

# Fostering human-Asian elephant coexistence with community involvement in the Anamalai hills



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## **Fostering human-Asian elephant coexistence with community involvement in the Anamalai hills**

### **Abstract**

Human-elephant conflict has been one of the critical conservation issues across Africa and Asia. Asian elephant (*Elephas maximus*) ranges outside Protected Areas into human-dominated landscapes, leading intense conflicts between people and elephants. Given that in countries such as India where millions of people and hundreds of elephants share resources and interact with each other, resolving human-elephant conflict is a high priority issue. In India, around 500 people and over 100 elephants lose their lives due to intense conflicts, which warrants conservation efforts to resolve conflicts and ensure safety of people and elephants is paramount importance. The project has been carried out in one of the critical conservation regions called the Valparai plateau in the Anamalai hills, which harbours second largest Asian elephant population in India. Loss of human life and property damage by elephants is a serious concern besides trauma and fear in people that elicit from conflicts. As many people who lost lives in direct encounters with elephants were primarily due to people were unaware of elephant presence. During the last two years (2017-19), we have tracked elephants on daily basis in the tea and coffee dominated landscape of the Valparai plateau which supports around 120 elephants and 70,000 people. Based on this information, we have established a multi layer 'Elephant Information Network' with stakeholders including plantation companies, state forest department field staff, and local people to implement simple, adaptable, and unique measures of early warning systems, using SMS and voice call alert systems and mobile operated alert beacons. During the past two years we have sent out an average around 2000 text messages and calls to peoples' mobile phones and installed alert beacons in critical strategic points that would indicate elephant presence and their movements to people who reside within 2 km radius from elephant locations on the Valparai plateau. These measures have been well regarded by local community and encouraged them to be part of early warning systems and management of human-elephant conflict. All these collective efforts resulted in zero accidental (surprise) encounters for the sixth consecutive year. Though there were three people lost lives in 2017-18 due to ignored early warning and unplanned chasings of elephants, which were addressed through awareness and sensitization programmes through street plays and formal meetings with local community. These efforts in the later year of 2018, resulted in '**no human death**' on the plateau. And also, over a long-term, human fatal encounters remained one person/year (2003-2019) for the last fifteen years as compared to the period between 1994-2002, prior to our work on elephants in the region. Property damage incidents have been reduced to more than 50% during the project period as compared to 2011. These measures have been replicated by other agencies such as state forest departments in the states of Kerala, Karnataka, and West Bengal and also tea companies in Gudalur region of Tamil Nadu. Our work warrants a shift from reactive '**Problem animal**' approach to proactive '**Problem location**' approach for peaceful coexistence between people and elephants in altered landscape of people and elephants.

## INTRODUCTION

Conservation of large mammals, particularly elephants, outside protected areas is increasingly becoming a challenge for scientific and conservation organizations, local communities, and park managers due to pressures as anthropogenic threats and compel coexistence with humans (Sitati and Walpole 2006, Graham *et al* 2010, Fernando *et al* 2012, Gubbi, 2012). Continuous degradation and conversion of natural habitats, fragmentation of natural habitats, and developmental activities posed a great threat to elephant survival in altered landscapes, leading to intense conflicts across Asia and Africa (Sukumar 1994, Sitati *et al* 2003, Chartier *et al* 2012). Effects of these threats, though not clearly documented, few studies (Burke *et al.* 2008; Ahlering *et al* 2011 & 2013) reported that human induced pressures increase stress levels in elephants and may affect their viability of population survival in human modified landscapes.

Asian elephant (*Elephas maximus*), recently recognized as National Heritage animal by the Indian Government, two third of its population lives in non-protected areas either close to or within human dominated landscapes giving opportunities into greater contact and conflict (Sukumar 1989, Madusudan *et al* 2015, Fernando *et al* 2019). Human-elephant conflict escalated with ever increasing human population coupled with hydro-electric projects, agriculture expansion, transportation networks and reservoirs within forested elephant habitats, resulted in fragmented populations (Leimgruber *et al* 2003) and pushed these pachyderms into neighboring human use areas (Desai 1991). Asian elephant worshiped as God, occupied cultural and religious prominence in human societies across Asia, is has been facing elevated threats due to human-elephant conflict. Thus, human-elephant conflict resolution is not only of scientific and conservation importance but a societal need to retain traditional values of tolerance in local communities towards elephants in human-elephant relationships.

