sub divided into three sub regions, (i) The western coastal strip having width around 20 km known as *Khalati*, (ii) The eastern portion covered by Sahyadri range and its offshoots known as *Ghat-matha* and (iii) in between there is a strip of small plateaus and flat lands known as *Valati*.

The district receives an average annual rainfall of 3,287 mm during June to September from South-Western monsoons. The climate is hot and humid in the summers and mild in winters. The average maximum and minimum temperatures recorded are 38°C and 13°C respectively. The major rock formations are laterite and Deccan trap which are poor in phosphorous and rich in nitrogen and potassium. Around 50% of the geographical area of Sindhudurg is covered by moist deciduous and semi-evergreen type of forests, out of which 89% is under the ownership of private landholders and communities.

Approximately 87% of the population of Sindhudurg is engaged in agriculture with an average landholding of one hectare. Major crops include rice, some millets and pulses. A large proportion of land has been brought under tree orchards of mango, cashew, coconut, areca nut, banana and pineapple. Spices like nutmeg and black pepper are also cultivated within coconut orchards. Home garden is widely adopted traditional agroforestry system. Politically the district is sub divided into eight talukas viz. Vaibhavvadi, Devgad, Kankavli, Malwan, Kudal, Vengurla, Sawantwadi and Dodamarg. There are total 748 villages spread across all these talukas.



Map 1: Map of Sindhudurg district

3.2 Data Collection

(Hoare, 1999a) has identified three approaches of human-elephant conflict studies. First, record of crop-raiding events reported to authority; second, actual losses to crops estimated by enumerator; and third, perceived losses by farmers through interviews. In the case of present study, all the three approaches have been integrated by taking compensation records from forest department which provide reported events along with estimate of loss and structured interviews of affected farmers which provide their perceptions.

Government of Maharashtra has been implementing a compensation scheme for loss of crop, property, limb and life caused by wild animals. The procedure involves reporting of the cases by farmers, verification and estimation of loss by forest department personnel and approval of compensation amount by the authorities. Incidentally, a register of all such compensation claims is maintained by the department. This secondary data especially the crop raiding records in these registers for the period between 2002 and 2015 were obtained from corresponding Range Forest Offices viz. Kankavli, Kudal, Kadawal, Amboli, Sawantwadi and Dodamarg.

For each crop raiding case, name of farmer, forest range of jurisdiction, taluka, village, date of crop raiding, crop damaged and its magnitude, compensation paid as recorded in the register were noted down. Additional information was collected from Divisional Forest Office, Sawantwadi. Annual data obtained from the Maharashtra Forest Department were translated from the local language Marathi into English and entered in Microsoft Office Excel[®] worksheet. Forest Department records during 2003 to 2014 were used to quantify elephant depredations patterns.

While using compensation data, care must be taken while applying the results to the behavioural aspects of elephants. It must be noted that it is always difficult to distinguish between 'visits' and 'raids' by problem elephants. There may be an inherent bias because sometimes elephants traverse the field and do little damage in the form of trampling only. But the raids are cases where crops are fed upon deliberately (Hoare, 1999a). It was convenient to analyse crop raiding behaviour in relation to administrative boundaries (here taluka), because data collection and practical decisions in relation to conservation planning and land use are often carried out in relation to geopolitical units (Erasmus et al. 1999, Graham et al. 2010). I also

collected data of area under cultivation for major crops viz. coconut, areca palm, banana and rice for each conflict taluka from Agriculture Department.

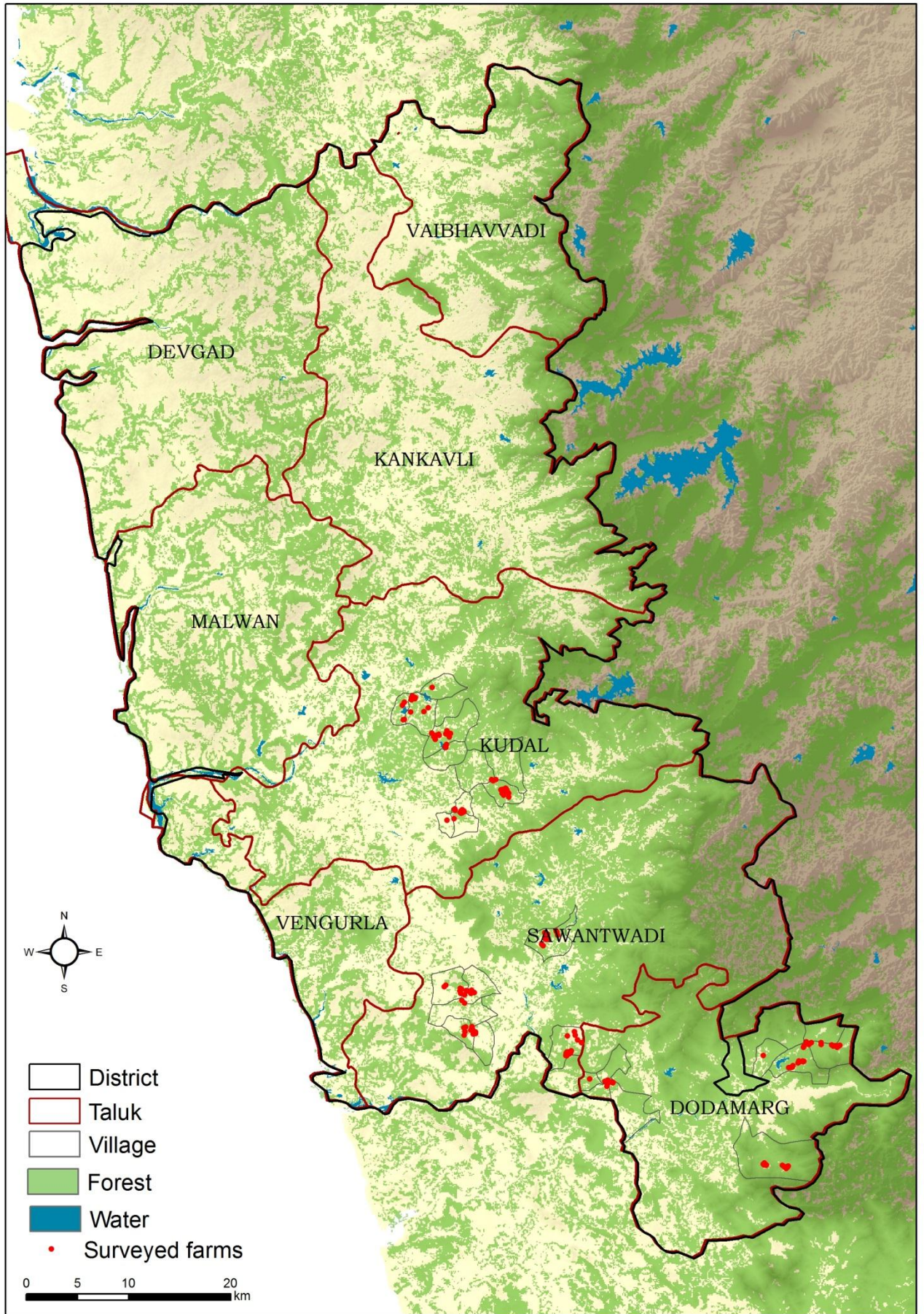
To study the people's perception about human-elephant conflict, door-to-door interviews were conducted during December, 2015 and February, 2016 (Plate 2). The basic analysis of crop raiding data revealed that 244 villages in seven talukas were affected. Therefore, four villages from each high conflict talukas viz. Kudal, Sawantwadi and Dodamarg were selected. The selection of villages was based on (i) highest number of crop raiding instances per village and (ii) spatial distribution of villages for getting representative sample over the spatial extent of conflict zone. Total 180 farmers (15 individuals in each village) were personally interviewed using structured questionnaire. I used household, defined as 'a group of persons who normally live together and take their meals from a common kitchen' (GOI, 2007) as a unit of recording perceptions.

Each interview lasted for around 30 minutes. Collected data were entered in Microsoft Office Excel 2010[®] worksheet. In addition, detailed notes were maintained for each response; comments were categorized and numerically coded afterwards. Group discussions were also conducted wherever possible. Site inspections were made to study the ground facts. Geographical coordinates of the affected farms of the interviewed farmer were recorded with the aid of a Garmin GPS receiver (Map 2).

3.3 Data Analysis

The data was summarized and presented in the form of tables and charts. For variables that could be compared across categories of taluka or years, seasons etc., appropriate tests were used to compare means (ANOVA) and medians (Kruskal-Wallis test). Mann-Whitney U test was used to compare median values of monthly crop raiding intensity. Wherever necessary, chi-squared goodness-of-fit test was also used. All data analysis was carried out using Microsoft Office Excel 2010[®] worksheet and PAleontological STatistics (PAST, Version 3.11) software.

Area under major crops was available from Agriculture Department at the taluka level and the data were used to calculate Hurlbert's standard niche breadth (Scale: 0 to 1). To further assess crop selectivity by raiding elephants, Jacob's index of selectivity



Map 2: Map showing locations of surveyed farms



Plate 2: Questionnaire survey and field visits in Sindhudurg district

(scale -1 to +1) was calculated for major crops based on number of raids and area under cultivation.

Hoare (1999b) suggested use of Raid Frequency Index (RFI), which, in the present case, can be calculated as elephant raids per village per month. The suggested RFI cannot be compared across studies, nor does it provide a standardized value between certain limits. Therefore, three different indices of crop raiding were used to assess spatial patterns of crop raiding by villages. These were Crop Raiding Frequency (CRF), Relative Crop Raiding Intensity (RCRI) and Crop Raiding Vulnerability Index (CRVI). CRF is the total raiding instances in a village over the entire study period. RCRI is a plain measure of crop raiding intensity incorporating the ratio of number of raiding instances to months of raiding occurrence. CRVI is based on standardized Levin's measure where the number of cases in a particular month is weighted (multiplied) by the number of years in which raiding occurred in that month.

$$\mathbf{CRF} = N_1 + N_2 + N_3 + \dots + N_i \quad \dots \text{ (I)}$$

Where,
 N = number of raiding cases in a year
 i = study period in years

$$\mathbf{RCRI} = \frac{\mathbf{CRF}}{j} \quad \dots \text{ (II)}$$

Where,
 j = number of nominate months in which raiding occurred

Here, for the purpose of this index, only the count of months out of 12 nominate months was taken and total number of months of raiding in entire study period was not considered.

$$\mathbf{CRVI} = \frac{\left(\frac{1}{\sum_{i=1}^{12} p_i^2} \right) - 1}{12 - 1} \quad \dots \text{ (III)}$$

$$\therefore p_i = \frac{q_i}{(\sum_{i=1}^{12} q_i)} \quad \dots \text{ (i)}$$

$$\therefore q_i = \frac{n_i k_i}{\sum_{i=1}^{12} n_i k_i} \times 100 \quad \dots \text{(ii)}$$

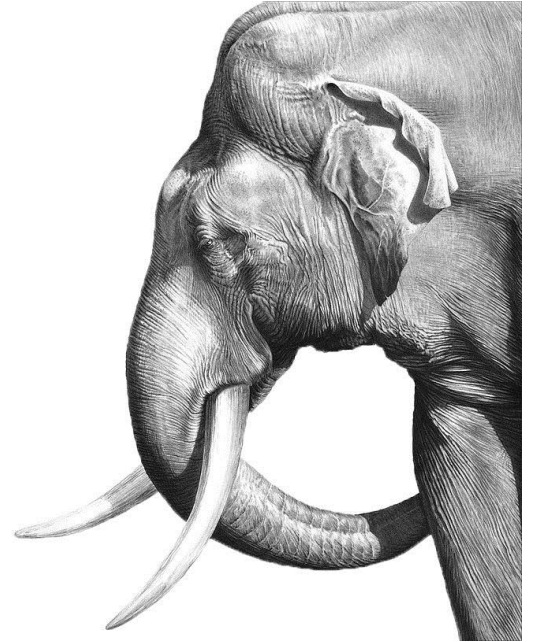
Where,

i = Corresponding to the nominate months (January to December)

n_i = Number of cases in i^{th} month in the entire study period

k_i = Number of years in which raiding occurred in the i^{th} month during the study period

Spatial data for district, taluka and village boundaries was obtained from opensource geodatabases (www.osgeo.org). The basic unit in this database was village whereas that in compensation database was a compensation claim registered in the name of a person. The compensation data was reduced to village level by calculating above mentioned indices. These indices were joined as attributes to the spatial database to prepare maps based on indices at the scale of villages. Further, the compensation data was sorted by years in the study period and similarly maps of raiding frequency were prepared for each year to show the progression of the crop raiding problem in the study area. Classified image data depicting forest cover and/or water was used as background to the maps. The locations of affected farms of the farmers selected for interviews were also mapped. This mapping was performed using opensource GIS software QGIS.



RESULTS AND DISCUSSION



Gray Hodges

4. RESULTS AND DISCUSSION

4.1 ASSESSMENT OF ELEPHANT CROP RAIDING

4.1.1 Extent of Crop Raiding by Elephants

The problem of crop raiding by elephants in Sindhudurg district was extensive in terms of its duration, area of influence, number of villages affected, number of farmers affected and number of crops damaged. These aspects as assessed from the compensation records with the forest department are presented here.

4.1.1.1 Annual extent

During the period for which data was collected, the highest number of cases was recorded in the year 2007 (Figure 1). However, it must be noted that the data for two years 2002 and 2015 are incomplete. Problem of crop raiding started towards the end of the year 2002 and therefore, data was not available for earlier months. Similarly, for year 2015, the cases recorded only up to August could be included in the present study due to time-frame of the study. Further, the elephants in Kudal were captured by Forest Department in February 2015 and hence, frequency of crop raiding reduced in that area.

There was gradual increase in raiding frequency from 2002 to 2008. Then, there was a sudden dip during 2009-10 after which it increased again. Then again in 2015 the raiding frequency dipped. Thus, excluding 2002 and 2015, the trend in annual raiding frequency seems to have followed the number of elephants active in those particular years. The number of elephants active in a particular year, in turn, was dependent on influx of elephants from and efforts of Forest Department to shoo them back to their southern original abodes. Reliable figures for number of active elephants by range or even for the entire study area were not available due to lack of systematic census. Various figures ranging from 4 to 11 at different times and from different sources were available (Sarma & Easa 2006, Mehta and Kulkarni 2013) but could not be verified with authorities.

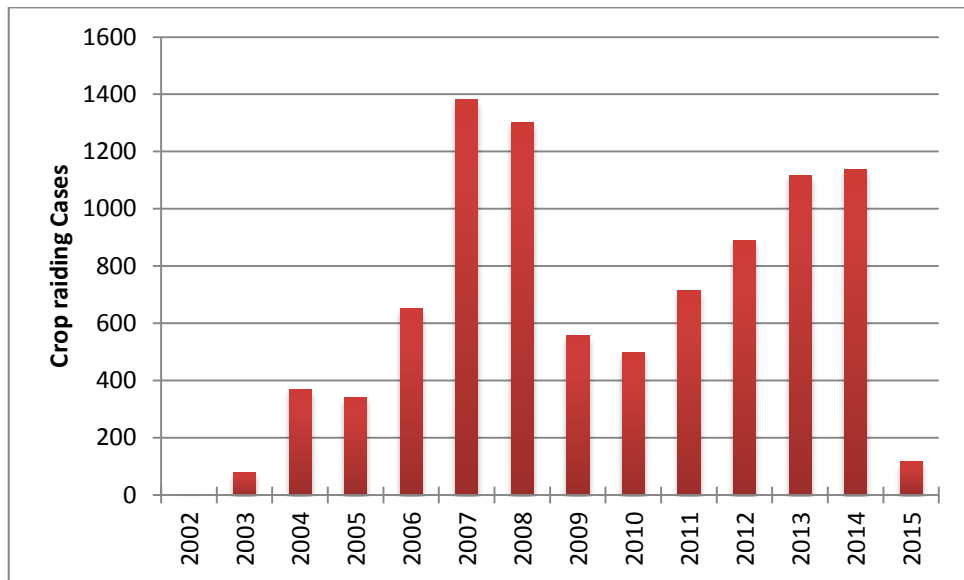


Figure 1: Annual crop raiding frequency by elephants in Sindhudurg district.

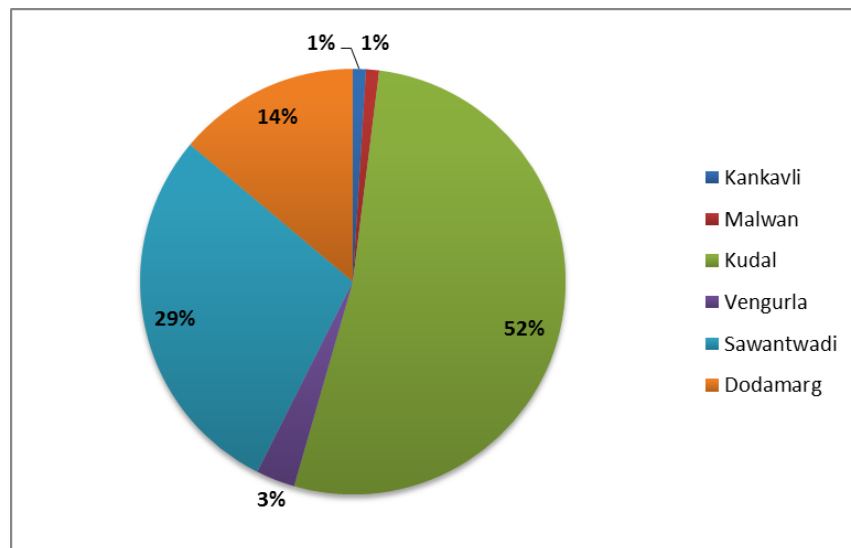


Figure 2: Proportion of elephant crop raiding cases in different talukas of Sindhudurg district.

Over a major part of the present study period, failure of various measures taken by Forest Department to minimize conflict was highlighted by Mehta and Kulkarni (2013). Present data also suggests that crop raiding by elephants was largely determined by the number of elephants and the only measure that could effectively reduce it was removal of elephants in 2009. Thus, it might appear that such efforts as elephant capture, translocation and domestication programs would prove successful in minimizing crop raiding. But, this cannot be considered as a permanent solution to the problem of wide-ranging animals like elephants. And data for later years proved it. It would be interesting to see the result of latest elephant removal operation in 2015.

Annual patterns in crop raiding found in this study are similar to those reported in Mehta and Kulkarni (2013) from 2002 to 2013 essentially because present study is a temporal extension of that study. However, Map 3 shows the gradual extension of conflict zone in to the Sindhudurg district over the period of 2002-2015. It could be clearly seen that during 2002 to 2008, the incursions of elephants were more widespread and exploratory in nature. Then in 2009, four elephants were captured out of which two died and two were translocated to Karnataka. It is presumed by villagers and forest department personnel that these two translocated elephants soon returned along with two others. In this second stint from 2010 to 2015, the map clearly shows that they directly approached the Kudal range and established a fairly concentrated home range with a high-conflict core zone and a relatively low-conflict buffer zone. Towards 2014-15, they had started to further explore northward.

4.1.1.2 Demographic Extent

Studies on crop raiding of such large areas and involving documentation of such a large number of crop raiding cases over such a long period as in the present study are rare. During the period under study (2002 to 2015), thousands of cases of crop-raiding by elephants had taken place in almost the entire Sindhudurg district. From the compensation records of Forest Department, information was available on 9148 cases in all but one talukas of Sindhudurg district. The conflict situation under study was spread over an area of nearly 4300 km² of Sindhudurg district. The database revealed that 244 villages (33% of the total villages in Sindhudurg) were affected by crop-raiding by elephants (Table 1).

The worst affected talukas in terms of villages affected were Kudal, Sawantwadi and Dodamarg. On the other hand, Vengurla, Kankavli, Malwan and Vaibhavvadi were comparatively less affected. Similar pattern could also be seen in terms of number of crop raiding cases (Table 1, Figure 2). Devgad Taluka was unaffected by elephant raids. Table 2 lists five worst affected villages of each taluka.

