Human-elephant coexistence: Community involvement in conflict resolution in a land-use mosaic of the Anamalai Hills, Western Ghats, India

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HUMAN-ELEPHANT COEXISTENCE: COMMUNITY INVOLVEMENT IN CONFLICT RESOLUTION IN A LAND-USE MOSAIC OF THE ANAMALAI HILLS, WESTERN GHATS, INDIA

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Human-elephant conflict resolution has been critical for elephant conservation in modern landscapes. Execution of human-elephant conflict management techniques with the involvement of local communities has far reaching positive impacts in reducing pressure on elephants and increase people tolerance towards elephant presence besides making mitigation measures sustainable. The 220 km² Valparai plateau is an island of rainforest fragments, tea, coffee, and Eucalyptus plantations within the Anamalai-Parambikulam Elephant Reserve. Wide spread human habitations with high human densities and regular movements of elephants led to frequent negative interactions due to loss of human life in accidental encounters besides damage to property by elephants. There were 38 people who lost their lives due to elephants during the period between 1994 – 2012 which caused fear, anger, and intolerance among communities towards elephants. Loss of life due to elephants in direct encounters was mainly due to absence of information about elephant presence and their movements in plantations to local communities. Most people lost their lives during December and February which denotes peak conflict period in a year. We have established a conflict response unit (CRU) which tracks elephants until they move into surrounding protected areas. Based on the information from CRU and local informants and the Forest Department personnel, we have experimented with three kinds of early warning measures to develop Elephant Information Network to avoid direct encounters between elephants and people. First, elephant information has been displayed on cable television channel in the evenings. Secondly, we have initiated daily SMS service to intimate people on their mobile phones about elephant presence within 2 km radius in English and Tamil for a nine month period. We have installed mobile phone operated red flashing LED indicator lights in strategic locations by involving local stakeholders who would operate them from their registered mobile phones to intimate elephant presence in respective localities within plantations for the days elephants were seen on the plateau. Response calls from people for television network and SMS initiative and messages received from indicators when operated by people were systematically recorded, categorized, and analyzed for their effectiveness in the management of human-elephant conflict. Response calls from people for television network were high between May and August but gradually declined in later months in a one-year period. High response calls from people for bulk SMS initiative were noticed between November and March. Response calls for SMS measure was positively correlated to number of messages sent to people's mobile phones. Comparatively, response calls for television network gradually declined from
July during which people response to SMS message service gradually increased. Most response calls from people were mainly to enquire about elephant presence and safety measures and conveying messages about elephant movements in respective localities. Elephant alert indicator operations by local community remained stable as compared to operations by the conservation organization which declined during five months experimental period. The results of the study clearly demonstrate active participation by local community and sustainable application of early warning measures in the management of human-elephant conflict on the Valparai plateau.
INTRODUCTION

Human-elephant conflict is one of the major conservation issues in elephant range countries across Africa and Asia (Madhusudan 2003 a, Sitati et al 2003, Hedges and Gunaryadi 2009, Graham et al 2010, Pillay et al 2011). Most of the Asian elephant (*Elephas maximus*) population in Asia lies outside protected areas and is increasingly coming into contact with people in areas adjacent to elephant habitats, leading to human-elephant conflicts such as crop and property damage or injuries and deaths of people and elephants (Sukumar 1990, Williams 2001, Madhusudan 2003 b, Fernando et al 2005, Kumar 2010). Ever-increasing demand for natural resources for human needs, developmental pressures and infrastructure growth, and high densities of human population has led to fragmentation of wildlife habitats.

Such factors have resulted in two major detrimental effects on elephant populations. First, extensive alteration of elephant habitats for cultivation has resulted in fragmented habitat and elephant populations compressed within protected areas (Sukumar 1990, Desai 1991, Singh et al. 2002). Second, increased interface between human and elephant habitats have led to conflicts between people and elephants causing fatalities on both sides besides damages to property and crops. In India, many elephant populations occur in fragmented habitats, in close proximity to humans, and in areas well developed with transportation networks (Leimgruber et al 2003). In southern India alone, nearly 10% of elephant range has been lost to monoculture plantations such as tea, coffee, *Eucalyptus*, teak etc. (Santiapillai and Jackson 1990). Decreased threshold of tolerance levels of humans towards elephant presence and increased negative human-elephant interactions and perceptions also affect conservation efforts (Hill 1998, Desai 2001).