There have been various techniques employed to deal with human-elephant conflict in interspersing areas of elephants and humans. Multiple methods of deterring elephants from human-use areas or crop lands by deploying physical barriers such as electric fences, elephant proof trenches etc., traditional methods of using crackers, use of tobacco – chilly rope, elephant drives etc., have showed mixed results in their efficacy in dealing with human-elephant conflicts (Nath and Sukumar 1998, Parker and Osborn, 2006, Kioko *et al* 2008, Chelliah *et al* 2010). Recently, numerous experimental trials focusing on innovative measures

have showed varying degree of success to mitigate human-elephant conflicts in Asia and Africa (King *et al* 2011, Davies *et al* 2011).

Of the various kinds of conflict mitigation techniques, early warning systems proved to be effective in reducing incidence of conflicts (Venkatraman *et al* 2005, Hedges and Gunaryadi 2009, Davies *et al* 2011). However, there have been very few human-elephant conflict studies which addressed long term monitoring on the efficacy of conflict mitigation techniques in terms of reduction in incidence of conflicts, adoptability of techniques by local communities, reduced stress levels in people, help increase levels of people tolerance towards elephants, and sustainability of conflict mitigation measures. Here in this report, we have addressed the following objectives.

- A) Monitor movement of elephants and their conflict with people between 2017 -2019
- B) Conveying of elephant presence alerts to people over early warning systems (2017-19).
- C) Community participation in early warning systems
- D) Functionality and impacts of early warning systems on incidents of conflict

## **MATERIALS AND METHODS**

### **A. Study area**

The Valparai plateau in the Anamalai hills is a landscape of tea and coffee plantations interspersed with rainforest fragments and Eucalyptus plantations. The 220 km<sup>2</sup> Valparai plateau in amidst of protected areas which form an important landscape for Asian elephants in the Western Ghats of India. Nearly, around 40 rainforest fragments within monoculture plantations act as refuges for elephants to move across the plateau (Mudappa and Raman 2007, Kumar *et al* 2010, Figure 1). The plantation industry on the Valparai plateau owned by national and multinational companies support nearly 70,000 people working in tea and coffee plantations. The inevitable situation of using the plantation landscape by elephants and people dependency over tea and coffee plantations for survival led to interactions between elephants and people, leading to human-elephant conflict (Kumar *et al* 2004). The only way to resolve human-elephant conflict on the plateau is to make people vigilant of elephant presence and adopting better practices to promote coexistence between people and elephants.

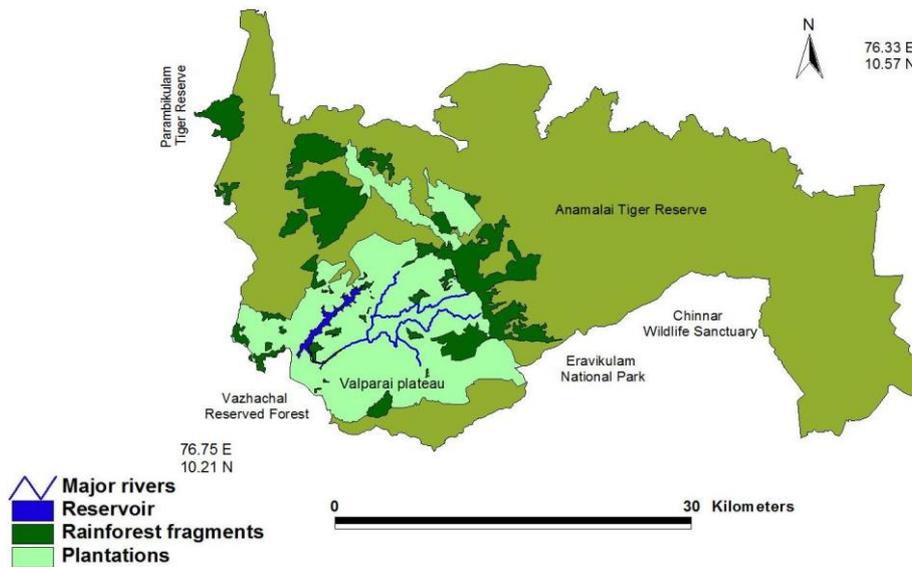


Figure 1. Map of Valparai plateau (light green) with rainforest fragments (dark green) and surrounding protected areas (dark green)