Table 1: Demographic profile of talukas in Sindhudurg district along with villages affected by crop raiding (CR) by elephants (2002-2015). Figures in parentheses indicate proportion of all villages in respective talukas. *Data sourced from Census of India, 2011 (www.censusindia.gov.in)

Taluka	Geographical Area* (km ²)	Villages*	Population*	Households*	Villages affected by CR	CR cases
Devgad	787.68	98	1,20,909	27,800	0 (00%)	-
Vaibhavvadi	427.03	59	43,845	11,545	5 (08%)	7 (0.1%)
Kankavli	819.77	105	1,10,886	27,864	16 (15%)	59 (01%)
Malwan	608.43	135	93,159	24,304	11 (08%)	51 (01%)
Kudal	809.30	124	1,39,609	34,127	83 (67%)	4,837 (52%)
Vengurla	277.12	83	73,409	18,372	20 (24%)	260 (03%)
Sawantwadi	797.85	82	1,11,924	27,154	62 (76%)	2,642 (29%)
Dodamarg	558.08	62	48,904	12,035	47 (79%)	1,292 (14%)
Total	5,085.26	748	7,42,645	1,83,201	244 (33%)	9148

Table 2: Villages worst affected by elephant crop raiding in various talukas of Sindhudurg district, Maharashtra. Number of crop raiding cases in respective villages during 2002-2015 is in parentheses.

Rank	Vaibhavvadi	Kankavli	Malwan	Kudal	Vengurla	Sawantwadi	Dodamarg
1	Achirne (2)	Pise Kamate (11)	Kalse (20)	Tulsuli K. Narur (468)	Tulas (53)	Sonurli (254)	Mangeli (209)
2	Pimpalwadi (1)	Bordave (9)	Asaroni (6)	Naneli (352)	Matond (35)	Dingne (250)	Hewale (165)
3	Khambale (1)	Shivdav (7)	Hiwale (9)	Wados (349)	Pendur (31)	Padlos (224)	Kalane (97)
4	Mohitewadi (1)	Kalasuli (6)	Dikval (5)	Karivane (322)	Math (26)	Majgaon (201)	Bambarde (95)
5	Narkarwadi (1)	Lore-2 (5)	Sukalwad (4)	Nivaje (296)	Asoli (15)	Otavane (127)	Konal (88)

Mehta and Kulkarni (2013) had collected data on 6,946 cases of crop raiding in Sindhudurg district for a period from 2002 to 2013. Present study is an extension of that study. Their study also envisaged parts of adjoining Kolhapur district. Their analysis was based on forest ranges rather than talukas. They had observed highest

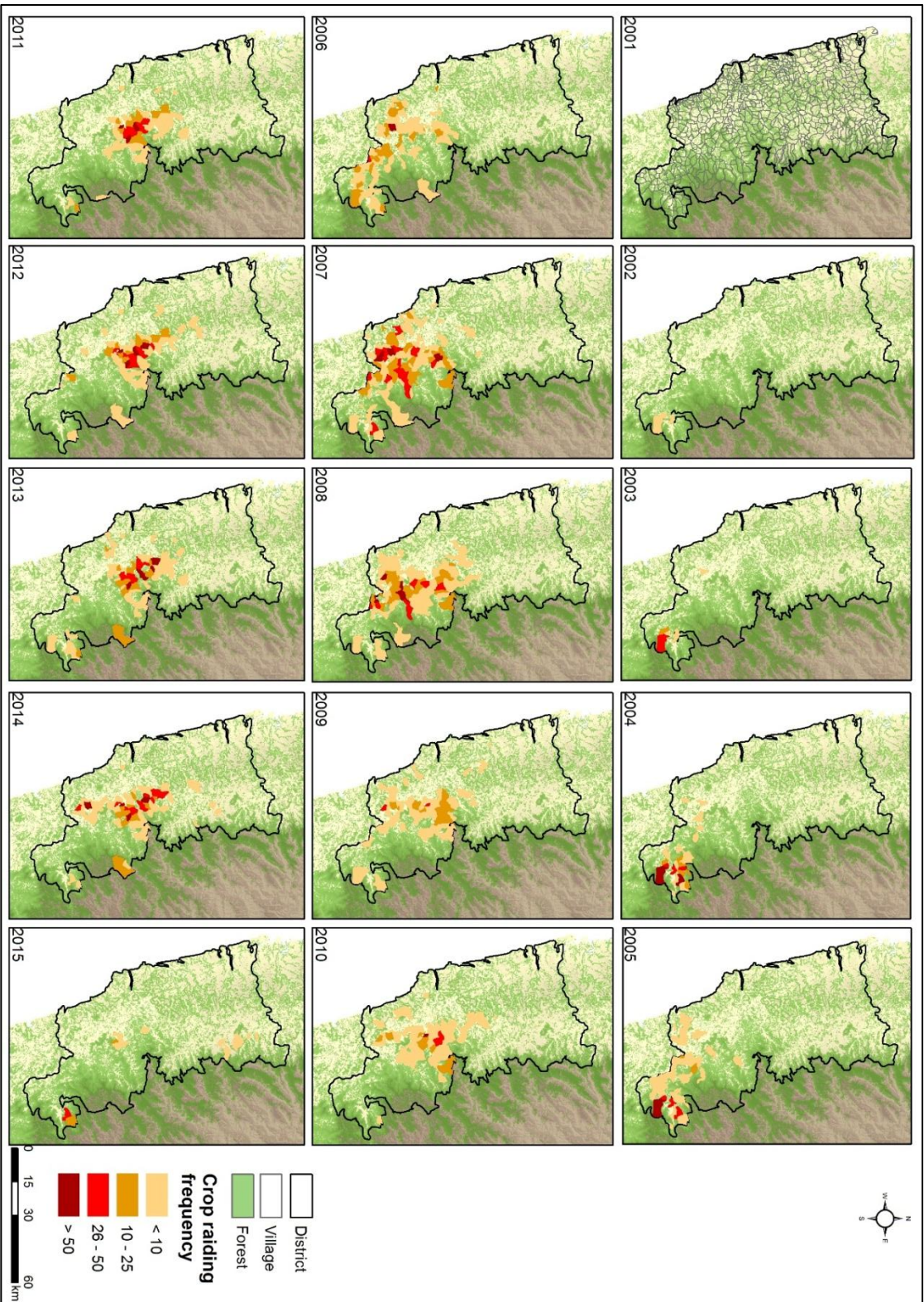


Plate 3: Annual progression of elephant crop raiding in Sindhudurg district (2002-2015)

numbers of crop raiding cases in Dodamarg range followed by Kudal, Sawantwadi and Kadawal ranges. On the contrary, present study points out that Kudal became the worst hit taluka/range during the period after their study. Thus, there was an obvious shift in the problem. Similar pilot study had been conducted by same authors previously (Kulkarni et al. 2008) and had submitted an action plan for mitigation of the conflict to the Forest Department (Kulkarni & Mehta, 2011).

Gubbi (2012) conducted similar study on human-elephant conflict in Nagarahole National Park, Karnataka. He collected compensation claim records from state Forest Department for four consecutive years (2006-09). His study area was spread over an area of 468.7 km² and involved 79 villages. Gubbi et al. (2014) conducted a large-scale study for which they collected records from Karnataka state Forest Department for a period from April 2008–March 2011. Twelve Districts and 40 talukas covering an area of nearly 19,000 km² were affected during the study period and a total of 60,939 incidences of crop loss were compiled and analysed.

Haturusinghe and Weerakoon (2012) collected secondary data on human-elephant conflict from Department of Wildlife Conservation for two years (January 1998 to December 1999) in North-Western province of Sri Lanka. However, they did not present any analysis of crop-raiding data for the said period. Campos-Arceiz et al. (2009) and Ekanayaka et al. (2011) studied human-elephant conflict in south-eastern Sri Lanka during 2004-05 and 2005-06 respectively and recorded 975 and 383 cases of crop raiding. Santiapillai et al. (2010) conducted conflict assessment study during January to March 2008. He randomly selected 100 villages and interviewed 100 families from five provinces in Sri Lanka. Sitompul et al. (2010) conducted similar study at two national parks in Lampung Province, Sumatra, Indonesia. They recorded total of 714 crop damage incidents during June 2000 – September 2002.

Thus, the present study seems to be one of a rare kind in which long-term historical crop raiding data has been collated and analysed. Therefore, comparable datasets are rarely available.

4.1.1.3 Crop damage extent

Total 36 crops (agricultural crops = 14; horticultural crops = 18 and forestry crops = 4) were raided over the period from 2002 to 2015. These include (i) horticultural Crops viz. coconut, banana, areca palm, mango, cashew, jackfruit, sapota, garcinia, pineapple, papaya, bread fruit, oil palm, jamun, lemon, drum stick, nutmeg, custard apple and java apple, (ii) agricultural crops viz. rice, ragi, sugarcane, chili, groundnut, cowpea, kulith, maize, watermelon, wal, sunflower, jowar, bajara and udid and (iii) forestry crops viz. bamboo, teak, rubber and sandal in order of dominance. Of all the 36 different crops damaged, coconut (44%), rice (22%), banana (20%) and areca palm (8%) were the worst affected crops in terms of raiding frequency (Table 3, Figure 3, Plate 3).

Table 3: crop raiding (CR) profile of talukas in Sindhudurg District, Maharashtra (2002-2015). Figures in parentheses are proportions of total cases. A single raid usually involved damage to multiple crops and hence, the total of raids by crop are much more than aggregate crop raiding cases.

Taluka	Coconut	Areca palm	Banana	Rice	Other Crops	Total CR cases
Vaibhavvadi	4 (0.1%)	0 (0%)	4 (0.1%)	0 (0%)	3 (0.3%)	7 (0.1%)
Kankavli	37 (0.5%)	3 (0.2%)	18 (0.6%)	17 (0.5%)	11 (1.1%)	59 (1%)
Malwan	33 (0.5%)	4 (0.3%)	15 (0.5%)	11 (0.3%)	8 (0.8%)	51 (1%)
Kudal	4044 (57.9%)	496 (37.5%)	1549 (49%)	1877 (54.7%)	576 (55.7%)	4837 (52%)
Vengurla	166 (2.4%)	30 (2.3%)	85 (2.7%)	87 (2.5%)	34 (3.3%)	260 (3%)
Sawantwadi	1872 (26.8%)	433 (32.8%)	1081 (34.2%)	983 (28.6%)	263 (25.4)	2642 (29%)
Dodamarg	826 (11.8%)	356 (26.9%)	410 (13.0%)	457 (13.3%)	140 (13.5%)	1292 (14%)
Total	6982	1322	3162	3432	1035	9148

Gubbi et al. (2014) recorded that 54 crops were damaged by elephants in Karnataka over a period of four months. Campos-Arceiz et al. (2009) in south-eastern Sri Lanka, found the elephants damaging some 30 cultivated crops.

Nath et al. (2015) reported that elephants principally raided rice crop in Assam. Santiapillai et al. (2010) found that rice, banana, coconut were the most favoured crops by elephants in Sri Lanka. Luo (2007) reported that rice, banana and bamboo

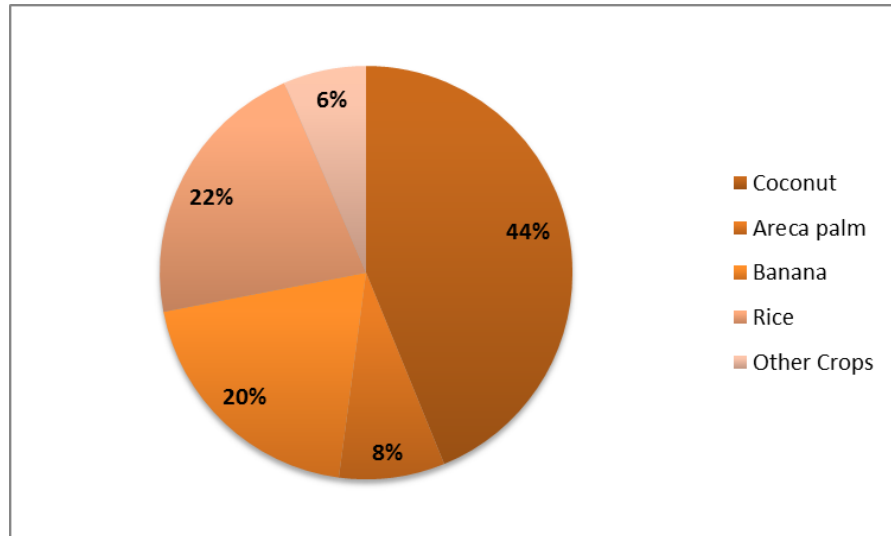


Figure 3: Proportion of crops damaged by elephants in Sindhudurg district.

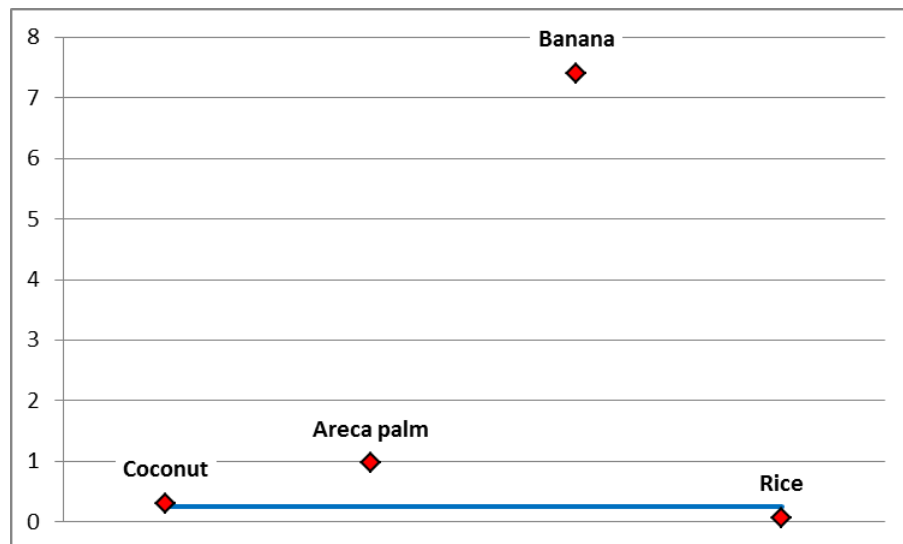


Figure 4: Ratio of number of elephant raids to area under crop for major crops in Sindhudurg district. The horizontal line indicates the normal ratio i.e. ratio of all raids to total area under all four crops.



Plate 3: Crop damage by elephants in Sindhudurg district.

were the most favoured crops by elephants in Upper Mekong Region. Ekanayaka et al. (2011) reported elephant raids more in banana than the paddy and perennial crops like jackfruit, coconut and sugarcane contributed equally with 5% in Sri Lanka. Campos-Arceiz et al. (2009) in South-Eastern Sri Lanka, found that banana, paddy and coconut were the chiefly damaged crops.

The Forest Department recorded damage to coconut in three categories – major or minor damage to bearing palms and damage to young palms. Similarly, damage to rice was recorded as that to standing crop, stacks in fields or stored grain. In field, coconut palms are attacked to feed on the apical meristem (heart of palm) or soft core of the young stems. This is achieved either by directly removing the apical meristem of shorter palms or by uprooting the tall ones. To uproot the palms, elephants push them by their rear. Nuts are not consumed. Rice crop when attacked is trampled and consumed whole. In banana, the succulent stem core and leaves are consumed whereas unripe fruits are not consumed. Areca palms are damaged but possibly not for consumption. They appear to be a collateral damage because mostly it is planted as an intercrop in coconut plantations.

Some insight into the elephants' preference of crops for raiding could be had from the overlap or non-overlap of raided crops in the present data. The elephants are large mammals and require huge biomass to feed. Although, raids by solitary animals are more frequent, raids by herds are common and are devastating compared to other animals. Therefore, the probability of damaging more than one crop during one raid is very high. From the compensation records, it was apparent that the probability of elephants damaging multiple crops during single raid was nearly 50 %. Of the raids in which single crop was damaged, nearly 50% cases involved coconut, 39% involved rice and rest were other crops. Of the raids in which two or more crops were damaged, coconut was again the major crop being damaged in 92% raids followed by banana in 65% raids, rice in 37% raids and areca palm in 28% raids.

Chi-square test was conducted to see if there was any association between number of crops damaged in a raid and types of crops damaged. There was strong association between these two factors ($\chi^2 = 2160$, d. f. = 34, $p = < 0.001$). Thus, when raiding involved multiple crops, the proportion of coconut, banana and areca palm increased considerably while that of rice remained nearly same.

This kind of analysis would prove useful when observations on raiding elephants are recorded. But in the present case, the raids were recorded as separate compensation claims of different farmers whose farms might have been raided on the same occasion. Thus, each compensation case is not an independent single instance. Therefore, such an analysis would not provide any meaningful insight into elephants' feeding preferences or crops' ability to satiate the elephants. However, a plain conclusion that coconut and rice were the most preferred crops for raiding could be drawn here.

On the other hand, comparing use of a resource to their availability is a standard procedure for understanding resource preferences. In the present case, relationship between elephants' relative raiding frequency and availability of crops could be tested at the scale of taluka. Area under major crops was available from Agriculture Department at the taluka level. The data is presented in Table 4. It was found that there was no significant correlation for any crop between area under crop and number of raids. This was an indication that the crops were not raided in proportion to their availability.

Table 4: Comparison of elephant raiding frequency on and area under major crops in different talukas of Sindhudurg district.

Taluka	Coconut		Areca palm		Banana		Rice		Total Raids	Hurlbert's Standard Niche Breadth
	Raids (n)	Area (Ha)	Raids (n)	Area (Ha)	Raids (n)	Area (Ha)	Raids (n)	Area (Ha)		
Vaibhavvadi	4	335	0	20	4	20	0	4160	8	0.0123
Kankavli	37	1110	3	58	18	40	17	13750	75	0.0370
Malwan	33	3510	4	155	15	40	11	10990	63	0.0420
Kudal	4044	4220	496	175	1549	45	1877	13690	7966	0.0571
Vengurla	166	3002	30	170	85	30	87	4190	368	0.0675
Sawantwadi	1872	3402	433	255	1081	120	983	7170	4369	0.1404
Dodamarg	826	1710	356	178	410	90	457	2670	2049	0.2816

Another way to explore this relationship was to calculate The Hurlbert's standard niche breadth value for each taluka. The four major crops were assumed to be resource states. Their frequency of raiding and availability were used to calculate this value (Table 4). Ideally, the value ranges from 0 to 1 indicating exclusive use of one

resource state and equal use of all resource states respectively. It was seen that the highest value of niche breadth was 0.28 for Dodamarg taluka. This means that in none of the talukas elephants raided crops in proportion to their availability. They were partial to certain crops. If niche breadths of only the talukas with more than 2000 raids are considered, it is clear that crop raiding was highly disproportionate to the available crops. Rice was raided highly disproportionately less than its availability and banana was raided highly disproportionately more than its availability.

Disproportionate raiding was further assessed by taking ratio of number of raids to area of available for each crop. This ratio was compared with the ratio of total raids on all crops to area of all crops (Table 5, Figure 4). It can be seen that while the raids on coconut were close to the normal proportion, banana was raided disproportionately more than its availability.

Table 5: Ratio of crop raiding frequency to area under crop for major crops in different talukas of Sindhudurg district. The ratio of total raids in major crops to total area under major crops was 0.26.

Taluka	Coconut	Areca palm	Banana	Rice
Vaibhavvadi	0.012	0.000	0.200	0.000
Kankavli	0.033	0.052	0.450	0.001
Malwan	0.009	0.026	0.375	0.001
Kudal	0.958	2.834	34.422	0.137
Vengurla	0.055	0.176	2.833	0.021
Sawantwadi	0.550	1.698	9.008	0.137
Dodamarg	0.483	2.000	4.556	0.171

To further assess crop selectivity by raiding elephants, Jacob's index of selectivity was calculated for major crops based on number of raids and area under cultivation. The index ranges from -1 to +1 indicating low to high selectivity. This index too showed high selectivity for banana followed by areca palm, coconut and rice (Figure 5). Here negative values for rice might lead to surprising results as in Mehta and Kulkarni (2013) but it is, in fact, not surprising. The elephants have raided rice crop so frequently that it is the second most raided crop. But rice is cultivated on such a large area that it is virtually impossible for the small population of raiding elephants to proportionately raid it. However, banana being cultivated on very small area compared to other crops and also being available in smaller extent at scattered locations, the elephants had to incur more effort in searching and raiding banana

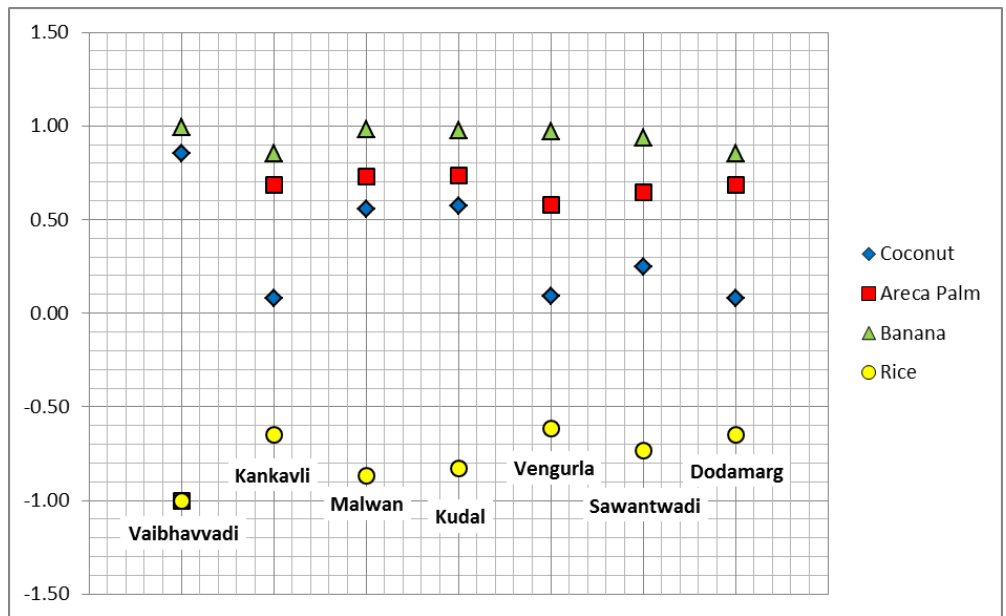


Figure 5: Jacob's Selectivity Index for major crops raided by elephants in different talukas of Sindhudurg district.