Human-elephant conflict elicits social, political, economic, and conservation problems with people residing in the interspersing human-forest habitats in elephant range countries (Madhusudan 2003 a, Osborn and Parkar 2003, Bandara and Tisdell 2004). Human-elephant conflict management outside protected areas is one of the major challenges for Government agencies, scientific and conservation organizations, and people living close to elephant habitats to find appropriate mitigation measures that would promote human-elephant coexistence. India, being a refuge for the largest Asian elephant population, human-elephant conflict resolution depends on types of techniques used, sustainability of measures, accessibility, and cost effectiveness of mitigation techniques (Fernando et al 2008, Graham et al 2010).
There are various kinds of conflict mitigation measures employed to address human-elephant conflicts. Protection of property from elephants varies from traditional methods of chasing elephants by shouting, crop guarding, use of crackers, to installation of physical barriers such as electric fences and elephant-proof trenches, early warning systems such as trip-wire alarm systems, and translocation of ‘problem’ elephants, in order to mitigate conflicts in many parts of Asia (Fernando et al 2008). Many human-elephant conflict mitigation measures have yielded mixed results (Nath and Sukumar 1998, Hedges and Gunayardi 2009, Thapa 2010, Lenin and Sukumar 2011, Davies et al 2011). Use of solar fences and elephant proof trenches encompassing large areas has not been effective in dealing with human-elephant conflicts (Sitati and Walpole 2006, Fernando et al 2008, Davies et al 2011, Lenin and Sukumar 2011). Use of beehive fences, chilies, and chemo-sensory repellents have been experimented to deter crop damage by elephants (Parker and Osborn, 2006, Hedges and Gunayardi 2009, Santiapillai and Reed 2010, Chelliah et al 2010, King et al 2011) but were not tested widely for their efficacy in many parts of Asia. As a result, conservationists continue to improve and refine methods, while looking for other alternatives.

Reaching and involving affected people and stakeholders is a crucial component of any strategy at mitigation conflict with wildlife. In this context, the rapid growth of media and mobile phone network, widely adopted for speedy communication among people across the World, is pertinent as a potential means both to communicate with and deliver services to local people. For instance, to promote health and prevent diseases, mobile phone text messaging has been used to deliver health care to people (Cole-Lewis and Kershaw 2010). Mobile text messaging is potentially a powerful tool and widely available, inexpensive, and nearly instantaneous to communicate with people in remote locations. Yet, benefits of information and communication technology have not been explored in wildlife conservation in Asia. Application of mobile phone technology to communicate elephant movements in human areas have been proven vital to deal with human-elephant conflicts in Africa (Graham et al 2009, Graham et al. 2011). Such experimental solutions to wildlife conservation problems are seldom addressed in many parts of Asia (Sutherland et al 2004, Stewart et al 2005).

The Valparai plateau, a landscape matrix of tea and coffee plantations interspersed with rainforest fragments in the Anamalai hills is an important conservation area for Asian elephants in India (Mudappa and Raman 2007). People’s dependence on plantations for their livelihood and the inevitability of use by elephants of the landscape necessitates that people and elephants share the plantation landscape
Human-elephant conflict mitigation in a land-use mosaic of the Anamalai hills (Kumar et al 2010). However, incidents of loss of human life due to elephants have caused fear and trauma and promoted negative attitude among local communities, who often engage in undesirable retaliatory reactions against elephants. These include chasing of elephants using trucks, throwing fire, bursting crackers, which are detrimental to elephants, particularly young ones, and may induce loss of fear in elephants against such reactions through habituation when inappropriately deployed. Such actions, may neither be beneficial to local people nor helpful for conservation of elephants, besides negatively affecting elephant behaviour in altered landscapes (Whitehouse and Kerley 2002, Bruke et al 2008, Kumar and Singh 2010). Besides damage to property by elephants, unquantifiable losses such as human death, reduced sleep, absenteeism at work due to guarding of property and life, and psychological stress may over-weigh actual loss associated with human-elephant conflicts (Madhusudan 2003 b). Our past research on elephants in this region identified three primary reasons. One, a serious lapse of ‘information network’ to communicate about elephant presence and their movements to people is the main reason for loss of human life due to elephants. Secondly, lack of ‘in-house’ warning systems for selected settlements and human property along elephant movement routes. Finally, lack of positive attitude, non-lethal precautionary methods, and community participation to prevent fatal encounters with elephants.