## Methods

Methods adopted during the study were briefed below:

- Establishing conflict response team (CRU) with a team of experienced tribal people who track elephants within plantation limits during the day and record information on date, time, identity of elephant herd, herd composition, incidence of conflicts, type of habitat, and movement with handheld GPS (Kumar *et al* 2004, 2010). The information from CRU was intimated to the elephant information centre on daily basis.
- Elephant information network was established by initiating bulk SMS and voice call services where information about elephant presence and their movement from CRU, local people, and field staff of Tamil Nadu Forest Department was communicated to people on their mobile phones residing within 2 km from the place of elephants (Fig 2). A database which includes information about name of the person, place of residence, division, estate, about 4500

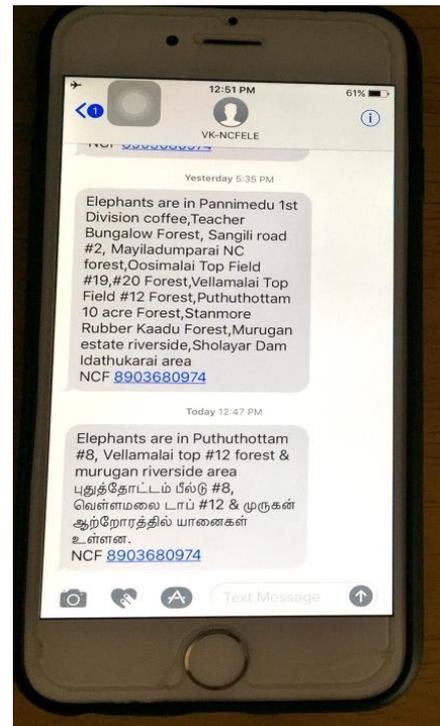


Figure 2. Text message alert in Tamil (local language) and English over mobile phone

residing within 2 km from the place of elephants (Fig 2). A database which includes information about name of the person, place of residence, division, estate, about 4500

people who were willing to receive elephant messages on their mobile numbers has been maintained. Responses from people for Bulk SMS have been systematically recorded, grouped, and analyzed for their efficacy. A detailed explanation on methods has been mentioned elsewhere (Kumar and Ganesh 2012).

- Early warning remotely mobile operated elephant alert indicators with red LED flashing units have been installed in 32 locations which are visible from a distance of 1 km from nearest bus stop (Fig 3). For each light, at least two people mobile phone numbers from local plantation workers community were registered. These people are authorized to operate alert indicators in case of



Figure 3. A GSM based mobile operated alert beacon in a tea estate in the Valparai region

elephant presence within 1km distance from the light. Information received in the form of SMS from alert indicators, when operated, was systematically recorded to understand involvement of people in alerting residents of respective localities about elephant presence. False alarms and failed operations were estimated based on elephant presence or absence within 1 km radius from each of the 32 lights installed on the Valparai plateau.

## ***Results***

### ***A. Monitoring elephant movements***

The Valparai plateau has been consistently used by around 120 elephants in tea and coffee plantations and rainforest fragments in year. During 2017-18 and 2018-19, 3573 herd-days and 3544, herd-days, respectively, (number of days of time spent by different elephant herds/solitary individuals which were more than a kilometer apart of time spent by elephants on the plateau. Elephant activity peaks between October and March in a year, a sensitive period for human-elephant interactions on the Valparai plateau. Elephant herds showed distinct ranging patterns with overlap in areas which has been consistent over years. This

matches with the findings of other studies carried out in Sri Lanka and Malaysia which indicate Asian elephants show strong fidelity to their ranges.

### *Human-elephant conflict*

#### *1. Property damage by elephants*

The property damage incidents have reduced significantly during 2018-19 (n = 64) as compared to the year 2017-18 (n = 112). However, in both years, property damage by elephants continued to be low as compared to the year April 2011 - March 2012 (150 incidents). However, property damage incidents due to elephants on higher side as compared to previous four years