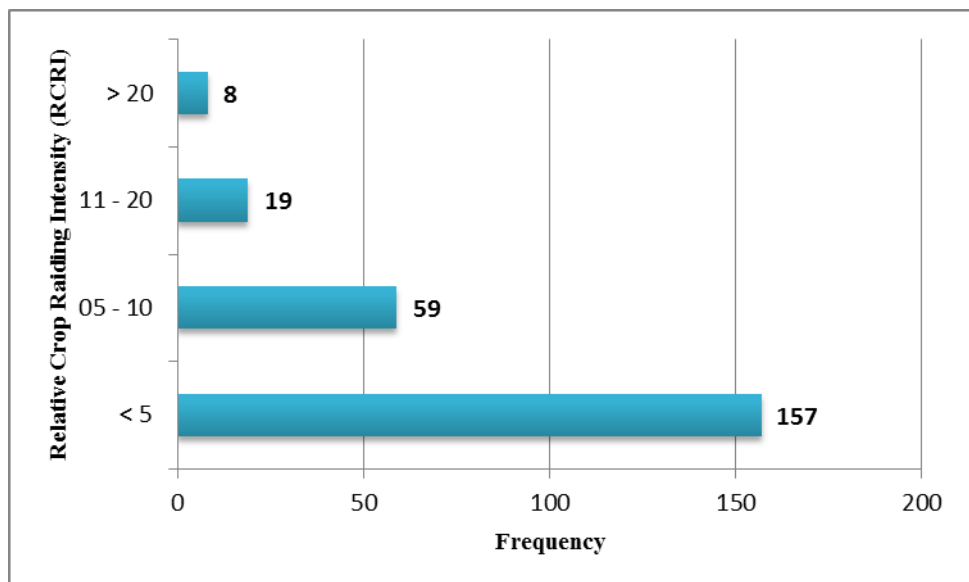


Figure 6: Frequency distribution of villages across classes of Relative Crop Raiding Intensity (RCRI).

plants. Yet banana experienced disproportionately more raids indicating that it was indeed selectively raided.

4.1.1.4 Compensation extent

Forest departmental records (2002-2015) revealed that of the total farmers (n = 4598) who claimed compensation, 64% claimed only once; 30% claimed between 2-5 times; and 6% claimed more than five times. Thus one in three farmers has suffered multiple crop raiding events on their farms. Multiple raiding events strongly alienate an individual or a household against elephant.

Over the period under study, State Forest Department has given compensation amount of ₹11,33,70,904 to the farmers of Sindhudurg district. The range of compensation amount given from individual claims varied between ₹96 to ₹5,18,160. The average compensation amount given was ₹12,393 (SD = 17,693, Median = 7,000). The highest amount of crop compensation ₹5,85,31,731 was given in Kudal taluka followed by Sawantwadi ₹2,99,69,716 and Dodamarg ₹2,19,68,438. Vengurla, Kankavli, Malwan and Vaibhavvadi received compensation of ₹20,17,582, ₹4,15,177, ₹4,04,816 and ₹63,444 respectively.

Mehta and Kulkarni (2013) reported that the Maharashtra government had given total compensation of ₹9.02 crore during 2002 to 2013 in Sindhudurg district i.e. the present study area. Zimmermann et al. (2009) recorded the total human-elephant conflict losses (crops and property) were ₹68,60,000 during 2005-2008 in Assam. Thaufeek et al. (2014) recorded the estimated property losses of ₹17,08,239 around the Sigiriya Sanctuary, Sri Lanka during 2008-2012.

4.1.2 Spatial Patterns and Indices of Crop Raiding

Although the problem of crop raiding by elephants was widespread in Sindhudurg district, the intensity and distribution of the problem was not uniform throughout. Several factors including elephant behaviour, topography and physiography of landscape, anthropological landuse and interventions determine these patterns. One of the aims of this study was to find out any distinct spatial patterns in crop raiding and

to prioritize areas for future interventions so that the recurring problem can be successfully handled.

It could be seen that crop raiding was severe in the talukas nestled in the Sahyadri ranges while coastal talukas had suffered relatively less (Figure 2). Similarly, because elephants extended their range from south to north, the northernmost talukas were either unaffected or lightly affected.

The Crop Raiding Frequency (CRF) of all affected villages is graphically presented in Map 4. This shows that even in case of talukas of Sahyadri, the steeper ranges were not affected much as compared to the foothills. However, the absolute CRFs or their proportion per village do not provide opportunity for comparing the intensity of crop raiding across studies. Therefore, an attempt was made to calculate two further indices of vulnerability of villages to crop raiding based on historical data. First was Relative Crop Raiding Intensity (RCRI). RCRI is a plain measure of crop raiding intensity incorporating the ratio of number of raiding instances to months of raiding occurrence. It was worked out for all affected villages and presented in Map 5. Figure 6 shows the distribution of villages in various RCRI classes.

Second index was Crop Raiding Vulnerability Index (CRVI). CRVI is based on Levin's measure. For data of one year, it incorporates the intensity and distribution of raids across the months of the year. For multi-year data, the number of cases in a particular month is weighted (multiplied) by the number of years in raiding occurred in that month. CRVI was calculated for all villages and presented in Map 6. Figure 7 shows distribution of villages in various CRVI classes.

CRF, RCRI and CRVI all provide useful information on identifying villages where historically severe problem of crop raiding has occurred. However, prioritization of villages based on CRF and RCRI is highly correlated as is witnessed by the rank-correlations found among these indices for the three most affected talukas (Table 6). These rank correlations were estimated for first 10 villages based on CRF. The high crop raiding villages identified using CRF and RCRI do not reveal the real picture because many of these comprise of villages affected for a brief duration with higher intensity. Ideally, these may not be vulnerable as elephants might have explored these villages for available resources intensively but finding them unsuitable, might have altogether stopped approaching them. CRVI, on the other hand, provided a completely

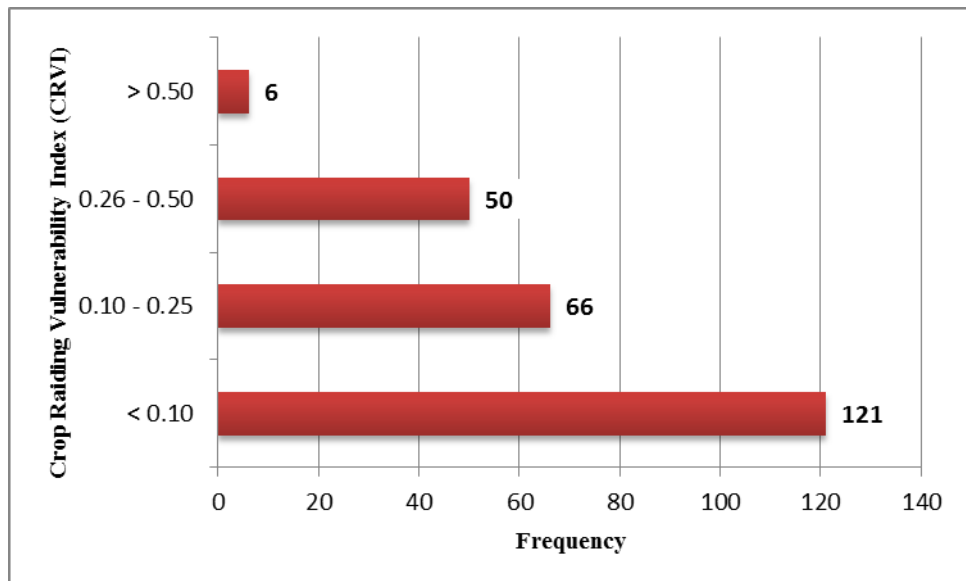


Figure 7: Frequency distribution of villages across classes of Crop Raiding Vulnerability Index (CRVI).

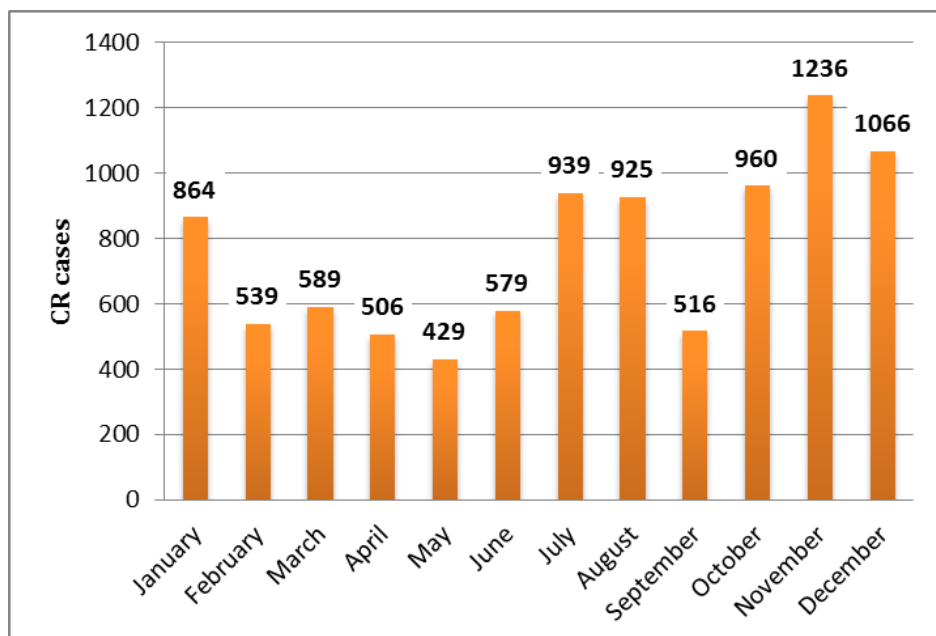
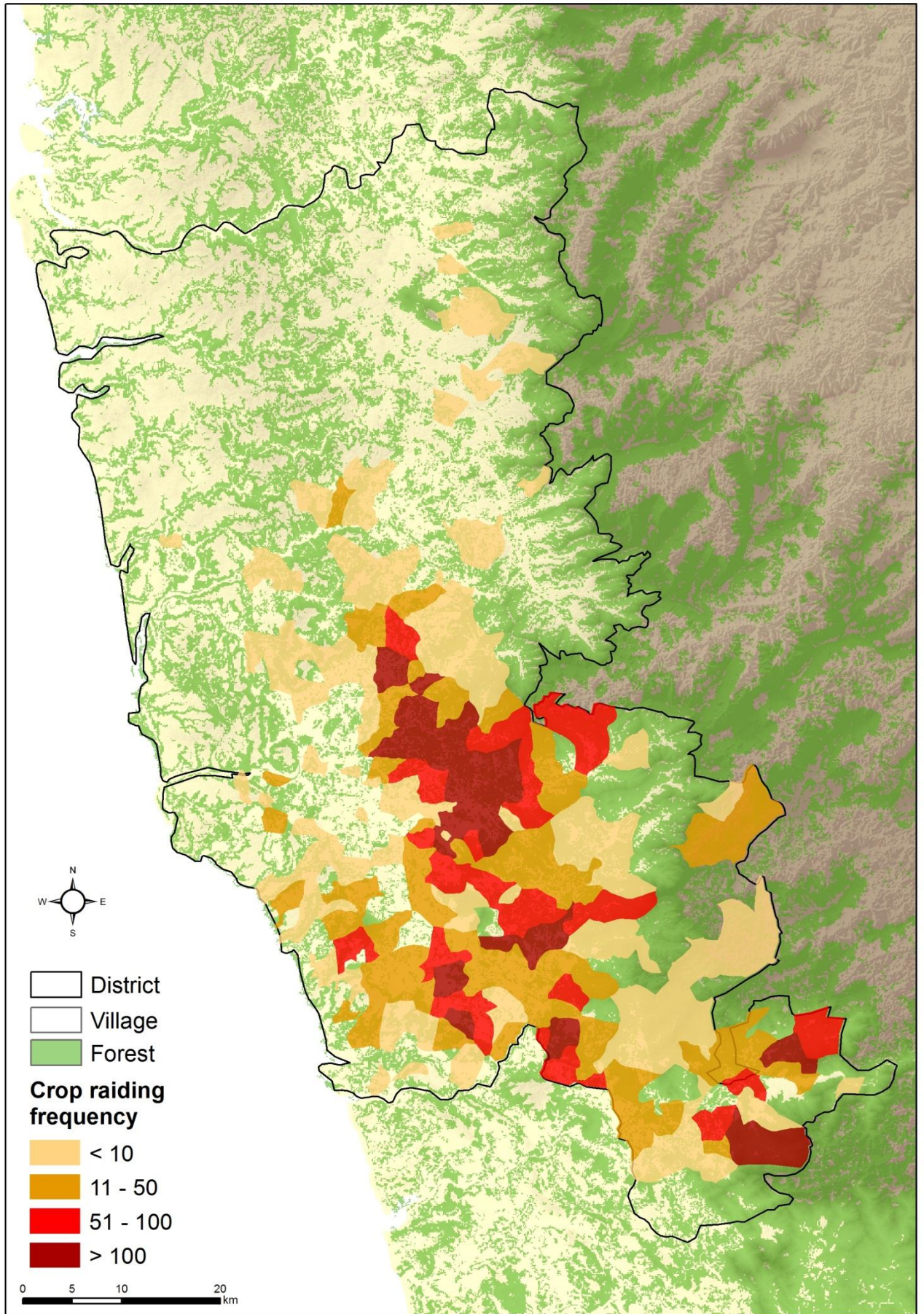
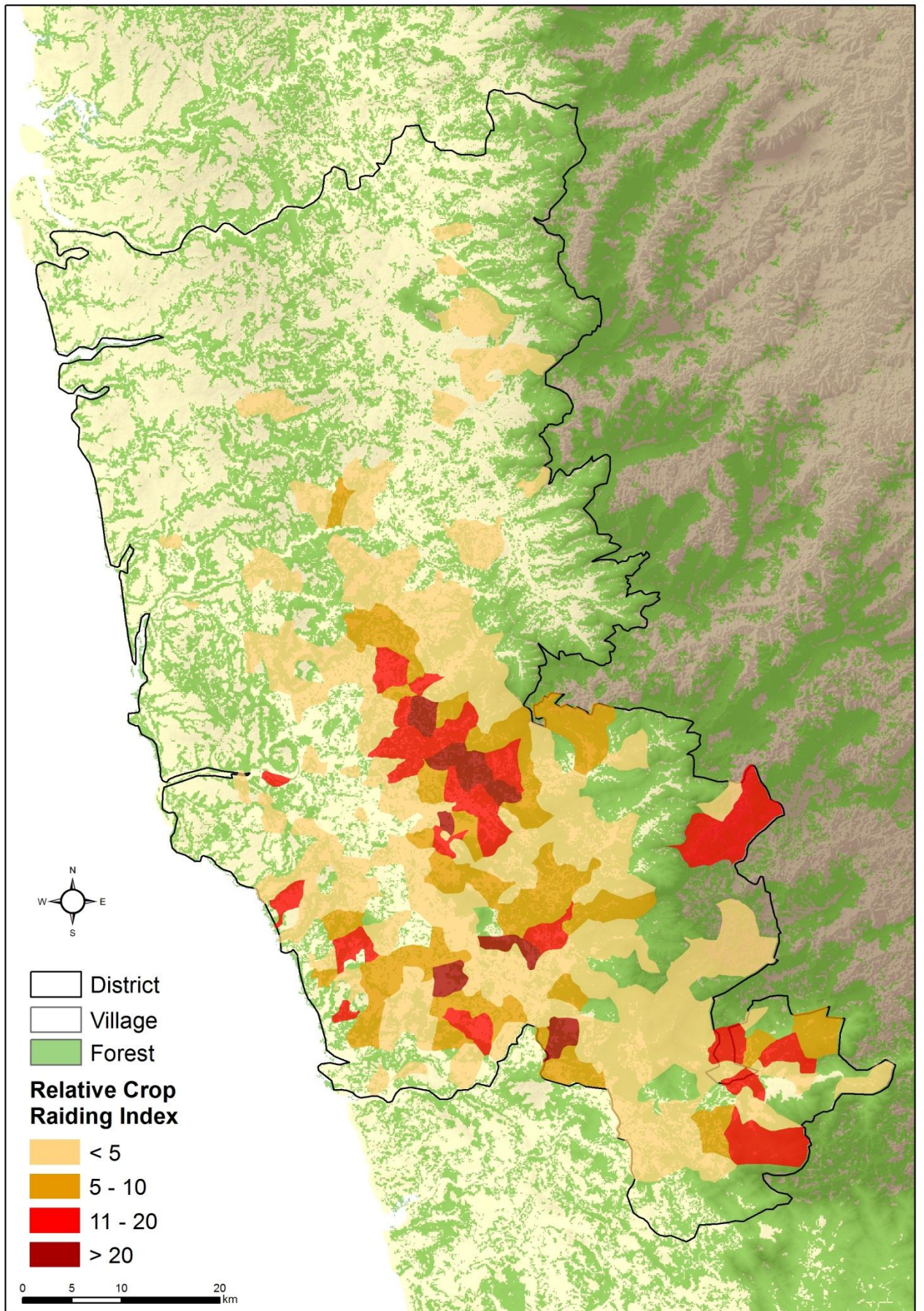


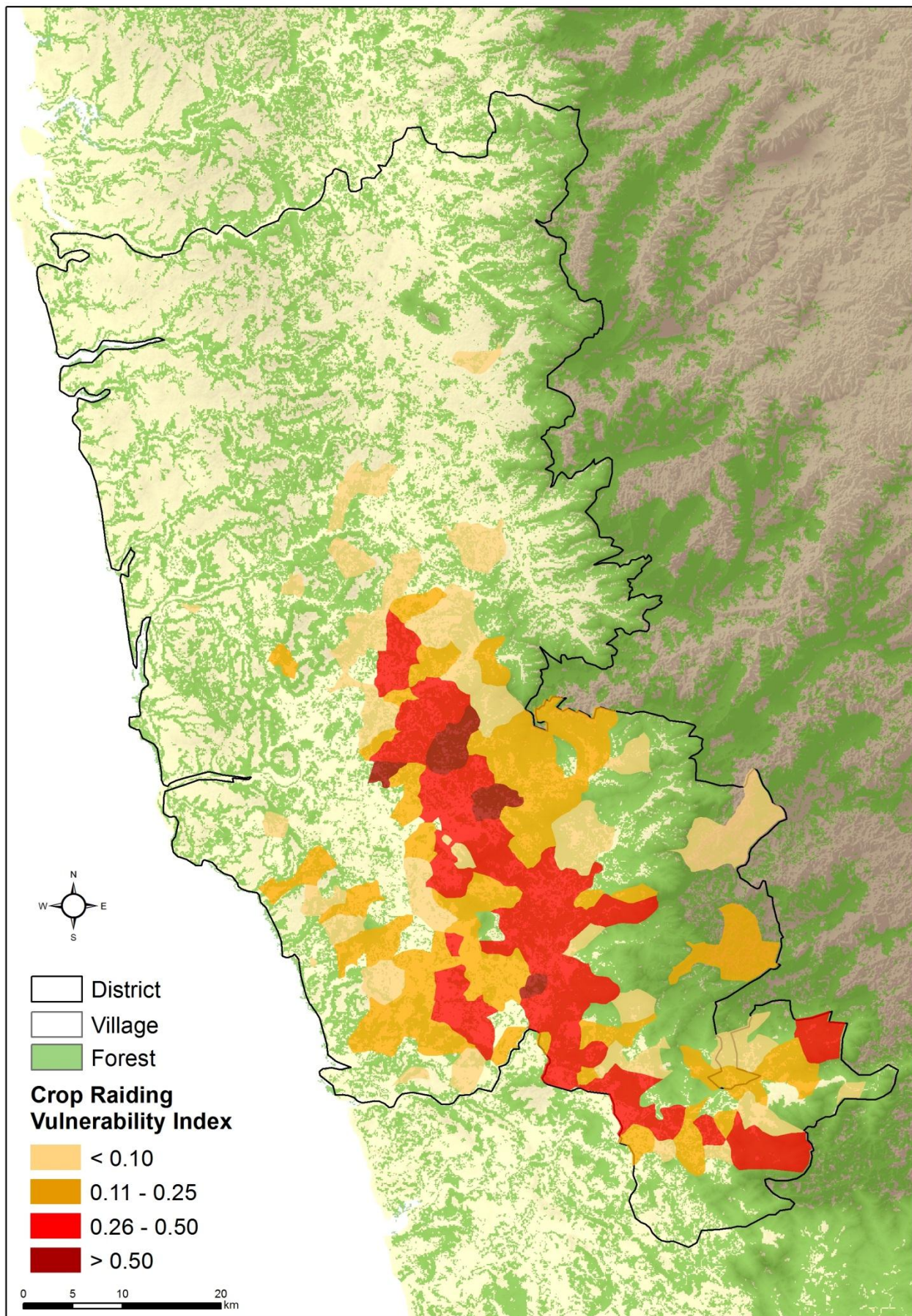
Figure 8: Number of crop raiding instances recorded per month in Sindhudurg district.