We present results of the study carried out between April 2011 and March 2012 to explore understanding of elephant movements, loss of human life due to elephants, and implemented measures to promote human-elephant coexistence on the Valparai plateau. We intended to (a) understand spatial and temporal patterns of fatal encounters of humans with elephants in a plantation landscape, (b) experimentally implement human-elephant conflict measures to avoid human deaths due to elephants, and (c) monitor the effectiveness of implemented conflict mitigation measures.

MATERIALS AND METHODS

A. Study area

The Valparai plateau in the Anamalai hills is a 220 km² of plantation landscape dominated by tea and coffee plantations with 30 – 40 rainforest fragments scattered across the plateau (Mudappa and Raman 2007, Figure 1). The Valparai plateau occupies a unique geographical location in the Anamalai hills and is surrounded by tiger reserves, national parks, wildlife sanctuaries, and reserved forests. The plantations on the plateau are largely owned by six major national and multinational companies and a host of small
plantation growers with 70,000 people working as estate workers living in widely spread human habitations. The plateau has been historically used and continues to be used by elephants to move across plantations into the surrounding protected areas, during which there is incidence of human-elephant conflicts (Kumar et al 2004).

![Map of Valparai plateau](image)

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

### B. Methods

1. **Tracking elephants and conflict: Conflict Response Unit**

   Direct sightings, fresh signs such as dung, and information from local informants were used to locate elephants within the plantation landscape. A Conflict Response Unit was initiated comprising three experienced people from the tribal community to track elephants that use plantations on the Valparai plateau. Information from local people and Tamil Nadu Forest Department personnel was also used to verify elephant presence in plantations. Once an elephant herd was located, it was followed by one or more members of Conflict Response Team on each subsequent day until the herd moved out of the plantations into surrounding Protected Areas (Kumar et al 2004, 2010). Details on GPS locations of elephant presence and their movement, incidence of property damage by elephants, incidents of loss of life due to elephants, and habitat parameters were recorded on elephant movement and conflict record form. Information on incidences of human deaths due to elephants was also obtained for the period between 1994 – 2002 from the forest range office of the Tamil Nadu Forest Department. Elephant herds were
identified based on physical markings such as cuts, size, and shape of holes in ears, lumps on the body, and shape of the tail, besides verifying age-sex composition and size of the herd (Moss 2001, Goswamy et al 2007).

2. Elephant Information Network
An elephant information network was established to intimate people in advance about elephant presence and their movement in plantations by initiating the following measures.

a. Use of television cable network
Information from the Conflict Response Unit's daily tracking reports of elephants during the day were fed into the local Cable Television Channel (Valparai TV) on a daily basis for the days during which elephant herds are seen inside plantations on the Valparai plateau. Information regarding elephant presence in tea and coffee estates was displayed after 5 pm as a text 'crawl' along the top of the television screen overlaid on regular programmes. The message on television carries information about location of elephant presence, name of the estate, and contact number of team member in English and Tamil languages. The cable television channel network has 5000 connections covering most part of the plateau.

b. Bulk SMS (Short Message Service) initiative
A bulk SMS text messaging was initiated with the help of GUPSHUP SMS SERVICE (www.smsgupshup.com) to send out SMS to people mobile numbers regarding elephant presence. A database of about 2400 mobile numbers of people including estate workers, women self-help groups, watchmen, security guards of companies etc., residing in tea and coffee estates, managerial personnel in tea and coffee plantations, press reporters, and Forest Department personnel has been maintained and grouped accordingly. Data base includes information about mobile number of person, sex, occupation, name of the residential colony, division and estate name. Elephant messages were sent in both Tamil (vernacular) and

Figure 2. Early warning SMS message to people about elephant presence in plantations
English languages on daily basis to people residing within the 2 km radius from elephants as soon as elephant information is received from the Conflict Response Unit. Each mobile phone would receive elephant information in two languages as unique messages. Google Transliteration (http://www.google.com/ transliterate) was used to send out messages in the local language. Message would carry information on elephant location, estate name, habitat, and mobile phone contact number of a team person. Response calls made by people have been systematically recorded on daily basis. Response calls of people indicating elephant presence were confirmed with the Forest Department personnel as well as with our daily tracking information.