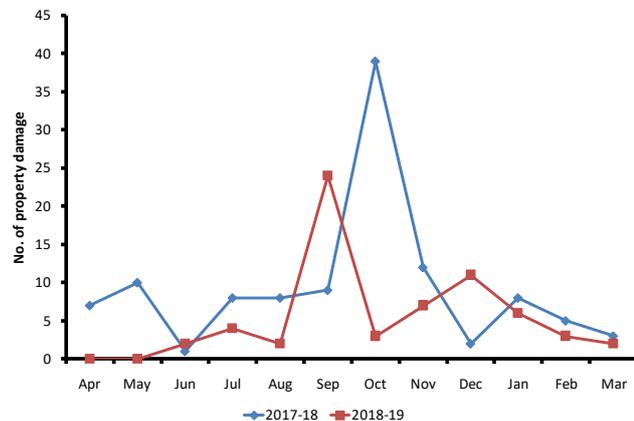


Figure 4. Distribution of property damage incidents by elephants across months during 2017-19.

between April 2016 - March 17 (71 incidents), April 2015 - March 16 (97 incidents) April 2014-March 15 (68 incidents), April 2013-March 2014 (97 incidents), April 2012-March 2013 (88 incidents). The slight increase in number of property damage incidents in the year 2017-18, were mainly due to changes in the way that food grains are stored and also negative interactions between elephants and people. Most of the property damage occurred between September and February (2017-18: 67%, n = 75, 2018-19: 84.4%, n = 54, Figure 4), denoting the peak conflict period which has been noticed over years. In both years, we have recorded high number of damages noticed to residential places (52 incidents, 46.4% in 2017-18 and 26 incidents, 41% in 2018-19), followed by ration shops and noon-meal centres (46 incidents, 41% in 2017-18 and 31 incidents, 48% in 2018-19) which store food grains such as rice, dhal, lentils, salt and sugar are located either inside or within 50 m distance from residential colonies which cause potential danger to people and their property.

#### *2. Human fatal incidents*

Over the past 25 years (1994-2019), of the 45 people who lost their lives to elephants, 35 fatalities attributed to the lack of awareness of elephant presence which lead to unexpected fatal encounters. During the past two years, early warnings about elephant presence and their movements in plantations resulted in no incident of human fatality due to lack of awareness

about elephant presence. However, unplanned chasing of elephants, ignoring warnings and inebriation resulted in three human fatalities. One particular incident where a person who was inebriated lost his life during a stone pelting drive incident. Angry mob demanded Kumkis (elephants used to chase or capture wild elephants) to drive away wild elephants which resulted in death of an elephant.

## B) Early warning systems

Our regular interactions with various estates and awareness programs with local communities, resulted in an increase in subscribers to the bulk SMS and voice call alert services. The number of subscribed users increased to 4,464 mobile phones. The database includes 3345 males and 1,119 females, a significant participation by women as compared to the beginning of the project (348 women), in the Elephant Information Network.

### 1. Bulk SMS text and outbound voice call alerts

In 2017-19, we have sent out 1,342,921 messages (2017-18: 736174 and 2018-19: 607745; with an average of 41,014 messages/month), covering estate workers, women self-help groups, merchants, daily wage workers, managerial staff, and forest

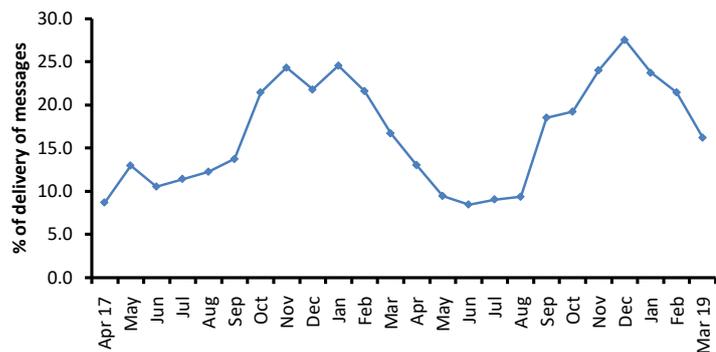


Figure 5. Percent of SMS delivered to people's mobile phones across months between 2017-19

department personnel. Delivery of messages peaked between October and March which corresponds with the peak elephant movement on the plateau (Fig 5). Such a network has facilitated the range forest officer to send out rapid response teams to the most sensitive areas which would require immediate attention in terms of safety of life and property. Similarly, 1,141,159 call alerts sent out between 2017-19, only 19% of calls (n=216,051) were attended by recipients. Of the total unattended calls (n=925102), 90% was mainly due to recipient phone was busy and in 9.3% of cases, the recipient did not pick-up the call.