Map 4: Elephant Crop raiding frequency (CRF) of villages in Sindhudurg district (2002-2015)



Map 5: Relative Crop Raiding Intensity (ECRI) of villages in Sindhudurg district (2002-2015)



Map 6: Crop Raiding Vulnerability Index (CRVI) of villages in Sindhudurg district (2002-2015)

different ranking of the villages thus showing low correlation with both earlier indices.

Table 6: Rank correlation among Crop Raiding Frequency (CRF), Relative Crop Raiding Intensity (RCRI) and Crop Raiding Vulnerability Index (CRVI). Figures below diagonal are Spearman's r values and above diagonal are probabilities.

Kudal			
	CRF	RCRI	CRVI
CRF		<0.001	0.44247
RCRI	0.99937		0.46644
CRVI	0.27467	0.26097	
Sawantwadi			
	CRF	RCRI	CRVI
CRF		<0.001	0.57841
RCRI	0.94225		0.36547
CRVI	-0.20061	-0.32121	
Dodamarg			
	CRF	RCRI	CRVI
CRF		0.020713	0.78784
RCRI	0.71269		0.04036
CRVI	-0.09792	-0.6537	

The rankings provided by CRVI appear to provide more meaningful geographical or ecological information. A comparative look at Map 4, 5 and 6 reveals that CRVI identifies villages in a narrow strip of foothills of Sahyadri Mountains as severely vulnerable (red colored in map). Foothills are characterized by smaller hills, less sloping and less undulating terrain. The cropping is typically with relatively large tracts of rice intermixed with coconut in the valleys and cashew orchards on the slopes. Bamboo is also a major cultivated crop here. In this part, ample cover is available through huge private and government forest patches. Numerous waterbodies in the form of perennial streams, rivers and dams are also available in this part.

Gross factors determining elephants' use of a certain area apart from food include cover and water. It appears that the best possible combination of these three factors was available to the elephants in the area identified by CRVI. Thus, CRVI could become a useful index to identify villages highly vulnerable to crop raiding by elephants and preventive and/or mitigation measures could be prioritized in these villages. Because this index is not dependent on number of villages or number of

years for which the data is available, it could also be used to compare vulnerability across studies.

It is necessary to remember that CRVI is based on historical crop raiding data. A further step would be to verify the prioritization based on CRVI with that done using elephant habitat suitability modelling or niche modelling. It would probably form basis of another study in the present study area.

Several studies have tried to find out behavioural and landscape correlates of elephant resource selection and/or crop raiding. But they have not used or developed an index which could be useful across studies. Some of their findings include conclusions like role of larger human settlements and steep terrain as barriers to elephant movement (Baskaran et al. 2013). Nyhus, et al. (2000) found that presence of forest cover adjacent to agricultural area as a good predictor of heavy crop raiding. Wilson et al. (2013) spatially analyzed elephant raids records in relation to other environmental variables viz. distance to the nearest refuge area, water body and village, human population and crop density and successfully established the positive correlation with those factors. Their study revealed that crop raiding elephants use a ‘hit-and-run strategy’ in which refuge areas are used as a safe retreat.

4.1.3 Temporal Trends of crop raiding

Monthly crop raiding frequency during the period under study is shown in Figure 8. This distribution shows two distinct peaks (i) during July-August and (ii) during November-December. To see if the raiding intensity varied significantly among the months, median monthly raiding intensities were compared. Kruskal-Wallis test revealed that crop raiding differed significantly among the months ($\chi^2 = 25.58$, $p = 0.007$). There were two distinct periods of lower (February to June) and higher (July to January) median crop raiding intensity.

Mann-Whitney U test revealed that November and December months formed a peak within high crop raiding intensity period with significantly higher median crop raiding intensity than all months in the lower crop raiding intensity period. Thus, the peak shown by raiding frequencies in July-August could be an artefact of abnormally lower raiding intensity in the month of September (Table 7, Figure 8). Reasoning behind

this abnormally lowered crop raiding intensity in the month of September is provided in a later section.

Table 7: Comparison of monthly crop raiding (CR) intensity by elephants in Sindhudurg district, Maharashtra during 2002-2015. In the columns, probabilities are shown only for those pairs of months which showed significant difference.

Months	Median CR intensity	May	July	October	November	December
May	25		0.018	0.006	0.000	0.005
April	30		0.024	0.017	0.002	0.008
March	33.5				0.023	0.049
February	41.5				0.010	0.027
June	43			0.026	0.003	0.016
September	52				0.006	0.039
January	62.5	0.041				
August	73					
October	79.5					
November	98					
July	99					
December	116					

Ekanayaka et al. (2011) found similar monthly variations in elephant raids in South-eastern Sri Lanka. They also recorded two peaks. However, the peaks were slightly different than those in the present study. Their peaks were in January-February and July-August. They also concluded that higher raiding frequency in certain periods may not be driven by non-availability of natural fodder but availability of and preference for crops. Campos-Arceiz et al. (2009) also had found similar monthly trends and concluded that the peaks in crop raiding could be expected during the dry and post-rainy season because crops become more attractive to elephants during these periods. They attributed increase in attractiveness of crops to either a decrease in the quality of wild fodder or an increase in the quantity and quality of crops. In the present study too the prominent peak of November-December roughly aligned with high availability of mature rice crop either standing in the fields, or harvested and stocked.

For the three conventional climatic seasons viz. summer (February to May), Monsoon (June to September) and winter (October to January), the raiding frequency was higher during winter season (n = 4126) followed by monsoon (n = 2959) and still

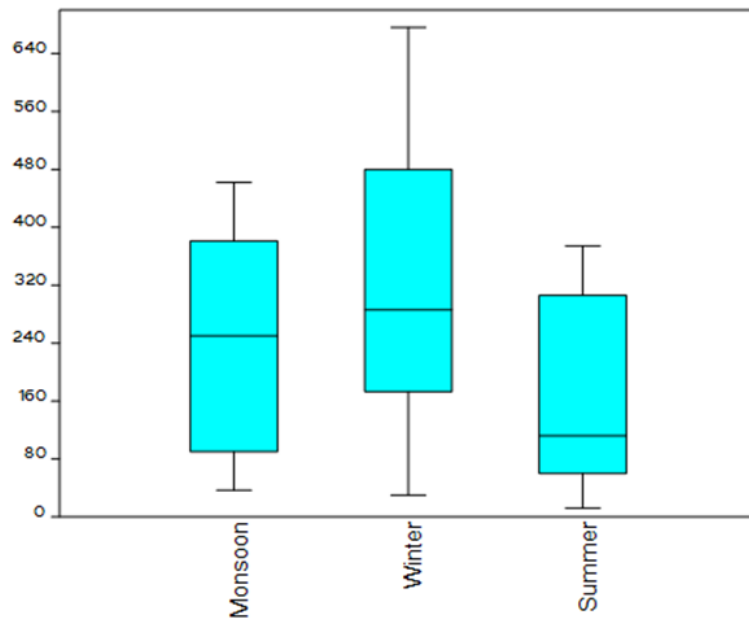


Figure 9: Seasonal distribution of crop raiding instances in Sindhudurg district.

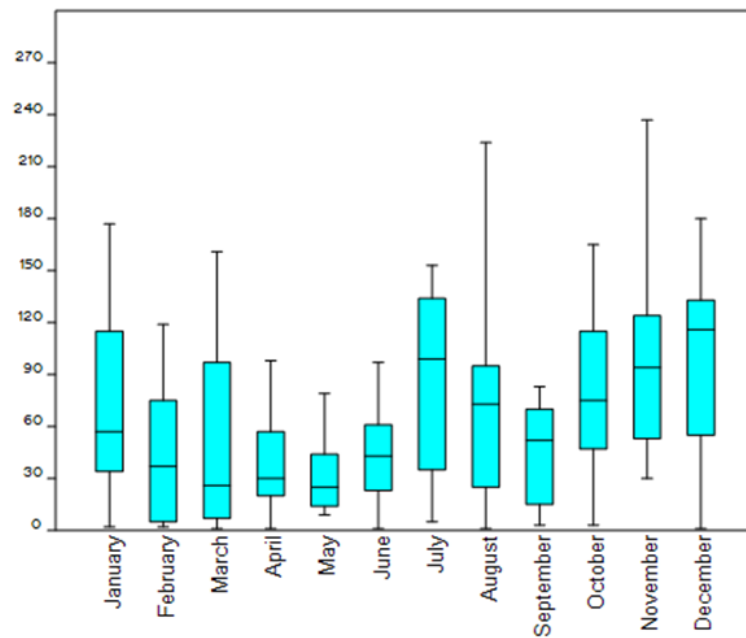


Figure 10: Monthly elephant crop raiding intensity in Sindhudurg district.

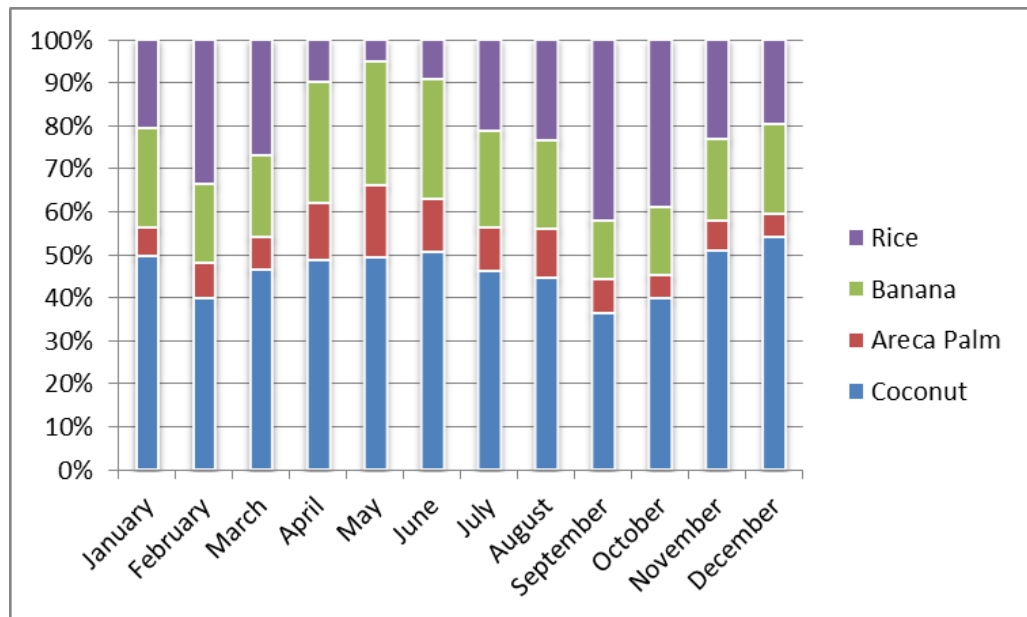


Figure 11: Relative percentage of crop raiding cases recorded on major crops per month in Sindhudurg district.

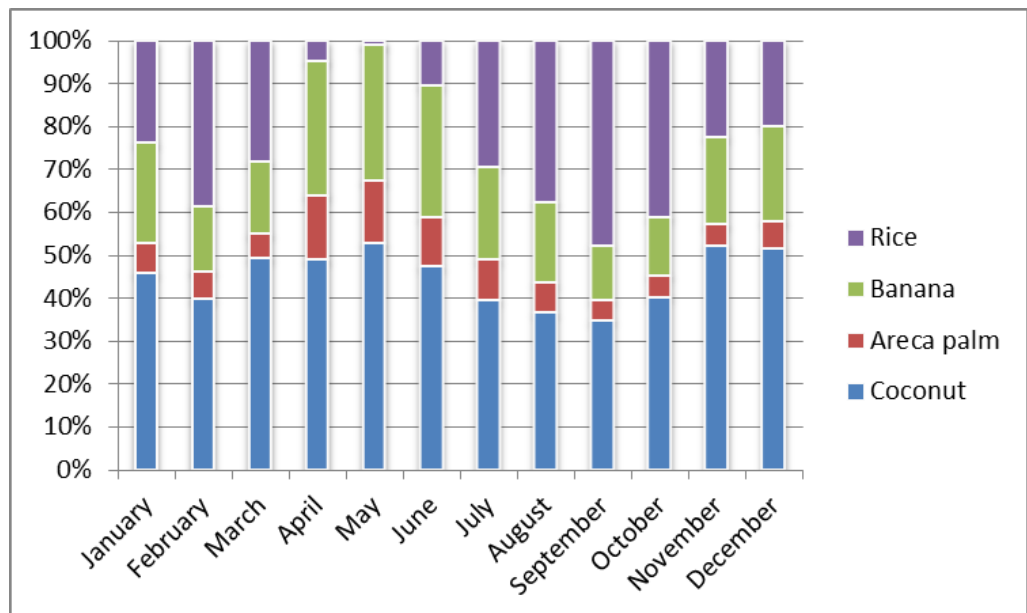


Figure 12: Relative percentage of crop raiding cases recorded on major crops per month in Kudal taluka.

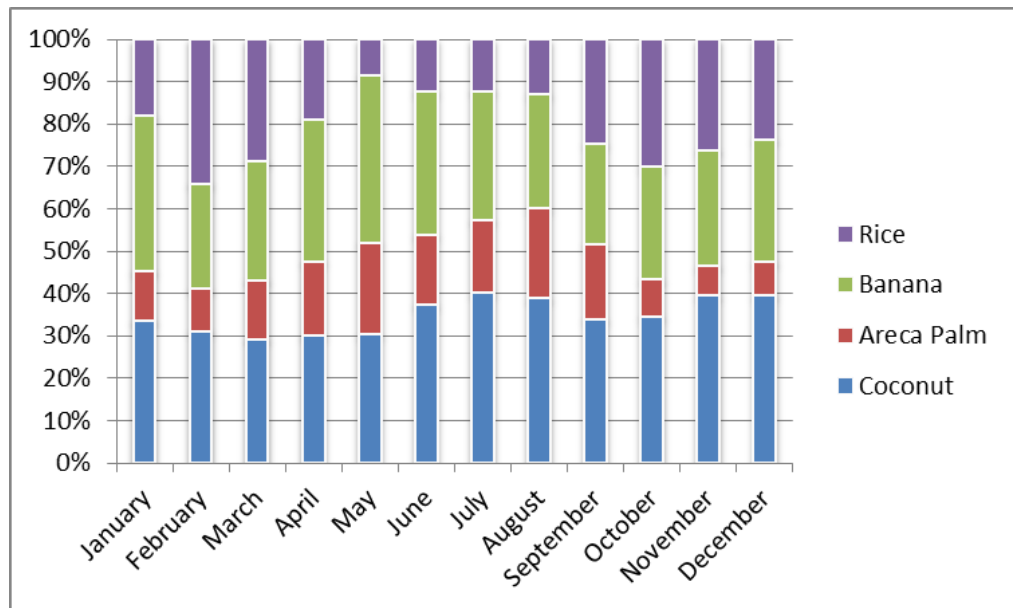


Figure 13: Relative percentage of crop raiding cases recorded on major crops per month in Sawantwadi taluka.

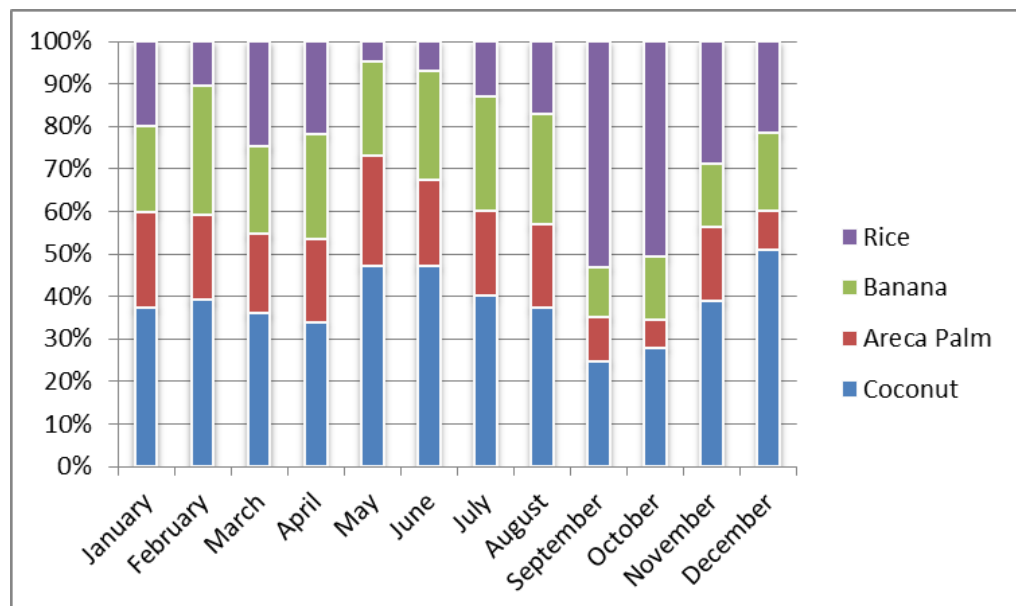


Figure 14: Relative percentage of crop raiding cases recorded on major crops per month in Dodamarg taluka.

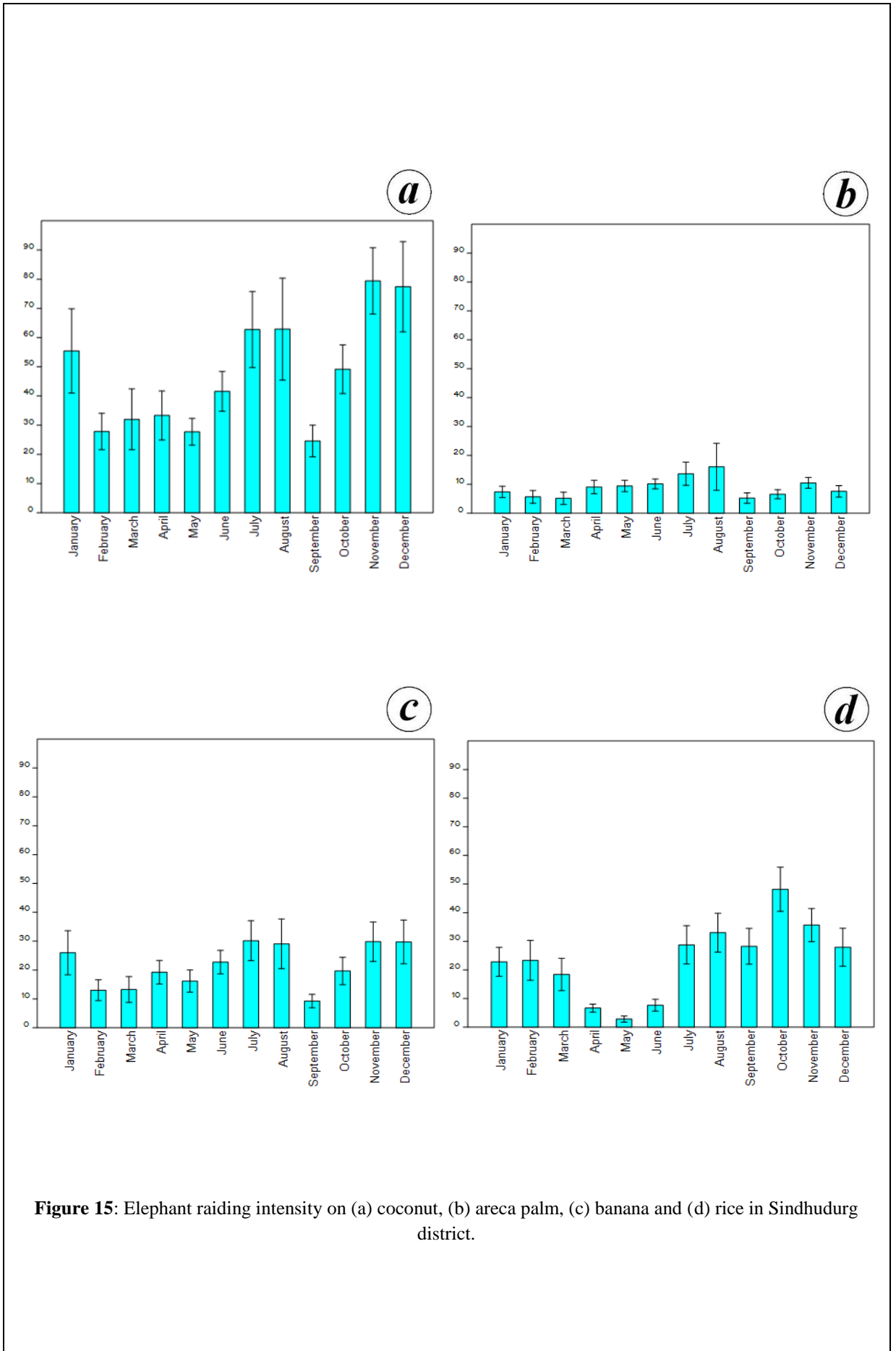


Figure 15: Elephant raiding intensity on (a) coconut, (b) areca palm, (c) banana and (d) rice in Sindhudurg district.