Telephonic responses from people to messages on the cable television network and from the bulk SMS have been systematically and separately recorded (different contact telephone numbers were provided for TV and SMS subscribers). The responses to conflict mitigation measures from people were categorized into the following classes:

**Enquiry:** Phone calls received to check about elephant presence and safety measures required to be taken by people.

**Inform:** Calls received to intimate about elephant locations in the respective localities of people residential and fields.

**Register:** Requests received over phone to register for bulk SMS elephant text-messaging service to avail information about elephants on mobile phones.

**Appreciation:** Conveying benefits of mitigation measures over phone by people.

**Unsubscribe:** Requests to exclude their numbers from the bulk SMS text-messaging service.

**Unrelated:** Response of people unrelated to conflict mitigation measures.

c. **Elephant alert indicators**

Mobile-operated elephant alert indicators were installed in 20 strategic locations in three plantation companies. These indicators are fitted with red flashing LED lights with in-built SIM card working on Global System for Mobile Communication (GSM) technology. Locations for lights were selected based on elephant movements, conflict locations, people’s use of plantations, and visibility factors. These locations include tea factories, residential colonies, and bungalows which are visible from nearest bus stops (Figure 3). Each lighting unit can be operated remotely by calls from a registered mobile phone. The SIM card in each indicator has been equipped with a bi-monthly SMS package which sends out messages indicating the status of light (On/Off) to registered
mobile numbers. Message from the light displays information about registered mobile number from which the light is operated, power supply, status of light, date and time of operation. The light operates on missed call system where call from registered mobile phone will be attended and disconnected after several rings. When a call was attended by a light from a registered mobile number, LED light goes into ‘on’ status after three rings and into ‘off’ status after seven rings. This kind of provision would help people to know the status of light who are unable to read messages sent by light to registered mobile phone. At least two persons per estate in each location of light, based on company recommendation, were identified and their mobile numbers registered with each alert indicator. A master phone which allows registering mobile numbers has been retained with the research team to monitor operational sequences of indicators by people. Field training for light operators was conducted in each of the locations to explain the method of light operations. On-field awareness programmes through direct interactions with estate people and through local news media were carried out to communicate about the significance and understanding of alert indicators (Appendix 1). Efforts have been made to communicate to people about early warning systems through a five-minute film documentary on cable television channel.

Figure 3. Elephant alert indicator as an early warning system in one of the critical human habitations on the Valparai plateau (Photo credit: Kalyan Varma)
RESULTS

Elephant movements

Field tracking showed that the Valparai plateau was used by 8 – 10 herds with a range of 80 – 100 elephants over the period of study (Figure 4). This included three regular herds and 5 – 7 peripheral herds. The three regular herds (namely Monica, Pig tail, and Stepear herds) comprised of 46 elephants and ranged over most of the plateau. During the last one year, Monica moved mostly from the centre towards north and northeast direction (red stars), the Pig tail herd (red triangle) concentrated along the river in the middle of the plateau towards southwest region. Stepear herd (blue square) moved mostly between southwest towards northeast direction. Peripheral herds (dark circle) largely found using the plateau along periphery of the surrounding protected areas. However, there was a high concentration of elephant herd locations along the Nadu Ar – Sholayar River in the middle of the Valparai plateau. There was a minimum of two to a maximum of five elephant herds recorded on the Valparai plateau on any given month in the last one year.

Figure 4. Map of spatial distribution of elephant herd locations on the Valparai plateau
Human-elephant conflict mitigation in a land-use mosaic of the Anamalai hills

*Human deaths*

Between 1994 and 2012, 38 people lost their lives in accidental encounters with elephants (average of 2 – 3 people per year). Spatially, human death locations are distributed across plantations, with TANTEA area in the southeastern portion being one of the highly sensitive areas with 9 of 38 deaths occurring there (Figure 5). Most (71%) human deaths (27 people) occurred on roads (main roads and estate roads) and 81% of the deaths occurred within tea and coffee plantations. Nearly 58% (22) of people who lost lives in direct encounters with elephants were aged between 50 and 65 and more men (27) than women (11) lost their lives. Of the 38 human deaths, except in three incidents, others occurred due to lack of information about elephants.