### 2. Mobile operate alert beacons

In addition to existing 30 flashing alert beacons, three more lights have been installed in critical locations of TATA Coffee plantation company. These alert lights are roughly

benefitting 20,000 people and help them about elephant presence within 1 km radius from each light location.

### **C) Community participation in elephant information network**

Active participation by local communities has steadily increased in the elephant information network over the past one year. Peoples' calls to the research team involves either to enquire or convey information about elephant presence in respective areas. This indicates the acceptance and seriousness with which local communities choose to make the best of use the facility made available.

Between 2017-19, 958 calls (2017-18: 421 and 2018-19: 532) response calls received from estate workers as a response to Bulk SMS and outbound voice call systems. Nature of calls received from people reveal that a majority of calls were related to conveying (47%) and enquiring (39%) of elephant locations to the research. Remaining calls were about request for help, request to subscribe for elephant alerts, and appreciation of alert services. The response calls indicate that people continue to rely upon these systems and created "My Message" attitude among local people since its inception in 2011

Alert beacons were operated 634 and 442 times in 2017-18 and 2018-19, respectively, whenever elephants were seen within 1 km radius from each light location. Around 72% of operations were carried out between October and March, corresponding with elephant movements on the plateau. Local community was involved in 99% of light operations, indicating their sustained responsibility in alerting people living in each light locations.

### **Awareness and sensitization activities**

Awareness and sensitization programmes are being carried out on a regular basis to convey the importance of elephants and our research findings while imparting precautionary steps to avoid fatal encounters with elephants. Between 2017-19, we have held 52 formal and field orientation interactions, covering 2, 700 estate workers on the field. For the first time in Valparai, seven street plays performed by Sword Adhiyaman KalaiKuzhu, a team of professional street play artists to convey the importance of the need to coexist with elephants, precautionary steps required to be taken while moving through elephant presence areas and ill effects of alcohol consumption in the elephant use areas. Tea and coffee estate management have been instrumental in executing these shows. In February 2018, Parry Agro Industries limited, TATA Coffee Limited, and Periya Karamalai Tea Company supported our

initiative by providing space and ensured that their estate workers (634 people) attended the event. This being the first time, we received a lot of positive feedback and also brought to light some of our shortcomings which could be improvised in the future.

### **Sharing results with Government officials**

As a way of promoting the impacts of project in promoting human-elephant coexistence we have interacted with Forest Department officers of various states in India.

- Conducted an interaction with 45 forest range officers trainees from Karnataka, Maharashtra, and West Bengal on human-elephant coexistence: communication technology in mitigating conflicts and community participation on 14 October 2017
- Conducted an interaction with IFS trainees on 18 September 2017 about 'Human-elephant coexistence: A science based approach'. The meeting was attended by 32 trainees from six states of India.
- Dissemination of project results during a talk titled "Of pachyderms, panthers, and primates: understanding human-wildlife relationships" on 28 October 2017 for officers of Tamil Nadu Forest Department.
- We had an interaction meeting on 2 January 2018 attended by five core officers of Anamalai Tiger Reserve to convey the importance of project results and chalk out strategies to deal with human-elephant coexistence in the Anamalais.
- We were invited by the Project Elephant, Government of India to the workshop on 'Right of passage to elephants to mitigate human-elephant conflict' share our work titled "Human-elephant coexistence: a need for scientific approach for conflict resolution" in Thiruvananthapuram, Kerala on 12 January 2018.
- We have participated in the stakeholders meeting organised by the Tamil Nadu Forest Department on 13 February 2018 attended by 55 representatives of tea and coffee plantation companies, six media persons, and 25 Forest Department field staff. Objective of the meeting was to strengthen proactive steps and coordination between forest field staff, plantation company management, and NCF to address human-wildlife conflicts in the Valparai region.

### **D) Impact of early warning systems**

- Consistent efforts and cooperation of local communities, plantation management and Tamil Nadu Forest Department field staff enabled to reduce human fatal incidents to zero

in 2018, besides providing increased safety to peoples' lives from elephants. And also, property damage incidents reached lowest with 64 incidents in 2018-19. Over a long-term, early warning systems helped to bring down human death incidents from an average of three persons/year between 1994 - 2002 (prior to our programme) to one person/year (2003 - 2019) for the last fifteen years. This has resulted in saving 23 people lives between 2003-2019, besides helped in increasing positive attitude in local people towards elephants.