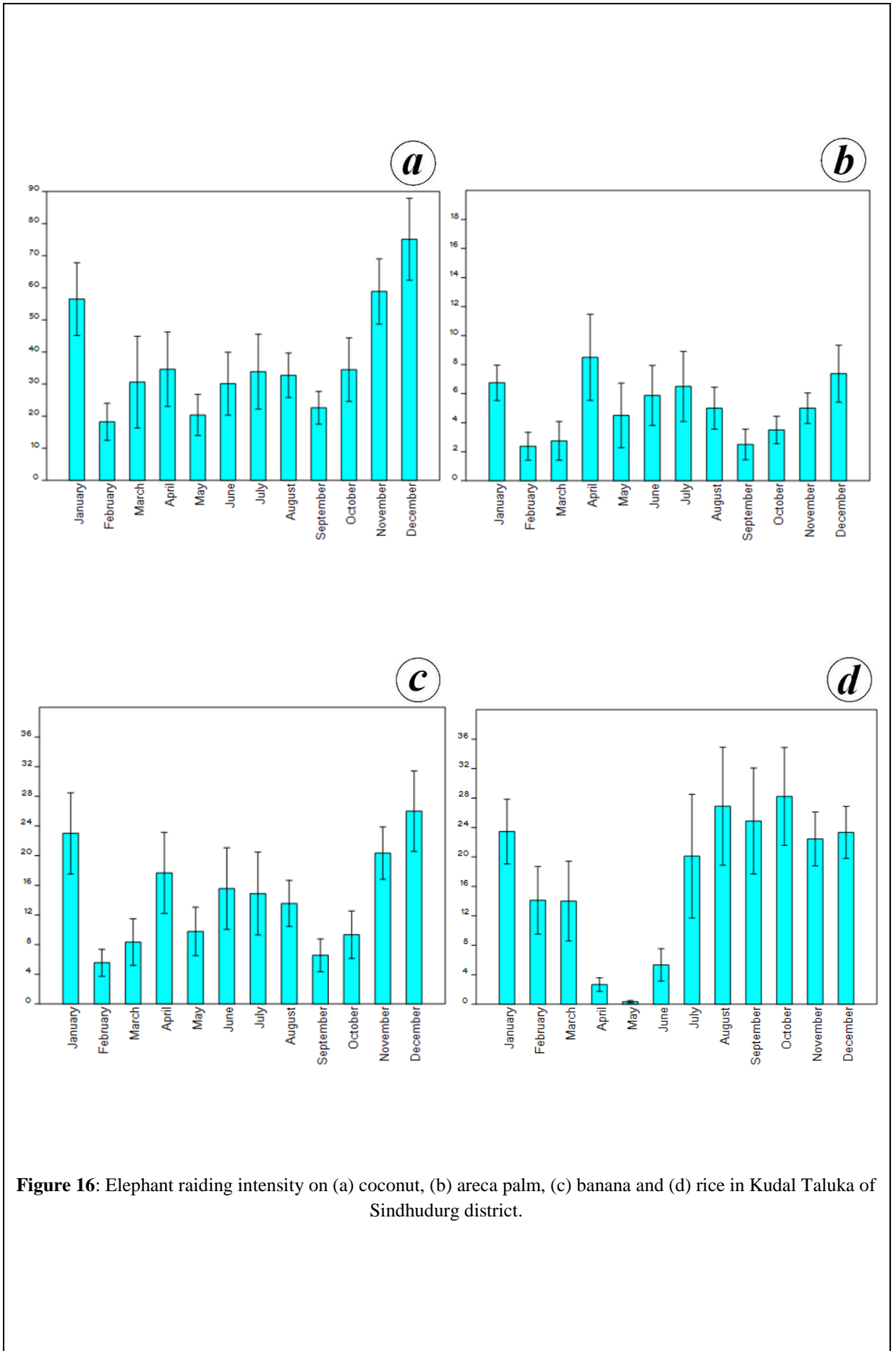


Figure 16: Elephant raiding intensity on (a) coconut, (b) areca palm, (c) banana and (d) rice in Kudal Taluka of Sindhudurg district.

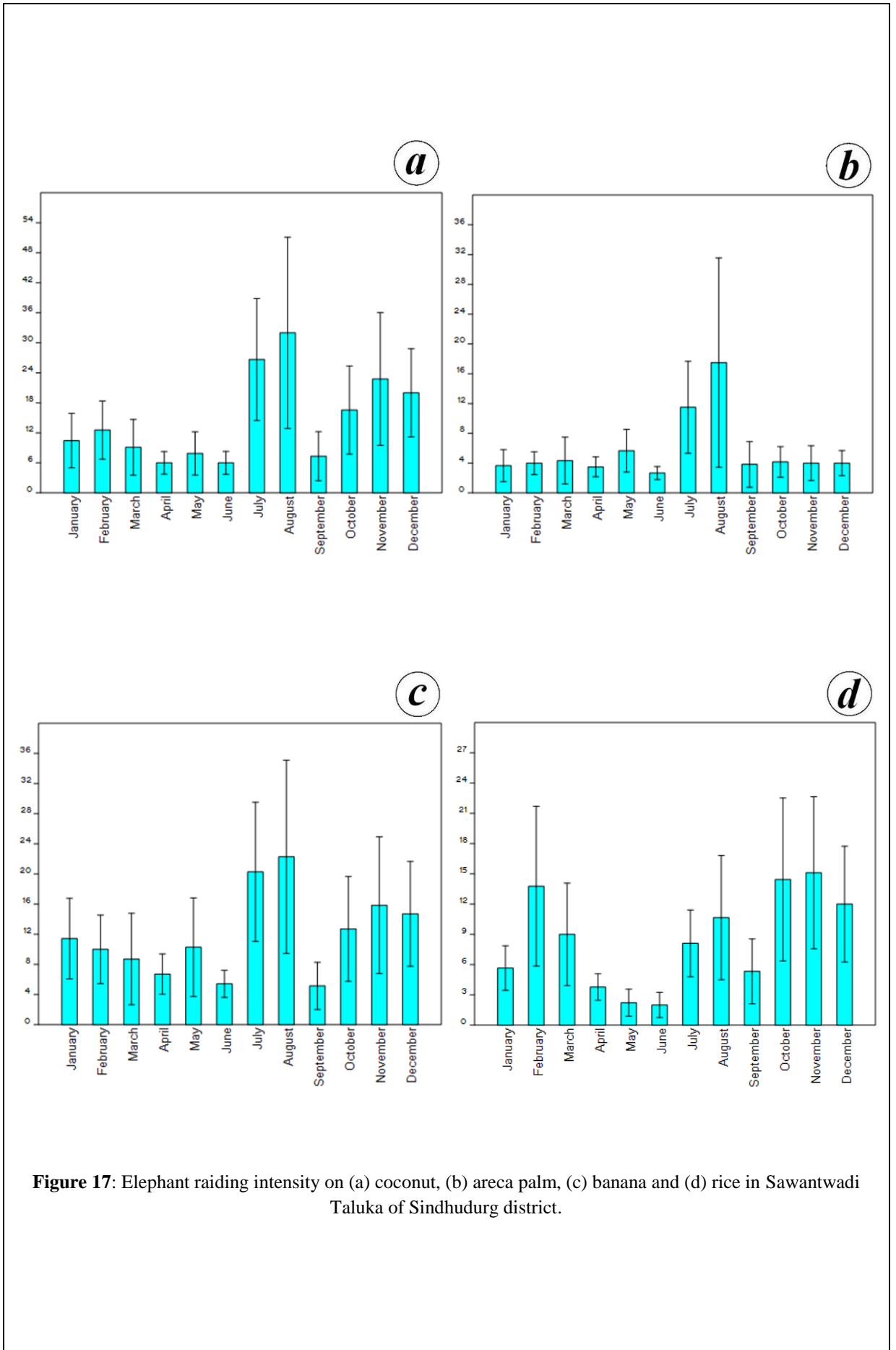


Figure 17: Elephant raiding intensity on (a) coconut, (b) areca palm, (c) banana and (d) rice in Sawantwadi Taluka of Sindhudurg district.

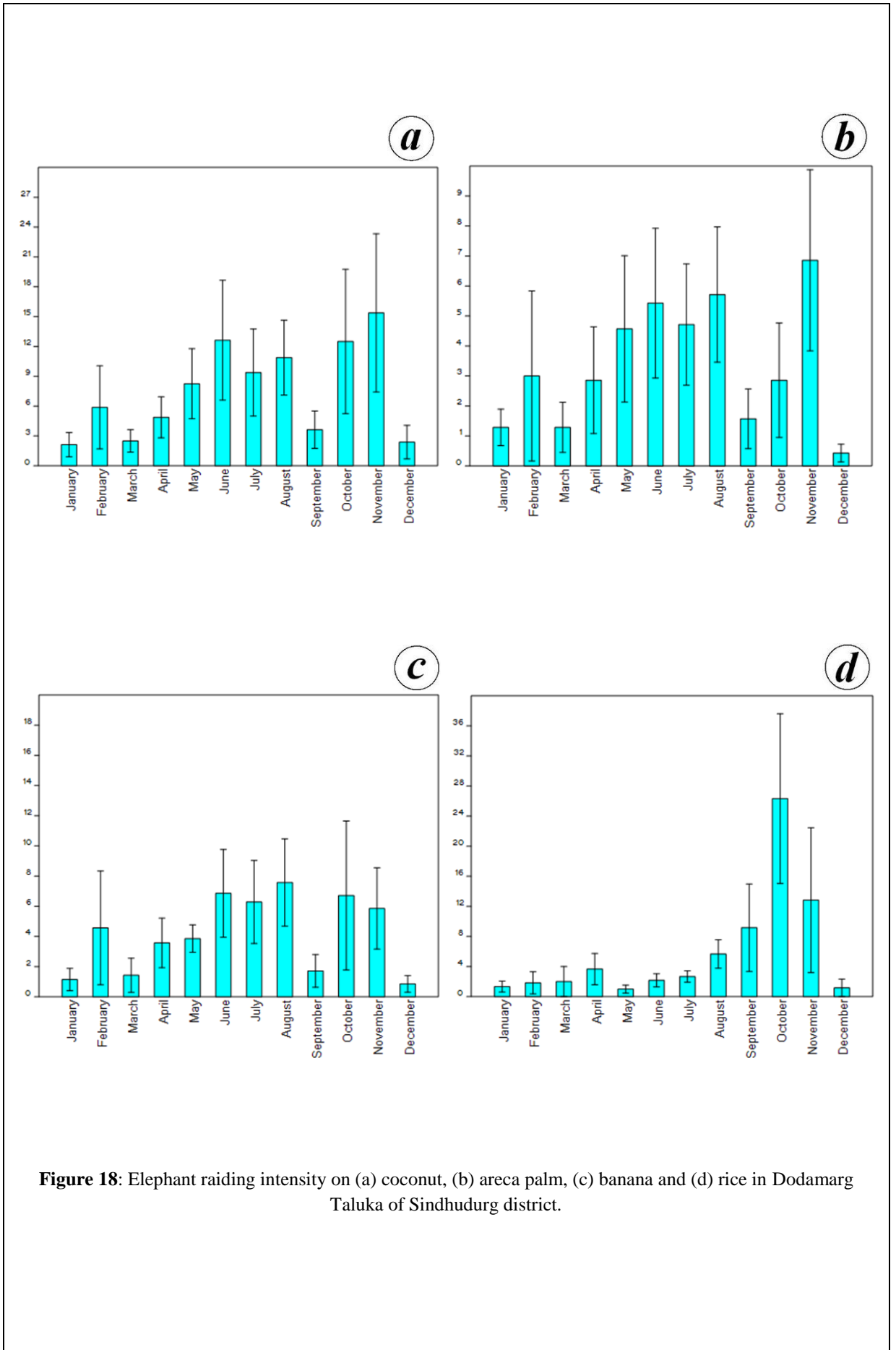


Figure 18: Elephant raiding intensity on (a) coconut, (b) areca palm, (c) banana and (d) rice in Dodamarg Taluka of Sindhudurg district.

lower in the summer (n = 2063). Distinctly lower proportion of crop raiding cases occurred in the summer season compared to winter and monsoon throughout the study period (Figure 9). However, median crop raiding intensity was not significantly different among the seasons ($\chi^2 = 3.005$, $p = 0.22$) (Figure 10).

For the entire study area, for major crops, the data showed that raiding intensity assumed a pattern of coconut > rice > banana > areca palm (Figure 11). Even in the three talukas severely affected, the patterns were similar (Figures 12, 13 and 14).

All the crops, whether in entire study area or major affected talukas, showed independence of monthly raiding intensities based on Chi-square test. The Chi-square values, degrees of freedom and associated probabilities are presented in Table 8. Figures 15 to 18 show this in graphical manner wherein the peaks of crop-raiding intensity for different crops can be seen.

Table 8: Results of Chi-square tests for goodness of fit for degree of association between monthly crop raiding intensities in major talukas and entire study area.

	Coconut (p < 0.001)		Rice (p < 0.001)		Banana (p < 0.001)		Areca Palm (p < 0.001)	
	χ^2	d. f.	χ^2	d. f.	χ^2	d. f.	χ^2	d. f.
Kudal	1244.70	99	759.35	88	643.37	88	223.16	77
Sawantwadi	870.67	88	783.96	88	480.60	66	267.16	55
Dodamarg	818.66	77	566.43	66	463.01	66	380.55	66
Sindhudurg	1573.60	121	1154.5	121	901.33	121	619.44	121

In the entire study area, coconut and banana showed relatively similar raiding trends with two distinct peaks in raiding intensity during July-August and November-December (Figure 15a, 15c). Rice showed maximum raiding intensity in October and minimum frequency in May (Figure 15d). Areca palms were mostly raided during July-August (Figure 15b).

In Kudal taluka, coconut shows gradual increase in raiding intensity from October to December (Figure 16a). Banana showed highest raids during November-January (Figure 16c). Rice showed higher raiding intensity in October (Figure 16d). Areca palms had relatively similar raiding intensity (<10%) throughout the study period (Figure 16b).

In Sawantwadi taluka, coconut and banana showed similar raiding intensity with two peaks during August and November (Figure 17a, 17c). Rice showed maximum raiding intensity in October- November and again in the month of February (Figure 17d) whereas areca palms were mostly raided during August (Figure 17b).

In Dodamarg taluka, coconut and banana showed two peaks of raiding intensity during June and November and July and October respectively (Figure 18a, 18c). Rice showed maximum raiding intensity during October and minimum during May (Figure 18d). Areca Palm showed relatively more raiding intensity during May to August (Figure 18b).

Various authors from Sri Lanka, Indonesia and India have reported that elephant chiefly damage rice crop as it attains maturity (Zimmermann et al. 2009, Santiapillai et al. 2010, Ekanayaka et al. 2011, Haturusinghe and Weerakoon 2012). Campos-Arceiz et al. (2009) found that banana was highly damaged in August whereas paddy received highest damage during January-February in Sri Lanka. Nyhus et al. (2000) found that rice was chiefly raided at its maturity (July to September) at Way Kambas National Park, Sumatra, Indonesia. Zimmermann et al. (2009) and Wilson et al. (2013) recorded that crop-raiding in Assam mainly occurred from June to February and the peak coincided with harvesting of rice during October to December. Similarly Gubbi (2012) found higher number of crop raiding instances on rice at its mature stage during October-November in Nagarahole National Park, Karnataka.

The monthly average crop-raiding cases for major crops (coconut, areca palm, banana, rice) were calculated and plotted along with associated standard error (Figure 19). The graph shows that the average monthly raiding on coconut was almost always severe than other crops. It was only lower than rice in the month of September. Raiding on rice has wider fluctuation across the year. The average monthly raiding for rice goes down considerably during April to June essentially because this is not the rice cropping season in the study area. As a consequence it could be seen that overall raiding cases also reduced considerably during April to June. This leads to speculation that rice is the key crop which governs raiding on other crops. Otherwise, raiding on perennial crops should have increased during April to June. It is also plausible to conclude that elephants are driven by attraction of more satisfying and, perhaps, nutritious rice crop. And this drive shapes the crop raiding patterns irrespective of the

availability of fodder in natural habitat (in wet season) or availability of perennial crops in cultivated areas (throughout year).

In this context, raiding on coconut can be clearly seen to follow the trend in rice. This could be a result of the structure of agriculture in this district where most of the coconut is planted on the bunds of rice paddies. But, this following of the trend between rice and coconut is severely disrupted in the month of November when raiding on rice goes down but raiding on coconut increases significantly. This could be explained by the fact that rice is a recognized attractant for the elephants. And the raiding on coconut is collateral damage at least when the rice is in fields. But immediately after rice is harvested, the elephants are still attracted to paddies and not finding rice, they go on rampaging the coconut. On the other hand, raiding on banana and areca palm does not show much wider fluctuation.

Average monthly raiding for all major crops dipped considerably in September. There could be three possible explanations for this. First, increased human activity/sounds in villages due to Ganpati festival could have deterred elephants. Second, religious sentiments of people associated with Ganpati the Elephant-God could have prevented people from reporting cases. Third, holidays in Ganpati festival could have prevented Forest Department personnel from recording cases. However, the data shows that raids on rice did not come down significantly as against other crops. This could be explained by the fact that rice is spread over large extent of area and other crops are mostly located near villages where the above three reasons could have had greater influence.