- Our project has encouraged and provided inputs to the Kerala Forest Department to implement early warning systems in 42 centres across the state . Our efforts have also inspired West Bengal Forest Department to take up bulk SMS alert systems.
- The Valparai work also gave us an opportunity to experimentally initiate early warning systems in collaboration with the state Forest Department in Karnataka state and also encouraged the forest department to initiate advanced intimation systems in the Kodagu region which has been experiencing severe conflicts in terms of loss of human and elephant lives in the state of Karnataka.

#### **Peer-reviewed publications**

- Kumar, M. A., Vijaykrishnan, S. and Singh, M. 2018. Whose habitat is it anyway? role of natural and anthropogenic habitats in conservation of charismatic species. *Tropical Conservation Science*.11:1-5. <http://journals.sagepub.com/doi/abs/10.1177/1940082918788451>.

#### ***Media coverage of the work between 2017-19***

- 1) Gupta, A. 2017. Giving elephants the space they need, one SMS at a time. The Wire magazine. 27 April 2017. <https://thewire.in/129142/elephants-bengal-deaths-kerala-drought/>
- 2) Bindra, P. S. 2017. The Vanishing: India's wildlife crisis. A mention in the book about early warning systems in Valparai. Penguin Random House Publishers,
- 3) Mizzi, S. 2017. Sharing space. BBC Wildlife magazine. July 2017. Pp: 64 - 71.
- 4) Interview of Ganesh Raghunathan by US fish Wildlife Service on 10 August 2017 on occasion of Elephant Day celebrations. <https://www.fws.gov/international/articles/world-elephant-day-broadcast.html>
- 5) Thyagarajan, S. 2017. Asian elephants: Gods who walk amongst us (Part I). Covered early warning systems in the Valparai region on NDTV under Born Wild Programme. <https://youtu.be/jvG9Orj6dh0>

- 6) Thomas, W. 2018. Hassan follows Valparai model in mitigating human-elephant conflict. The Hindu. 1 January 2018. <http://www.thehindu.com/news/cities/Coimbatore/hassan-follows-valparai-model-in-mitigating-human-elephant-conflict/article22341752.ece#!>
- 7) Singh, A. K. New Initiatives to reduce human elephant conflict in Karnataka. 25 January 2018. <https://www.youtube.com/watch?v=ouvZH0seQ18>
- 8) Patel, P. 2018. A corridor for elephants. DNA. 22 April 2018. <https://www.dnaindia.com/just-before-monday/report-a-corridor-for-elephants-2607266>
- 9) Perinchery, A. 2018. An elephant never forgets. The Hindu. 11 August 2018. <https://www.thehindu.com/sci-tech/energy-and-environment/an-elephant-never-forgets/article24643166.ece>
- 10) Vijayakrishnan, S. 2018. From conflict to coexistence between humans and elephants: A story from Anamalai. 15 August 2018. <https://www.firstpost.com/tech/science/acknowledging-the-elephant-in-the-room-a-world-elephant-day-special-4950791.html>
- 11) Ghosh, P. 2018. Do we need flexible spaces for animals? Mongabay India. 15 October 2018. <https://india.mongabay.com/2018/10/15/do-we-need-flexible-spaces-for-humans-and-animals/>
- 12) Ghosh, P. 2018. Research on India's lion-tailed macaques shows why humans need to rethink habitat fragmentation. Recent findings highlight the role of natural and anthropogenic habitats for the existence of three charismatic species. *Scroll.in*. 24 October 2018. <https://scroll.in/article/898364/research-on-indias-lion-tailed-macaques-shows-why-humans-need-to-rethink-habitat-fragmentation>.
- 13) Lenin, J. 2018. Elephant in the room: Why Ananda Kumar studies elephants. The Hindu. 4 November 2018. <https://www.thehindu.com/sci-tech/energy-and-environment/the-elephants-in-the-room/article25401209.ece>
- 14) Ramanan, S. S. 2019. Landscape-level approach necessary to address human elephant conflicts. Down to Earth. 15 February 2019. <https://www.downtoearth.org.in/news/wildlife-biodiversity/landscape-level-approach-necessary-to-address-human-elephant-conflicts-63242>
- 15) Niyogi, D. G. 2019. Early elephant warning systems help, but are short-term measures: experts. Down to Earth. 21 February 2019. <https://www.downtoearth.org.in/news/wildlife-biodiversity/early-elephant-warning-systems-help-but-are-short-term-measures-experts-63311>
- 16) Sreedharan, V. 2019. Reducing human-elephant encounters with calls, texts, and digital signs. Mongabay India. 6 March 2019. <https://news.mongabay.com/2019/03/reducing-human-elephant-encounters-with-calls-texts-and-digital-signs/>
- 17) Sreedharan, V. 2019. Ping! Elephants ahead: reducing human-elephant conflict, one SMS at a time. Mongabay India. 5 March 2019.

<https://india.mongabay.com/2019/03/ping-elephants-ahead-reducing-human-elephant-conflict-one-sms-at-a-time/>

- 18) Sreedharan, V. 2019. In India new tactics are being implemented to prevent human-elephant clashes. Pacific Standard. 9 March 2019. <https://psmag.com/environment/preventing-fatal-clashes-between-humans-and-elephants>
- 19) Sreedharan, V. 2019. How a Karnataka town used SMS alerts to reduce human-elephant conflicts. Scroll.in. 14 March 2019. <https://scroll.in/article/915480/how-a-karnataka-town-used-sms-alerts-to-reduce-human-elephant-conflicts>
- 20) Kannadasan, A. 2019. The story of how elephant ChinnaThambi was tamed. The Hindu. 20 March 2019. <https://www.thehindu.com/life-and-style/travel/on-a-trunk-call-with-chinna-thambi/article26589096.ece>
- 21) Bohlmark. A. 2019. Big social nomad. An half-an-hour documentary on elephants in India. April 2019.

## References

- Ahlering, M. A., Millspaugh, J. J. Woods, R. J. Western, D. and Eggert., L. S. 2011. Elevated stress hormones in crop-raiding male elephants. *Animal Conservation*. 14: 124 – 130.
- Ahlering, M. A., Maldonado, J. E., Eggert, L. s., Fleischer, R. C., Western, D. and Brown, J. L. 2013. Conservation outside Protected Areas and the Effect of Human-Dominated Landscapes on Stress Hormones in Savannah Elephants. *Conservation Biology*, 27: 569 – 575.
- Burke, T., Page, B., Van Dyk, G., Millspaugh, J. and Slotow, R. 2008. Risk and ethical concerns of hunting male elephant: behavioral and physiological assays of the remaining elephants. *PLoS ONE*. 3: e2417. Doi:10.1371/journal.pone.0002417.
- Chartier, L, Zimmermann, A. and Ladle, R. J. 2012. Habitat loss and human-elephant conflict in Assam, India: does critical threshold exist. *Oryx*. 45: 528 – 523.
- Chelliah, K., Kannan, G., Kundu, S., Abilash, N., Madhusudan, A., Baskaran, N. and Sukumar, R. 2010. Testing the efficacy of a chilli-tobacco rope fence as a deterrent against crop-raiding elephants. *Current Science*. 99: 1239 – 1242.
- Davies, T. E., Wilson, S., Hazarika, N., Chakrabarty, J., Das, D., Hodgson, D. J. and Zimmermann, A. 2011. Effectiveness of intervention methods against crop-raiding elephants. *Conservation Letters*. 4: 346 – 354.
- Desai, A. A. 1991. The home range of elephants and its implications for management of the Mudumalai Wildlife Sanctuary, Tamilnadu. *Journal of Bombay Natural History Society*. 88: 145 – 156.
- Fernando, P., Leimgruber, P., Prasad, T. and Pastorini, J. 2012. Problem elephant translocation: Translocating the problem or the elephant? *PLoS ONE*. 7: e50917. doi:10.1371/journal.pone.0050917.