4.2 SURVEY OF AFFECTED FARMERS

4.2.1 Profile of Respondents

4.2.1.1 General profile of the respondents

Age of respondents ranged from 20 to 95 years. Most of the respondents represented the age class 60-69 years (Figure 20). A large proportion of respondents (82%) had educational qualification below Secondary School Certificate (SSC) examination. While 13% of the respondents had educational qualifications above SSC examination,

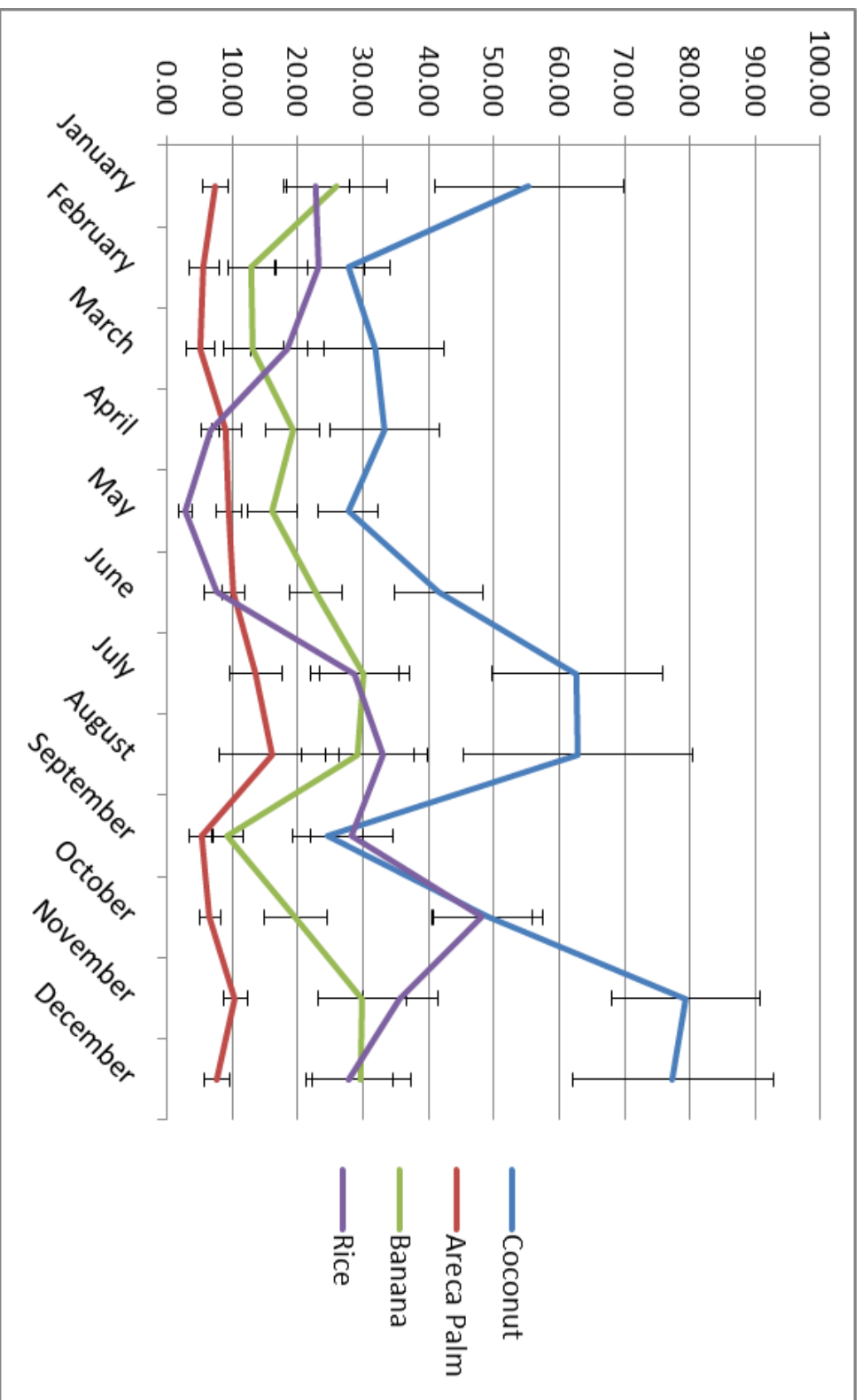


Figure 19: Number of crop raiding instances recorded per month in Sindhudurg district.

only 5% of them were uneducated (Figure 21). Most of the respondents (89%) reported farming as their sole occupation whereas only 9% had another source of income along with farming (Figure 22). The reported annual income of 86% of the respondents was less than ₹ 50,000 and only 10% earned more than ₹ 100,000 per annum (Figure 23). The households resided in kachcha (48 %) and pakka (52%) houses in approximately equal proportions. Around 80% of the respondents had less than six members in their household (Figure 24).

The above figures indicate typical rural households in Sindhudurg district. The district is one of the highly educated Districts of Maharashtra. The young generations are typically based in metropolitan cities like Mumbai and Goa whereas elderly members of household are engaged in farming.

Similar surveys have been conducted elsewhere in elephant prone areas. In North-Western Sri Lanka, Haturusinghe and Weerakoon (2012) conducted interview survey in 100 villages which were stratified into high, medium and low conflict categories based on historical crop-raiding data. However, their two respondents from each village were chosen randomly. In the present study, the villages were selected so as to represent high crop raiding levels over a broad geographical distribution. The respondents were selected from the tabulated compensation data and were thus always affected by crop-raiding.

Chartier et al. (2011) studied people's perceptions about human-elephant conflict in Sonitpur District, central Assam, India. They found similar profile of respondents but their respondents were selected by determining criteria or age 50 years and above. Thaufeek et al. (2014) conducted grid based questionnaire survey of 115 villagers in Sri Lanka. Here the age of respondents varied from 21 to 90 years and the age group with highest frequency was 31 to 40. They also recorded that 92% of the respondents were farmers. They recorded the income range of respondents varied from ₹ 12,000 to ₹ 2,500,000.

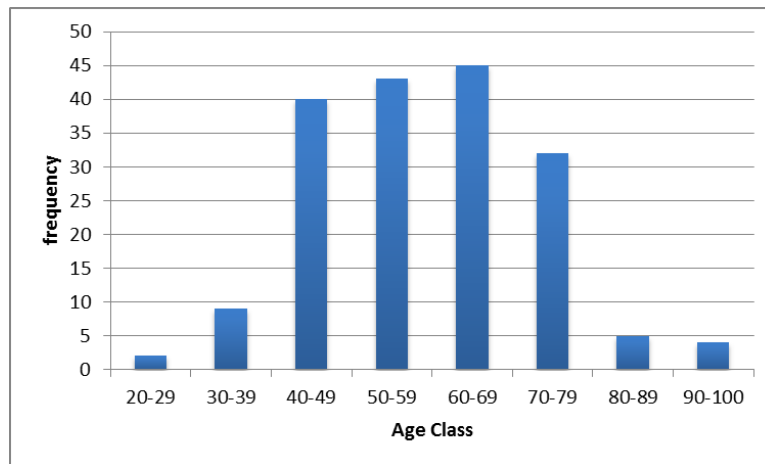


Figure 20: Distribution of age of respondents in Sindhudurg district.

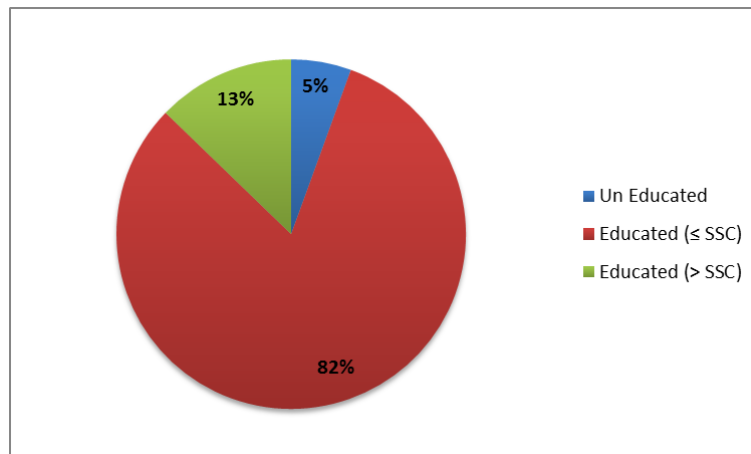


Figure 21: Educational qualifications of the respondents in Sindhudurg district.

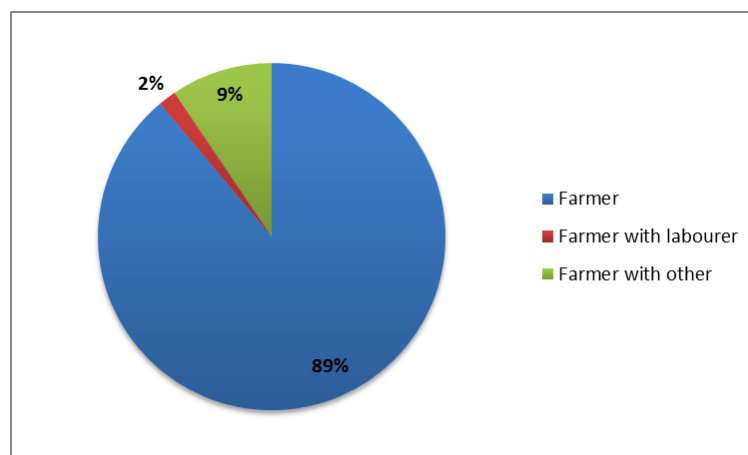


Figure 22: Relative percentage of occupation of the respondents in Sindhudurg district.

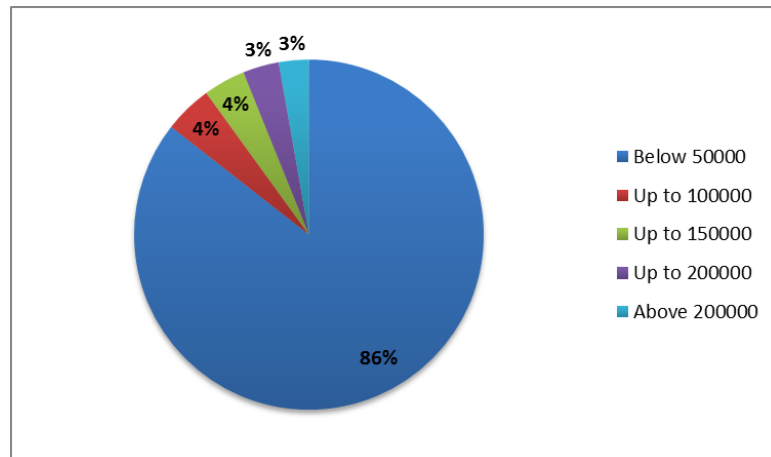


Figure 23: Annual income of the respondents in Sindhudurg district.

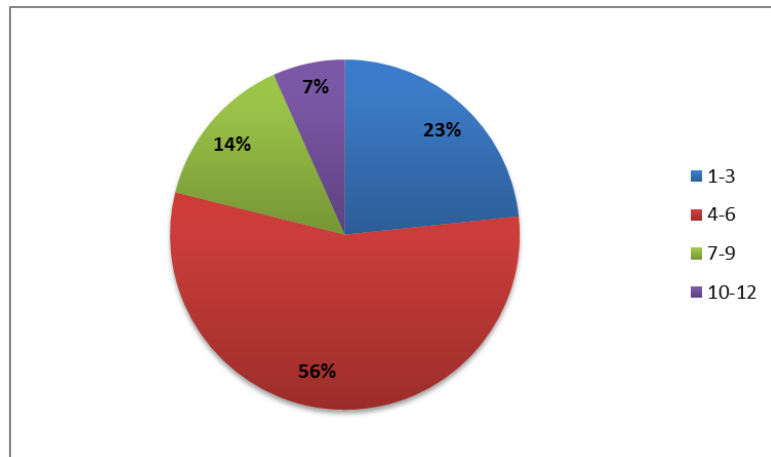


Figure 24: Family members per household of respondents in Sindhudurg district.

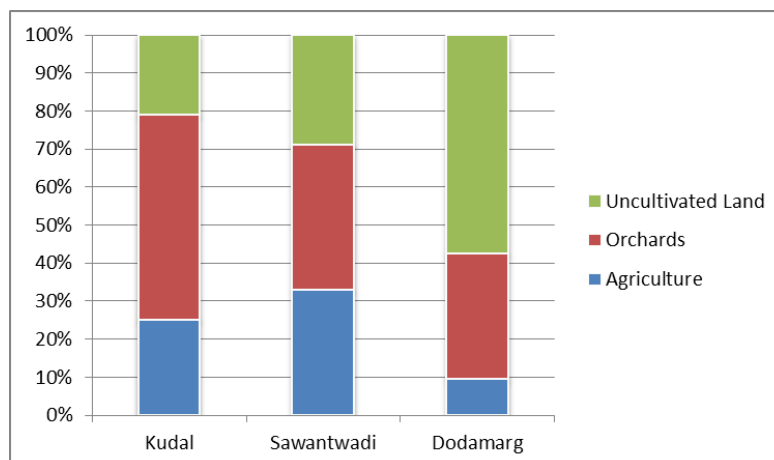


Figure 25: Taluka wise landuse profile of respondents in Sindhudurg district.

4.2.1.2 Land use profile

Average land-holding of the surveyed respondents was 5 ha which comprised of average 1 ha and 2.7 ha land under agriculture and horticulture respectively. The profile of land under agriculture, horticulture and uncultivated based on the respondent survey is shown in Figure 25. It was found that highest proportion of land under agriculture (which is mostly rice) was in Sawantwadi taluka. The same for land under horticulture was in Kudal taluka. And the same for uncultivated land was in Dodamarg taluka. Dodamarg is a largely hilly taluka and hence proportion of uncultivated privately owned land is very high there.

4.2.1.3 Crop cultivation profile

Figure 26 shows cultivation profile of major crops in three categories viz. Kharif, Rabbi and Perennial crops amongst the surveyed households. Large proportion of households cultivates Kharif rice and only a very small fraction of farmers cultivate other Kharif crops. Similarly higher proportions of households had coconut and cashew orchards or homesteads. Even areca palm and bamboo were found to be cultivated by relatively large proportion of households. A large variety of Rabi crops each represented by a small proportion were cultivated by the surveyed households.

The proportion of respondents cultivating major crops in the study talukas is presented in Figure 27. It can be seen that bamboo is a preferred crop in Kudal taluka just as areca palm and banana were in Dodamarg. Cashew crop was cultivated by similar proportion of farmers in the three talukas. In case of rice and coconut, relatively smaller proportions of farmers cultivated these in Sawantwadi taluka.

4.2.2 Perceptions on Human-Elephant Conflict

4.2.2.1 Crop raiding preference

The respondents' perception of crops preferred by elephants for raiding is presented in Figure 28. Most farmers ranked coconut as the most susceptible crop. For the remaining crops, the order of dominance in Kudal was banana > rice > bamboo.

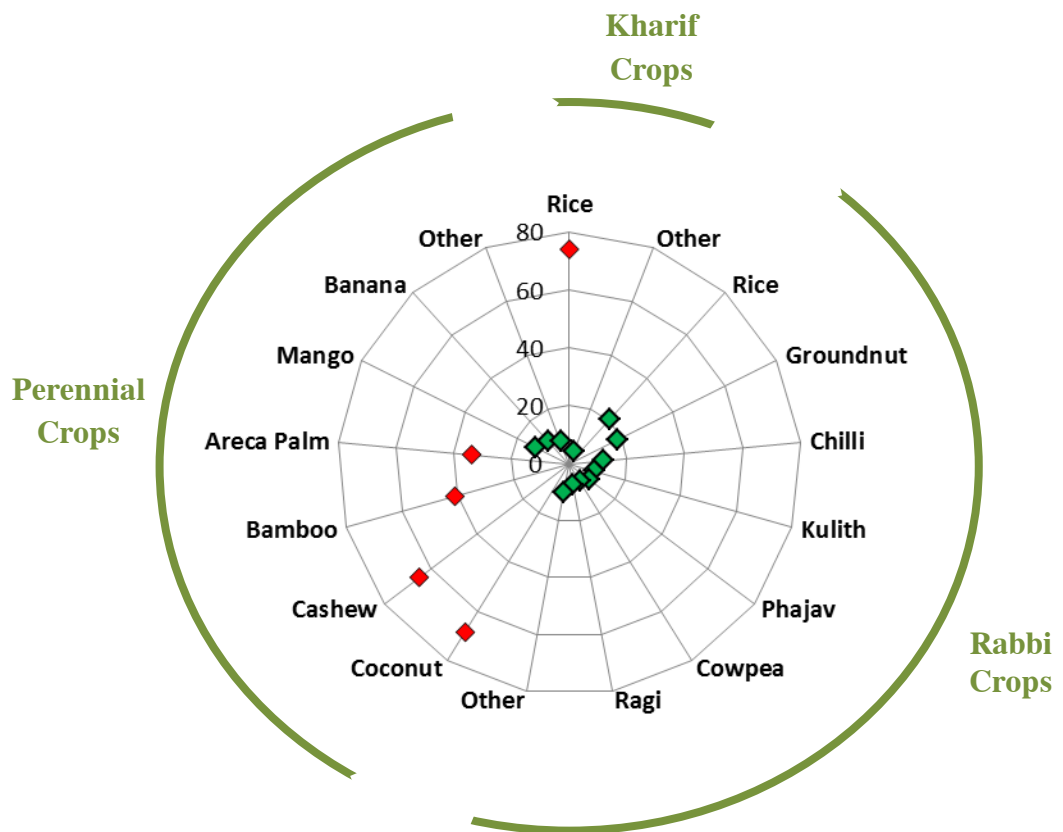


Figure 26: Crop cultivation profile of respondents in Sindhudurg district

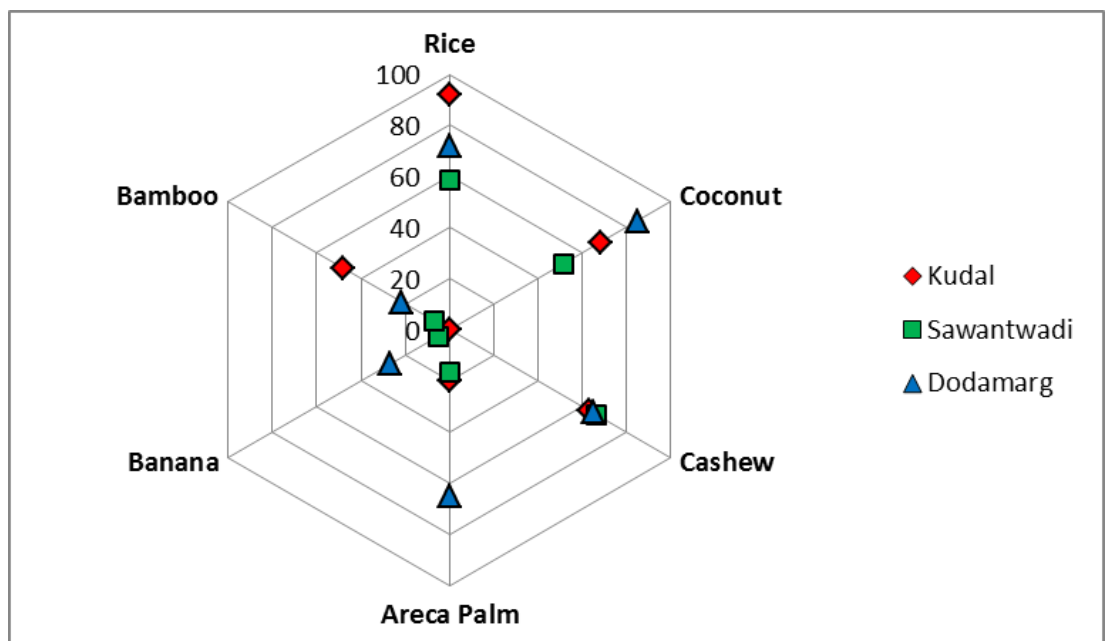


Figure 27: Proportion of respondents cultivating major crops per taluka of Sindhudurg district.

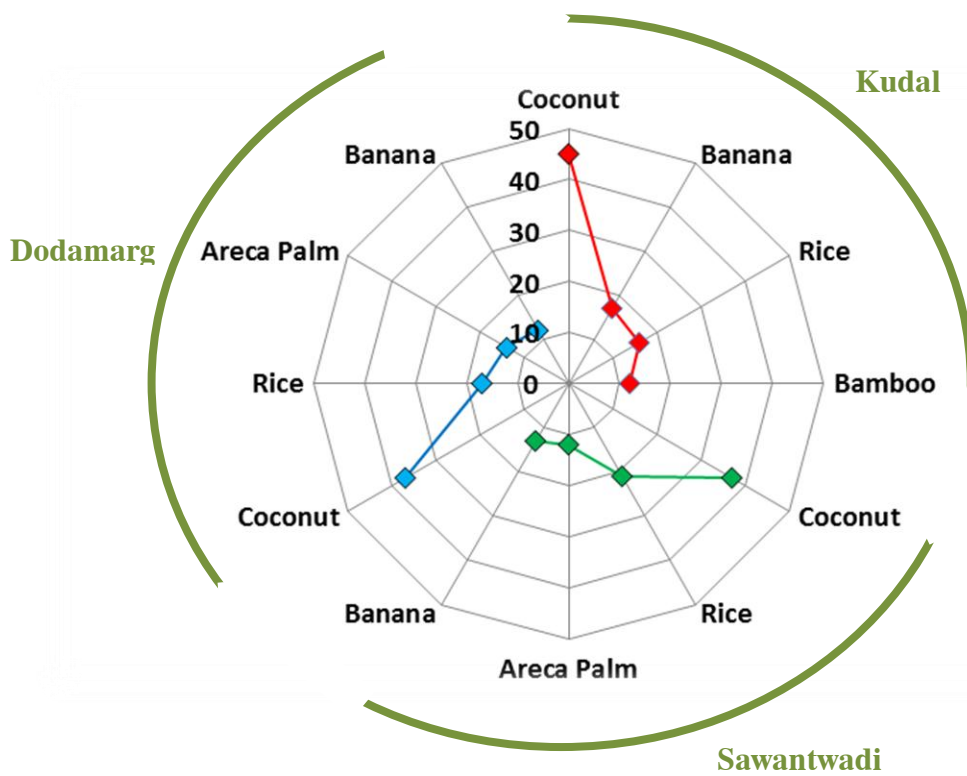


Figure 28: Respondents' perception on crop raiding preferences of elephants in Sindhudurg district.

Whereas in both Sawantwadi and Dodamarg it was rice > areca palm > banana. However, it could be clearly seen that there is a large gap between coconut and the next crop indicating that majority of respondents believe that coconut is more preferred by elephants.

Managa bamboo *Dendrocalamus stoscksii* is a widely cultivated species in the present study area. Farmers said that bamboo was one of the highly damaged (or preferred) crops by elephants. Unfortunately, bamboo crop is not included in the compensation scheme of the Government of Maharashtra. This could be one of the reasons behind much lower record of claims for bamboo damage than actual damage extent. Farmers also claimed that elephants cause relatively little damage to the cashew trees. This was appropriately represented in the compensation records.

4.2.2.2 On compensation scheme

The problem of crop raiding was so widespread and intense that it was expected that not all raids would be claimed for compensation by afflicted farmers. This expectation was proved true with only 64% farmers admitting that they had claimed all crop-raiding cases on their farms. The rest had claimed compensation for some cases but had ignored others.

The maximum times that a farmer had claimed compensation was 47. However, the median number of claims was much lower at three. For acceptance of claims, the maximum remained same at 47 but the median reduced to two which means that not all the claims were accepted for compensation.

The surveyed respondents had submitted all together 744 compensation claims. Of these, 79% were accepted by the Forest Department and rest (21%) were rejected. Out of the accepted claims, nearly 97% claims were duly compensated whereas the rest did not receive any compensation. However, the period required to receive compensation ranged from 2 to 24 months. The median period required for this was 6 months.

About the accepted claims, none of the farmers were satisfied with the amount they got and the time required for receiving the amount. Most felt that the compensation

received did not justify the cost involved in reporting and pursuing the claim let alone the crop loss. Most of the respondents claimed this to be the main reason (47%) behind not reporting minor or sometimes even major crop losses. Of the other provided reasons, (i) difficulty to procure land and other records, (ii) minimal cooperation of Forest Department staff and (iii) communication difficulties to inform the authority were ranked in this order by the respondents. Some farmers even complained that, “it was irritable to inform Forest Department since there was frequent crop raiding, and departmental staff was unwilling to come and record raiding claims. Sometimes they were even told that same person would not get compensation repeatedly.”

For the 21% rejected claims, the concerned farmers (n = 20) were mostly unaware of the reason (40%), or were given reason of their land being designated as forest previously, or because necessary land-record documents were not available in time, or were unable to procure consent from all concerned legal land-holders etc.

Compensatory approaches play an important role in wildlife conflict situations and can build up positive relationship between farmers and authority. However some authors reported that sometimes farmers show reluctance to report compensation claims. Haturusinghe & Weerakoon (2012) reported that Farmers in North-Western Sri Lanka did not even apply for compensation for minor losses. Ogra & Badola (2008) discussed that involvement of farmers in the crop compensation schemes is a critical issue which was highly influenced by factors like wealth, gender, social networks, and pre-existing expectations of the claimants. They also highlighted that inadequate remuneration of direct and indirect costs of conflicts, logistical challenges, and delays in payment are the core problems for the success of compensation schemes.

There was an overwhelming majority (96%) among respondents regarding ineffectiveness of resolving human-elephant conflict through compensation. This was in line with arguments of most scientists. Compensation schemes have several drawbacks and all of these were evident in the present study area (Table 9).

Indeed, the aim of any compensation scheme is to compensate for the loss and dissipate anger of affected humans towards wild animals. It cannot physically prevent

crop damage. Crop loss can be avoided only through crop protection measures. This too can only shift the problem from actively protected areas to unprotected areas.

Table 9: Common drawbacks of compensation schemes and their presence in the study area.

Drawback	People's perception	Researcher observation
Subjective assessment	Yes	Yes
Corruption	No	Yes
False claims	Yes	Yes
Insufficient amount	Yes	Yes
Bureaucratic delays	Yes	Yes
Neglect of crop protection	Yes	Yes
Animosity towards implementing agency	Yes	Yes

4.2.2.3 Crop Protection Measures

Of all the respondents, only 60% were using any crop protection measures. It included 16 different methods and their combinations. Use of firearms (24%), beating of drums to chase the crop raiding animals (13%) and night vigilance (12%) were the measures adopted by relatively large proportion of respondents. Other methods include use of chilli smoke, high power hand held search lights, solar/electric fencing, trenches, lighting fire/lantern/electric lamps along the farm boundary, use of ropes smeared with oil and chilli powder, barbed wire fencing, tying of old sarees along the farm boundary and putting phenyl/kerosene along the farm boundary. Some of these were active methods in which farmers needed to be present on the farm while others were passive methods.

One innovative measure used by a farmer (Ramkrishna Dalavi, Naneli, Kudal) included tying thorny branches of Karvand *Carissa congesta* to the Coconut stem and he found it quite successful. Another farmer (Dhondu Naik, Sonurli, Sawantwadi) tried putting Thimate pouches in rice fields to repel elephants. However successful, he felt that it could become cost-restricted and weather influenced.

Nath et al. (2015) found in villages adjoining Manas National Park, Assam that 65% of the total raided farms were not guarded by any means. Farmers around Shwe-U-Daung wildlife sanctuary, Myanmar were using similar crop protection measures. Besides they were using loud speakers, small noisy wind mills, trigger alarms, stringing Compact Disks (CDs) along the farm boundary as reflectors for the people's

flashlights in the night Allendorf et al. (2015). Zimmermann et al. (2009) reported use of spotlights is effective when used in conjunction with noise, fencing and chilli smoke. Zimmermann et al. (2009) and Thaufeek et al. (2014) highlighted the importance of electric fences for areas exceptionally prone to crop-raiding.

4.2.2.4 Effectiveness of crop protection measures

Only eight farmers had experience of solar-powered fence and all of them considered it to be the most successful crop protection measure. However, all other methods fared badly in the perception of farmers who used them.

Allendorf et al. (2015) found that combination of light, sound and smell was always effective against crop raiding elephants. They also described overwhelming success of ‘brush cleaning’ which was hailed by 96% of the respondents. It involved clearing a stretch of uncultivated land having width of around 400m between farmers’ fields and sanctuary. Thus, the hesitation of elephants to enter open areas and ability of crop-guards to spot and deter them before entering farms were taken benefit of in this method. However, this would not be feasible in the present study area as there is no defined protected area here and elephant retreats are scattered all over among the cultivated areas. Although, uncultivated areas are extensive, they comprise of at least secondary forest and this would mean violation of several laws and ignorance of prudence.

Baishya et al. (2012) constructed two strands of ropes running at 3ft and 5ft height smeared with chilli paste (*Capsicum frutescens* var. *nagahari*) and found no elephant raids on the experimental plot. Farmers in Terai Arc Landscape, India are using integrative crop protection measures as an effective measure against crop raiding elephants e.g. loud noise in combination with fire as a scaring tool for the elephants (Jasmine et al., 2015)

Chelliah et al. (2010) studied effectiveness of chilli - tobacco powder mixed with waste oil as a deterrent for crop raiding elephants where he found that female-led herds were more deterred than solitary males. Haturusinghe & Weerakoon (2012) found community guarding of crops is the most effective method where farmers can manage elephant drives before they could damage the entire farmland.

Various measures of conflict resolution on the part of Forest Department had failed in the affected areas (Mehta and Kulkarni 2013). They have resorted to suggesting solutions like ‘...minimizing crop damage by active crop guarding by local farmers and preventing encounters with elephants.’ This is unreasonable because the farmers are already burdened with vagaries of natural and market forces. One additional burden of protecting crops from elephants could be the last straw that broke camel’s back. Indeed, crop protection by guarding from machan is a risky proposition because it was observed that on entering farms, elephants first attacked these. Further, situation in the present study area is very much unlike in many other studies. There is no protected area here to which the elephants could be driven back from the cultivated area. And crop guarding would result only in shifting of the problem from one farm to another. To keep safe distance from wild elephants is a good strategy to avoid disastrous encounters but there will always be chance fatal encounters.

Jasmine et al. (2015) conducted an attitude assessment survey of the local people in Terai Arc landscape, India where the people believed that forming local elephant control teams and enclosing the affected village with a tall cemented wall could be effective measures to reduce elephant intrusion and these were under trial.

Nyhus et al. (2000) highlighted that traditional conflict mitigation measures e.g. loud noise, yelling, firecrackers, hitting metal objects, cracking whips, flame torches, powerful flashlights become less effective over time as elephants get habitual towards them. However, 68% of the respondents from their survey replied that guarding crop fields during night and chasing or scaring elephants with combination using fires, noise or lights were most effective methods of crop protection.

4.2.2.5 Expectations from Forest Department

To an open-ended question, the respondents voiced their 12 different expectations. Of these, the one which was expected by all respondents was resolution of the crop raiding problem by the Forest Department. Others included raising solar fencing around the cultivation area (12%), declaration and management of government forest as protected area (8%), planting food plants in the natural habitat. Most respondents

expected greater cooperation from Forest Department while resolving the compensation issues.

Other methods suggested by farmers included capturing of problem animals, increasing the amount of compensation and providing immediate relief in the form of compensation possibly within one month. It was a general observation that many farmers had given up cultivation of expensive cash crops and smaller farmers were even more distressed unable to meet ends.

However, around 80% of the respondents were also aware that Forest Department staff could not possibly do anything over and above the work assigned to them and had no skills or resources to prevent elephant intrusion on farmlands. In this situation where people know that Forest Department is not capable of reducing crop raiding and resolve the problem, indeed the reliance on crop guarding suggested by Mehta & Kulkarni (2013) in the last section becomes a possible approach. On the other hand, some respondents voiced extreme views. They told that they would gladly cultivate crops only for the sake of elephants and other wildlife if Forest Department provided them real and actual foregone cost of the crops.

It is a worldwide phenomenon that people expect the agencies responsible for conservation and management of wildlife to resolve the problem of human-wildlife conflict (Fernando et al 2008). Thaufeek et al. (2014) similarly recorded that > 90% of the respondents felt that the human-elephant conflict mitigation is the responsibility of the Government authority. Most of the farmers in North-Western Province of Sri Lanka similarly expected that human-elephant conflict and crop raiding issues must be solved by the government and all elephants should be removed from the area (Haturusinghe & Weerakoon, 2012).

Dickman (2010) has identified two-tier social perceptions at local level and distant level. Distant people typically have 'hyper-awareness' about risks of human wildlife conflict while being comfortable in their city-based dwellings. However, rural people who have experience of living alongside wild animals tend to be less fearful of them. Nevertheless, Mitra (2013) found awareness and building of public trust as key requirements to minimize human-elephant conflict. Allendorf et al. (2015) highlighted that participatory action plans for mitigation of conflict situations were always effective.

Dharmaratne & Magedaragamage (2014) also proposed to plant fodder trees/grasses in the elephant habitat. Corea (2001) while highlighting the significance of large electric fences around the agricultural settlements to reduce crop raiding, emphasized that long term success of elephant conservation programs is only possible through the support of local people by such means as sharing benefits with the local people. However, there are other views like which consider that people living amidst wildlife conflict zones typically have to borne certain costs and rarely derive financial benefits from conservation activities (Humavindu & Stage, 2015).

4.2.2.6 Perceptions on elephant protection

When asked whether elephants should be protected, 97% of the respondents replied that elephants should be protected despite higher level of conflict. However, there was large difference in opinion as to why. Nearly 56% of the respondents promoted elephant protection because it is part of nature and one of the most magnificent creatures on the earth. Nearly 36% of respondents regarded elephant protection as necessary for religious reasons. Only 7% were aware of legal protection requirements envisaged in the Wildlife (Protection) Act, 1972.

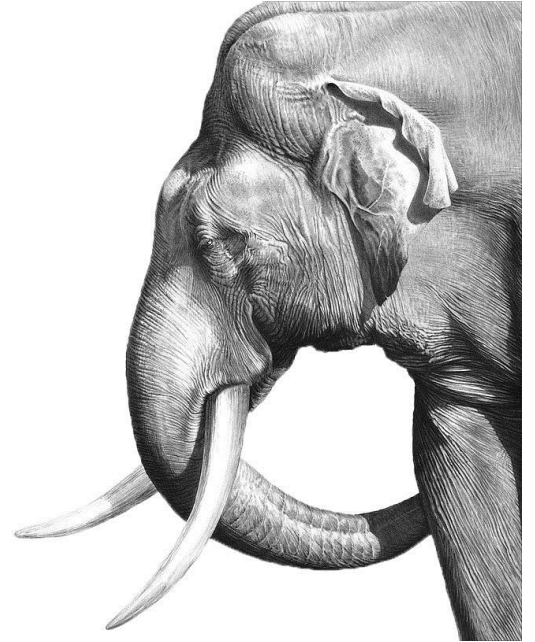
Thus, largely sympathetic view towards elephants is a reflection of age-old religio-ethical values prevalent in India everywhere. Allendorf et al. (2015) reported similar findings around Shwe-U-Daung wildlife sanctuary, Myanmar where the 77% of the respondents opined that elephants should be protected. Majority of the respondents (66%) in that study said that elephants entered in villages because they liked cultivated crops. Nath et al. (2015) conducted a questionnaire survey 562 residents around Manas NP, Assam. They too had found similar positive attitude towards elephants

4.2.2.7 Possible co-existence

Even as the farmers promoted protection of elephants, most of them (94%) believed that presence of elephants and agricultural cultivation were not congruent with each other. They understood that this kind of co-existence was not possible in a landscape

where there is no food in elephant's natural habitat and several attractive crops are lined up in the human habitat. However, they were ready to accept elephants if somehow Forest Department could restrict them to their natural habitat possibly through solar fencing. They also perceived that absence of formal protected area in Sindhudurg district was a major hindrance to this.

But people were generally receptive to the potential changes in cropping pattern and to advanced methods of crop protection. Santiapillai et al. (2010) found that Lime, Orange, Sesame and Neem were the most likely crops/plantations to be avoided by elephants. They also proposed raising a green buffer of Neem between agricultural areas and elephant reserves. Two farmers in the present study also suggested that planting turmeric, ginger and Lemon especially in high conflict zones could be effective because elephants apparently did not consume these.



SUMMARY AND CONCLUSION



Gray Hodges

5. SUMMARY AND CONCLUSION

Present study was conducted in Sindhudurg district of Maharashtra with the objective to analyse recent elephant crop-raiding patterns and to assess people's perceptions about these.

Total 9148 elephant crop raiding records in Sindhudurg district during 2002 to 2015 were analyzed. The database revealed that the problem under study was spread over an area of nearly 4300 sq km of study area. A total of 244 villages (33% of the total villages in Sindhudurg) were influenced by elephant crop raiding. The worst affected talukas in terms of villages affected were (i) Kudal, (ii) Sawantwadi and (iii) Dodamarg.

Of all the 36 different crops damaged, coconut (44%), rice (22%), banana (20%) and areca palm (8%) were the worst affected crops and the former two were the most preferred crops by elephants. The relative proportion of crop raiding with respect to their availability showed no significant correlation. The disproportionate patterns of crop raiding were confirmed by Hurlbert's standard niche breadth values. Jacob's Index of Selectivity highlighted that elephants were highly selective in case of banana followed by areca palm, coconut and rice which indicates that banana was indeed selectively raided.

Crop raiding records showed that in all 4598 farmers claimed compensation. Of which 64% claimed only once; 30% claimed between 2-5 times and 6% claimed more than five times during 2002 to 2015. The total compensation amount given by the forest department to the claimants was ₹ 11,33,70,904.

The temporal sequence of crop raiding from 2002 to 2015 provided insight into elephant behaviour of establishing new home ranges. In the earlier part of this period, elephants' raiding patterns were exploratory and widespread. But in the later part they became more concentrated in, probably, the most suitable area i.e. Kudal taluka.

Three crop raiding indices – Crop Raiding Frequency (CRF), Relative Crop Raiding Index (RCRI) and Crop Raiding Vulnerability Index (CRVI) were used to study the spatial patterns of crop raiding at village scale. CRVI was developed for the first time

based on Levin's measure of resource selection. The rank-correlation analysis of three indices estimated for first 10 villages of the most affected talukas highlighted that CRF and RCRI were highly correlated. On the contrary, CRVI provided a completely different ranking of the villages and, therefore, showed low correlation with both earlier indices. The rankings provided by CRVI also appeared to provide more meaningful geographical and ecological information. It identified villages in a narrow strip of foothills of Sahyadri Mountains as severely vulnerable. This area emerged as a hotspot of crop raiding.

CRVI was found to be a reliable indicator of crop-raiding vulnerability of villages based on multi-year crop raiding data. Its reliance on distribution of crop raiding events across nominate months in a year, perhaps, incorporated several factors responsible for crop-raiding by elephants. The seasonal variations witnessed in crop raiding in the present and other studies might have been captured well in this index. It could be used in other localities and tested for its ability to predict potentially vulnerable areas.

In general, crop raiding frequency was higher during winter season followed by monsoon and still lower in the summer. November and December months formed a peak within high crop intensity period with significantly higher median crop raiding intensity than all months. Coconut and banana showed relatively similar crop raiding pattern with gradual increase in raiding intensity from July to December whereas rice showed maximum raiding intensity in October when it reaches maturity. Additionally the average monthly raiding on coconut was almost always severe than other crops. Raiding on banana and areca palm does not show much wider fluctuation.

Rice is a recognized attractant for the elephants. And the raiding on coconut is collateral damage at least when the rice is in fields. But immediately after rice is harvested, the elephants are still attracted to paddies and not finding rice, they go on rampaging the coconut.

People's perception survey revealed that, besides four major crops, Managa bamboo *Dendrocalamus stoscksii* was a widely cultivated and highly damaged (or preferred) crop by elephants in the study area. This was not evident from the compensation data as, unfortunately, the crop was not included in the crop compensation scheme.

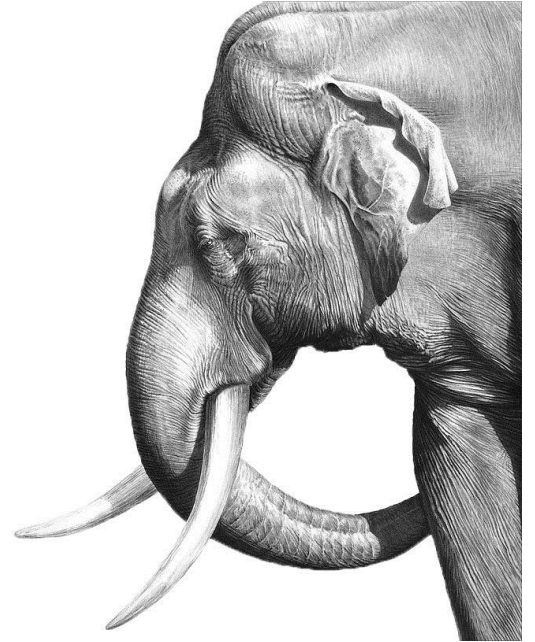
Only 64% farmers admitted that they had claimed all crop-raiding cases on their farms. Of these, only 79% claims were accepted by the Forest Department and rest (21%) were rejected. The median period required to receive compensation amount was six months. About the accepted claims, none of the farmers were satisfied with the amount they got and the time required receiving that amount. Farmers felt that the compensation received did not justify the cost involved in reporting and pursuing the claim let alone the crop loss. 47% of the respondents claimed this to be the main reason behind not reporting minor or sometimes even major crop losses. Farmers also highlighted that major hurdles to report crop raiding claims were (i) difficulty to procure land and other records and (ii) the delayed or sometimes 'no-cooperation' attitude of the departmental staff.

Only 60% of the farmers were using any crop protection measures. The total of 16 different crop protection methods and their combinations were reported. Experience of some farmers emphasized that solar-powered fence could be the only viable crop protection measure in the study area.

97% of the respondents replied that elephants should be protected despite the higher level of crop raiding. They were ready to accept elephants if somehow Forest Department could restrict them to their natural habitat possibly through solar fencing. They also perceived that absence of formal protected area in Sindhudurg district was a major hindrance to this. Farmers also suggested that planting of food plants in the natural habitat may somehow minimize crop raiding.