- Fernando, P., de Silva, M. K. C. R., Jayasinghe, L. K. A., Janaka, H. K. and Pastorini, J. 2019. First country-wide survey of endangered Asian elephant: towards better conservation and management in Sri Lanka. *Oryx*. doi:10.1017/S0030605318001254.
- Graham, M. D., Notter, B., Adams, W. M., Lee, P. C. and Ochieng, T. N. 2010. Patterns of crop-raiding by elephants *Loxodonta Africana* in Laikipia, Kenya, and the management of human elephant conflict. *Systematic and Biodiversity*. 8: 435 – 445.
- Graham, M. D., Adams, W. M. and Kahiro, G. 2011. Mobile phone communication in effective human elephant–conflict management in Laikipia County, Kenya. *Oryx*. 46: 137 – 144.
- Gubbi, S. 2012. Patterns and correlates of human-elephant conflict around a south Indian reserve. *Biological Conservation*. 148: 88 – 95.
- Hedges, S. and Gunaryadi, D. 2009. Reducing human-elephant conflict: do chillies help deter elephants from entering crop fields? *Oryx*. 44: 139 – 146.
- King, L. E., Douglas-Hamilton, I. and Vollrath, F. 2010. Bee hive fences as effective deterrents for crop raiding elephants: field trials in northern Kenya. *African Journal of Ecology*. 49: 431 – 439.
- Kioko, J., Muruthi, P., Omondi, P. and Chiyo. 2008. The performance of electric fences as elephant barriers in Amboseli, Kenya. *South African Journal of Wildlife Research*. 38: 52 – 58.
- Kumar, M. A., Mudappa, D., Raman, T. R. S. and Madhusudan, M. D. 2004. The elephant hills: Conservation of wild Asian elephants in a landscape of fragmented rainforests and plantations in the Anamalais, India. *CERC Technical Report No. 10*, Nature Conservation Foundation, Mysore. Available at <http://www.ncf-india.org/publication.php?type=technical+report&title=54>.
- Kumar, M. A and Raghunathan, G. 2014. Fostering human-elephant coexistence in the Valparai landscape, Anamalai Tiger Reserve, Tamil Nadu. In: *Human-Wildlife Conflict in the Mountains of SAARC Region - Compilation of Successful Management Strategies and Practices*. Pp 14 - 26. SAARC Forestry Centre, Thimpu, Bhutan
- Kumar, M. A., Mudappa, D. and Raman, T. R. S. 2010. Asian elephant *Elephas maximus* habitat use and ranging in fragmented rainforest and plantations in the Anamalai Hills, India. *Tropical Conservation Science*. 3: 143 – 158.
- Leimgruber, P., Gagnon, J. B., Wemmer, C, Kelly, D. S, Songer, M. A. and Selig, E. R. 2003. Fragmentation of Asia's remaining wild lands: implications for Asian elephant conservation. *Animal Conservation*. 6: 347 – 359.
- Madhusudan, M. D., Sharma, N., Raghunath, R, Baskaran, N., Bipin, C. M., Gubbi, S., Johnsingh, A. J. T., Kulkarni, J., Kumara, H. N., Mehta, P., Pillay, R. and Sukumar, R. 2015. Distribution, relative abundance, and conservation status of Asian elephants in Karnataka, southern India. *Biological Conservation*. 187:34–40.
- Mudappa, D. and Raman, T. R. S. 2007. Rainforest restoration and wildlife conservation on private lands in the Valparai plateau, Western Ghats, India. In: *Making Conservation at Work*. Shahabuddin, G. and Rangarajan, M (Eds.), pp. 210–240. Ranikhet: Permanent Black.

- Nath, C. and Sukumar, R. 1998. Elephant-human conflict in Kodagu, southern India: distribution patterns, people's perceptions and mitigation methods. *Unpublished report*, Asian Elephant Conservation Centre, Bangalore.
- Parker, G. E. and Osborn, F. V. 2006. Investigating the potential for chilli *Capsicum annum* to reduce human-wildlife conflict in Zimbabwe. *Oryx*. 40: 1 – 4.
- Sitati, N. W., Walpole, M. J., Smith, R. J. and Leader-Williams, N. 2003. Predicting spatial aspects of human-elephant conflict. *Journal of Applied Ecology*. 40: 667 – 677.
- Sitati, N. W. and Walpole, M. J. 2006. Assessing farm-based measures for mitigating human-elephant conflict in Transmara district, Kenya. *Oryx*. 40: 279 – 286.
- Sukumar, R. 1989. *The Asian elephant: ecology and management*. Cambridge University Press, Cambridge.
- Sukumar, R. 1994. *Elephant days and nights*. Oxford University Press, New York, USA.
- Venkataraman. A. B., Saandeeep, R ., Baskaran, N., Roy, M. Madhivanan, A. and Sukumar, R. 2005. Using satellite telemetry to mitigate elephant-human conflict: An experiment in northern West Bengal, India. *Current Science*, 88: 1827-1831.

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