Farmers were generally receptive to the potential changes in cropping pattern like planting non-palatable crops with more market value e.g. turmeric, ginger etc. and are ready to implement advanced methods of crop protection. But farmers needed at least hand-holding support from Government Departments.

Thus, although crop raiding by elephants has been minimized recently through capture and removal of elephants, the problem may not have been resolved permanently. The findings of this study especially the vulnerable areas based on CRVI could form the priority area for implementing various crop-protection measures. The perceptions expressed also would be useful in formulating participatory conflict resolution strategies.



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Gray Hodges

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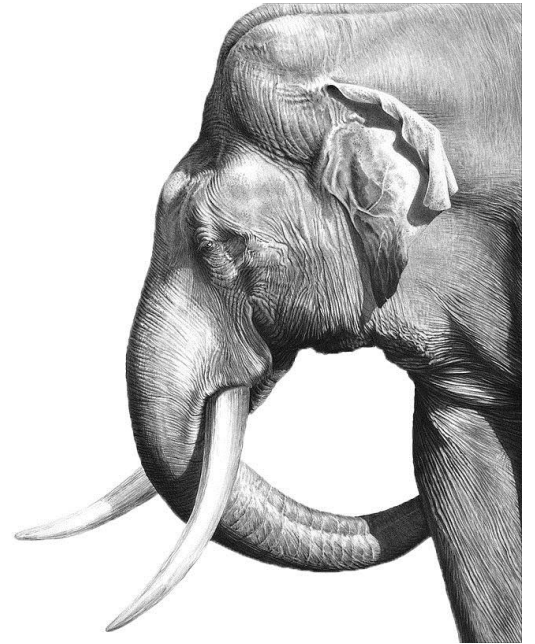
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APPENDICES



Gray Hodges

Appendix I

Questionnaire for perception survey

form no.	date	time

GENERAL PROFILE
name:
address:
age:
education:
occupation:
total annual income:
house type:
family members (total):

LAND USE	agri. crops	orchard	uncultivated	private forest	total
area (acre)					

CROPPING PATTERN			
No.	kharif (monsoon crops)	area	yield
1			
No.	rabi (dry season crops)	area	yield
1			
No.	perennial crops (horticulture / forestry)	area/no.	yield
1			

FARM OBSERVATIONS			
latitude	longitude	elevation	upland / lowland

CROP RAIDING					
crops preferably eaten	coconut	rice	banana	areca palm	other
ranking					
compensation (y/n)					
property damage	livestock	cattle shed	granary	salt bags	other
ranking					
compensation (y/n)					

COMPENSATION	
Q1	Did you claim compensation for every raiding event? (Y/N)
A.	How many times you did claim?

A1.	How many times your claim was accepted?
A1a.	How many times your claim was accepted? And received the compensation?
i	Time required to receive compensation (days /months):
ii	Is it OK? (Y/N)
iii	Present compensation amount is sufficient / insufficient
A1b.	How many times your claim was accepted? But not received the compensation?
	Why?
a.	
A2.	How many times your claim was rejected?
	Why?
a.	
B.	How many times you did not claim?
	Why?
a.	
Q2	Giving compensation is an effective way to reduce HWC? (Y/N/Don't know)
	Why?

CROP PROTECTION MEASURES	effective	less effective	not effective
a.			
Either FD or any other organization conducted workshop or awareness programme in your area regarding crop protection measures? (Y/N)			
If Yes (details)			

PERCEPTIONS
What are your expectations from FD?
What are your expectations from Gram Panchayat and at local level?
Whether elephants should deserve protection (Y/N)
Why?
How?
Would it be possible to cultivate the crops in areas where elephants exists (Y/N)
How?

Appendix II
Lists of villages by taluka alongwith their CRF, RCRI and CRVI

Vaibhavvadi			
Village	RF	RCRI	CRVI
Achirne	2	2.000	0.000
Pimpalwadi	2	2.000	0.000
Khambale	1	1.000	0.000
Mohitewadi	1	1.000	0.000
Narkarwadi	1	1.000	0.000
Kankavli			
Pise Kamate	11	5.500	0.090
Bordave	9	2.250	0.050
Shivdav	7	3.500	0.030
Kalasuli	6	3.000	0.020
Lore-2	5	5.000	0.000
Bidwadi	4	4.000	0.000
Lore-1	3	1.500	0.070
Ashiye	2	2.000	0.000
Damare	2	2.000	0.000
Ghonsari	2	2.000	0.000
Kasavan	2	1.000	0.090
Tarandale	2	1.000	0.090
Bhiravande	1	1.000	0.000
Osargaon	1	1.000	0.000
Phanas Nagar	1	1.000	0.000
Varavade	1	1.000	0.000
Malwan			
Kalse	20	20.000	0.000
Asarondi	6	3.000	0.030
Hiwale	6	3.000	0.040
Dikval	5	1.670	0.120
Sukalwad	4	2.000	0.050
Chunavare	3	3.000	0.000
Chindar	2	2.000	0.000
Rathivade	2	2.000	0.000
Golwan	1	1.000	0.000
Kusarave	1	1.000	0.000
Nandos	1	1.000	0.000
Kudal			
Tulsuli K.Narur	468	39.000	0.700
Naneli	352	29.330	0.490
Wados	349	29.080	0.670

Karivane	322	26.830	0.460
Nivaje	296	24.670	0.440
Hirlok	202	16.830	0.820
Khocharewadi	169	14.080	0.480
Tembgaon	148	13.450	0.370
Ghavanale	144	12.000	0.480
Amberi	138	11.500	0.600
Gothos	138	13.800	0.230
Mangaon	128	10.670	0.480
Digas	124	10.330	0.390
Bambarde T.Kalsuli	121	13.440	0.320
Dholkarwadi	121	10.080	0.390
Oras Bk.	114	14.250	0.290
Vetal Bambarde	109	9.910	0.180
Bengaon	102	8.500	0.420
Kaleli	124	11.270	0.410
Taligaon	77	6.420	0.470
Akeri	74	7.400	0.380
Narur	68	6.180	0.110
Khutvalwadi	66	6.000	0.350
Mitkyachiwadi	65	10.830	0.130
More	57	8.140	0.200
Salgaon	55	6.110	0.150
Kunde	54	9.000	0.270
Nileli	54	7.710	0.220
Kasal	48	8.000	0.060
Oras Kh.	47	5.880	0.240
Nerur K.Narur	45	5.630	0.110
Kinlos	44	5.500	0.310
Rumadgaon	38	7.600	0.140
Avalegaon	34	4.250	0.390
Tulsuli	31	3.440	0.530
Keravade K.Narur	25	5.000	0.130
Narur K.Narur	25	2.780	0.090
Humras	24	4.800	0.120
Ghatakarnagar	23	3.830	0.130
Jambharmala	21	3.000	0.190
Humarmala	17	3.400	0.040
Pulas	16	3.200	0.120
Girgaon	15	3.000	0.080

Bhattgaon	14	2.000	0.090
Ambrad	12	3.000	0.160
Pandur	11	2.750	0.190
Pawashi	11	1.380	0.560
Anav	10	5.000	0.070
Hirlok-Hateri	10	3.330	0.080
Kadawal	10	3.330	0.080
Kanduli	9	1.800	0.130
Kusabe	9	4.500	0.070
Bhattwadi	7	2.330	0.110
Kattagaon	7	2.330	0.070
Namaspur	7	1.400	0.310
Bamnadevi	6	2.000	0.140
Kusagaon	6	2.000	0.090
Tulsuli T.Mangaon	6	1.500	0.100
Nirukhe	5	1.670	0.120
Padave	5	2.500	0.080
Tendoli	5	1.670	0.120
Warde	5	1.670	0.120
Pokharan	4	1.330	0.090
Bhadgaon Bk.	3	1.500	0.040
Raygaon	3	3.000	0.000
Zarap	3	1.500	0.070
Gaorai	2	2.000	0.000
Sarambal	2	2.000	0.000
Wasoli	2	1.000	0.090
Bambarde T.Mangaon	1	1.000	0.000
Belnadi	1	1.000	0.000
Gandhigram	1	1.000	0.000
Goveri	1	1.000	0.000
Kavilkate	1	1.000	0.000
Mudyacha Kond	1	1.000	0.000
Mulade	1	1.000	0.000
Namasgaon	1	1.000	0.000
Pinguli	1	1.000	0.000
R Tulsuli	1	1.000	0.000
Ranbambuli	1	1.000	0.000
Shirgaon	1	1.000	0.000
Shirgaon-Panivata	1	1.000	0.000
Waingavade	1	1.000	0.000
Vengurla			
Tulas	53	10.600	0.170
Matond	35	8.750	0.070

Pendur	31	4.430	0.220
Math	26	8.670	0.050
Asoli	15	15.000	0.000
Ubhadanda	15	5.000	0.100
Hodawade	14	3.500	0.210
Vetore	13	4.330	0.080
Adeli	12	3.000	0.220
Talekarwadi	12	12.000	0.000
Ansur	7	7.000	0.000
Khanoli	6	3.000	0.030
Dabholi	5	5.000	0.000
Sataye	5	1.670	0.120
Adari	3	1.500	0.070
Bhendamala	2	2.000	0.000
Pal	2	2.000	0.000
Palkarwadi	2	2.000	0.000
Devasu	1	1.000	0.000
Kelus	1	1.000	0.000
Sawantwadi			
Sonurli	254	23.090	0.320
Dingne	250	22.730	0.300
Padlos	224	18.670	0.400
Majgaon	201	22.330	0.280
Otavane	127	11.550	0.380
Madura	91	10.110	0.260
Dongarpal	89	8.090	0.410
Niravade	87	8.700	0.250
Kesari	82	8.200	0.470
Ronapal	82	7.450	0.340
Bavlat	80	7.270	0.460
Kolgaon	71	7.890	0.200
Degave	68	6.800	0.390
Netarde	68	6.800	0.340
Vetye	62	8.860	0.230
Galel	54	6.750	0.250
Kariwade	47	5.220	0.500
Kaleli	124	11.270	0.410
Charathe	43	6.140	0.220
Vilavade	42	4.200	0.350
Madkhol	41	6.830	0.280
Aros	34	5.670	0.190
Insuli	32	3.560	0.240
Amboli	31	10.330	0.080

Wafoli	31	3.440	0.500
Nemale	29	4.830	0.090
Talavade	27	5.400	0.180
Tamboli	26	4.330	0.270
Bhalawal	25	3.570	0.280
Nhaveli	25	2.780	0.210
Kumbharli	24	4.000	0.170
Kshetrapal	23	4.600	0.240
Banda	22	3.140	0.280
Malgaon	20	2.860	0.350
Kunkeri	18	3.600	0.260
Satuli	16	2.290	0.240
Ambegaon	14	4.670	0.140
Kas	13	4.330	0.170
Nangartas	12	6.000	0.030
Sarmale	10	2.500	0.080
Dandeli	8	2.000	0.210
Nigude	8	2.000	0.130
Padve Majgaon	8	2.000	0.060
Danoli	7	1.750	0.140
Dhakore	7	7.000	0.000
Malewad	7	1.750	0.140
Satarada	7	2.330	0.040
Sherle	7	7.000	0.000
Bhom	6	1.200	0.200
Bhairavwadi	5	1.670	0.160
Choukul	5	1.670	0.120
Gele	5	5.000	0.000
Masure	5	2.500	0.020
Sangeli	5	2.500	0.090
Nirukhe	4	1.330	0.150
Bramhanpat	2	1.000	0.090
Ovaliye	2	2.000	0.000
Talawane	2	1.000	0.090
Aronada	1	1.000	0.000
Brahmanpat	1	1.000	0.000
Dabhil	1	1.000	0.000
Kalambist	1	1.000	0.000
Dodamarg			
Mangeli	209	17.420	0.310
Hewale	165	18.330	0.150
Kalane	97	8.820	0.450
Bambarde	95	8.640	0.350

Konal	88	11.000	0.220
Khanyale	73	7.300	0.230
Ghatiwade	52	5.780	0.370
Bodade	51	6.380	0.270
Palve	50	16.670	0.080
Adali	47	4.700	0.440
Phondye	41	5.130	0.160
Sasoli	29	3.630	0.260
Bhike-Konal	28	3.500	0.420
Morle	23	11.500	0.010
Sonawal	22	7.330	0.050
Ker	21	4.200	0.100
Terwanmedhe	17	4.250	0.030
Ghotgewadi	15	2.500	0.120
Morgaon	15	3.750	0.160
Khokaral	14	7.000	0.050
Aynode	13	3.250	0.120
Kudase	13	2.170	0.350
Maneri	12	4.000	0.110
Talkat	10	2.500	0.130
Tilari	9	3.000	0.090
Wayangantad	8	8.000	0.000
Zarebambar	8	2.000	0.150
Sateli Bhedshi	7	2.330	0.130
Kumbral	6	2.000	0.090
Zolambe	6	3.000	0.030
Ambeli	5	2.500	0.020
Kendre Bk.	5	2.500	0.080
Pikule	5	1.250	0.230
Bhekurli	4	4.000	0.000
Kasai	4	4.000	0.000
Ugade	4	2.000	0.050
Kendre Kh.	3	3.000	0.000
Ghotge	2	2.000	0.000
Girode	2	2.000	0.000
Khadpade	2	2.000	0.000
Kolzar	2	2.000	0.000
Konas	2	2.000	0.000
Panval	2	1.000	0.090
Shirange	2	1.000	0.090
Shirwal	2	2.000	0.000
Bambarde-Kharadi	1	1.000	0.000
Usap	1	1.000	0.000

Appendix III

Profile of elephant crop raiding in different talukas of Sindhudurg district by crops affected (2002-2015)

Crop count	Dodamarg	Kankavli	Kudal	Malwan	Sawantwadi	Vaibhavvadi	Vengurla	Total
Coconut	826	37	4044	33	1872	4	166	6982
Rice	457	17	1877	11	983	0	87	3432
Banana	410	18	1549	15	1081	4	85	3162
Areca Pam	356	3	496	4	433	-	30	1322
Mango	19	-	166	1	28	-	8	222
Cashew	49	2	53	-	55	-	5	164
Ragi	17	-	82	1	33	0	2	135
Sugcane	1	8	20	0	43	3	0	75
Harvested Paddy	1	-	20	5	42	-	6	74
Jackfruit	15	-	20	0	21	0	2	58
Chilli	4	-	33	0	14	0	3	54
Bamboo	9	1	34	0	6	0	0	50
Groundnut	-	-	43	0	0	0	0	43
Cowpea	-	-	32	0	5	0	3	40
Teak	18	-	-	-	2	-	1	21
Kulthi	-	-	20	0	0	0	1	21
Maize	1	-	9	-	-	-	-	10
Sapota	-	-	4	1	4	-	-	9
Garcinia	-	-	6	-	2	-	-	8
Pineapple	2	-	2	-	2	-	-	6
Papaya	-	-	4	-	-	-	1	5
Watermelon	-	-	5	-	-	-	-	5

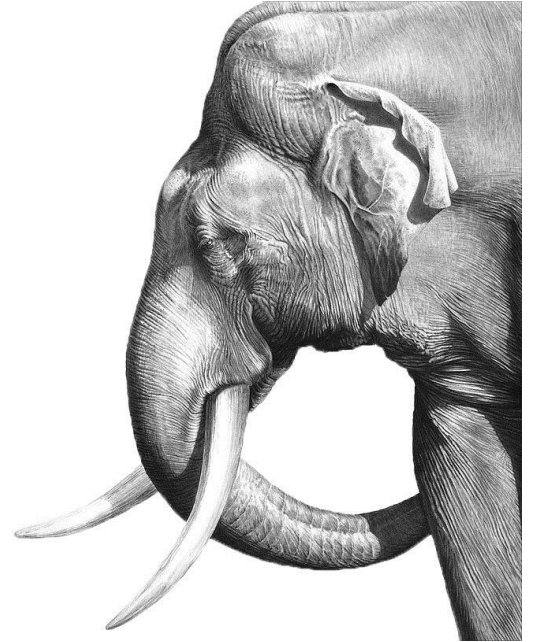
Wal	-	-	3	-	-	-	-	1	4
Sunflower	-	-	4	-	-	-	-	-	4
Bread Fruit	2	-	1	-	-	-	-	-	3
Jowar	-	-	3	-	-	-	-	-	3
Bajara	-	-	2	-	-	-	-	1	3
Rubber	1	-	-	-	2	-	-	-	3
Oil Pam	-	-	3	-	-	-	-	-	3
Jannun	-	-	2	-	-	-	-	-	2
Leamon	1	-	1	-	-	-	-	-	2
Drum stick	-	-	2	-	-	-	-	-	2
Nutmeg	-	-	-	-	1	-	-	-	1
Groundnut Cake	-	-	-	-	1	-	-	-	1
Custard Apple	-	-	-	-	1	-	-	-	1
Jam	-	-	1	-	-	-	-	-	1
Sandal	-	-	-	-	1	-	-	-	1
Utidi	-	-	1	-	-	-	-	-	1
Total	2189	86	8542	71	4632	11	402	15933	

Appendix IV

Demographic profile of surveyed villages for perception survey

Villages	GA	HH	TP	M	F	Healthcare Facility			PWS	GFA	NAL	BUL	CWL	NAS	UIL
	(He)	(n)	(n)	(n)	(n)	A	D	NG	Y/N	(He)	(He)	(He)	(He)	(He)	(He)
Dodamarg															
Bambarde	1370.10	53	232	118	114	0	0	0	Y	431.58	35.43	269.46	7.91	26.75	26.75
Hewale	955.15	106	449	238	211	0	0	0	Y	153.91	13.96	173.93	123.75	429.02	0.00
Kalane	662.27	231	951	454	497	0	Y	0	Y	0.00	4.99	155.34	176.35	80.32	5.63
Mangeili	2327.86	381	1543	716	827	0	Y	Y	Y	0.00	18.90	190.22	152.09	1538.52	0.00
Kudal															
Sawantwadi															
Dingne	996.78	196	844	423	421	0	0	0	Y	0.00	2.00	214.18	0.00	710.44	11.62
Olavane	1089.22	636	2625	1314	1311	0	0	Y	Y	228.74	10.22	337.61	220.45	240.20	0.00
Padlos	844.00	229	896	432	464	0	0	0	Y	142.69	75.06	0.00	14.08	612.17	2.90
Sonurti	1188.12	384	1484	693	791	0	0	Y	Y	0.00	8.80	180.32	4.50	763.45	7.50

GA: Geographical Area, **HH:** Household, **TP:** Total Population, **M:** Male, **F:** Female, **A:** Hospitals Allopathic, **D:** Dispensary, **NG:** Non-Government Medical facilities, **PWS:** Perennial Water Sources, **Y:** Yes, **N:** No, **GFA:** Government Forest Area, **NAL:** Non Agricultural Land, **BUL:** Barren & Un-cultivable Land, **CWL:** Cultivable Waste Land, **NAS:** Net Area Sown and **UIL:** Un-irrigated Land



CURRICULUM VITAE



Gray Hodges

CURRICULUM VITAE



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RESEARCH INTEREST

Wildlife: Ethology and natural history of higher mammals

Bamboo: Flowering behaviour; intra-species variation; ecological significance

EDUCATIONAL QUALIFICATION

Degree	Board/University	Percentage	Grade
B.Sc. Forestry (2014)	DBSKKV, Dapoli	8.63/10	First Class with Distinction
HSC (10+2) (2010)	MS-SHSEB	76 per cent	First Class with Distinction
SSC (10th) (2008)	MS-SHSEB	93 per cent	First Class with Distinction

GENERAL PROFILE OF PUBLICATIONS

Sl. No.	Type of Publication	Number
1	Journal articles	11
2	Magazine articles	05
3	Book chapters	01
4	Conference abstracts/proceedings	03
5	Article in regional language (Marathi)	02
Total		22

PUBLICATIONS RELATED TO THE TITLE OF THE THESIS

- 1) **Patil, M. D.** (2014). Final destination: range expansion and behaviour of Asian elephants in Northern Western Ghats, India. Gajah, 41: 32-35.
- 2) **Patil, M. D.** (2014). Book review: "The Story of Asia's Elephants" by Raman Sukumar. ZOO's PRINT, 29(4): 33-34.
- 3) **Patil M. D.** (2016) प्राणी मस्त, शेतकरी त्रस्त. Maharashtra Times - Diwali Ank, October: 160-165. (An essay on trends and patterns of wildlife crop raiding in India, the legal aspects, causes and solutions from farmers' perspectives. in Marathi)
- 4) **Patil, M. D.** (2015) 'हत्ती-पकड' मोठीम. Lokprabha, 42(11): 28-31. (An essay on capturing wild elephant herds in Sindhudurg District, Maharashtra. in Marathi)