![Map of spatial distribution of human deaths due to elephants on the Valparai plateau (1994 - 2012)](image)

Figure 5. Map of spatial distribution of human deaths due to elephants on the Valparai plateau (1994 - 2012)

Temporally, although loss of human life due to elephants was noticed in all months except for July, the period between December and February accounted for 63% of human deaths (24) which denotes the peak conflict period (Figure 6).
The cable television network

A total of 217 responses to calls were received from people over phone during one year period between April 2011 and March 2012 (average of 18 calls/month). Most of the responses were to enquire about elephant presence in respective locality of people, safety measures, and conveying information about elephant presence in their locality to display on cable television channel (88%, Figure 7). Other category of responses include request to add numbers to avail bulk SMS service and a few unrelated responses from people.
People response to Cable television channel network

Responses of people calls were analyzed across months for one year (Figure 8). Nearly 60% of response calls received between May and August. However, number of responses to television network over phone gradually declined from July and reached lowest between December and March.

![Figure 8. Distribution of responses of people to cable television channel network across months](image)

Bulk SMS text-messaging service

Distribution of mobile numbers

Around 2400 mobile numbers of people working in tea and coffee estates across nine plantation companies, government departments, and others which include business people, auto drivers were registered for the service. Nearly 84% of mobile numbers of people were from BBTC, TATA Coffee, PKT, Wood Briar, and Parry Agro Industries as these companies occupy a major part of plantation landscape on the Valparai plateau (Figure 9).

![Figure 9. Distribution of mobile numbers of people across groups](image)
Elephant alert messages vs responses

We analyzed the information on elephant messages sent and responses received for a period of nine months between July and March (Figure 10). Of the total of 155,704 messages nearly 78% of messages were sent to people's mobile numbers between November to March. Similarly, of the total of 1075 responses (average of 119/month) received from people, November to March accounted for 64% of responses. There is a significant correlation found between messages sent and responses received from people (correlation coefficient 0.80, \( P < 0.01 \)). The rate of response to unique SMS messages sent was higher during July – September and stabilized later during October and March. Further analysis indicated that the rate of response calls from people in relation to unique messages sent was about 1.2% per month.

Response of people to bulk SMS elephant text-messaging

Responses from people for SMS messages were grouped into six categories (Figure 11). A total of 1079 responses were received from people. Majority of responses were enquiring about elephant presence and safety measures require to be followed, conveying elephant information, and request to add mobile numbers to receive elephant messages. These categories together amounted to 93%, and 5.5% of people responses included appreciation of SMS elephant message facility.
Elephant early warning indicators

Spatial distribution of elephant alert indicators

Elephant alert indicators (#20) were installed in three companies such as Parry Agro Industries (#6), TATA Coffee Ltd., (#6) and Bombay Burmah Trading Corporation Ltd., (BBTC, #8) covering 13 tea estates on the Valparai plateau (Figure 12). There is a high concentration of alert indicators (#12) in the south western part of the plateau which has large number of human habitations and is a region of high incidence of conflict.
Community involvement in elephant alert indicator

Of the 439 instances of light operations, local community operated elephant alert indicators 65% of times (#286) as compared to NCF (#153) between November 2011 and March 2012. Gradual decrease in the use of indicators by NCF was noticed from January. However, operations by the local community remained active between January and March (Figure 13).

![Figure 13. Frequency distribution of elephant alert indicator operations by NCF and local community across months.](image)

DISCUSSION

Conservation of elephants in human-dominated landscapes largely depends on conflict mitigation measures that would enhance human-elephant coexistence between people and elephants. Human-elephant conflict mitigation in such landscapes requires a two-pronged approach to strike a balance between people and elephants. One, is to understand the ecological and behavioural aspects of elephants in terms of critical areas, availability of natural habitats, and their movement in a mosaic of habitats in modified landscapes. Secondly, understanding human perspective of conflicts in terms of spatial and temporal distribution patterns and identifying causal factors responsible for occurrence of human-elephant conflicts. Such an approach would help implement appropriate, adaptive, simple, and inclusive measures to alleviate negative consequences of human-elephant interactions and promote coexistence.
Elephant movements and human-elephant conflict

The Valparai plateau in the Anamalai hills has been intensively used by several elephant herds. Of which, the three regular herds which range over most of the part of the plateau showed consistent movement patterns as noticed in the previous studies (Kumar et al 2004, Kumar et al 2006, Kumar et al 2010). This would reiterate the findings shown by other studies that elephants show strong fidelity to their ranges (Fernando et al 2008). Peripheral elephant herds were mostly restricted to areas bordering the surrounding protected areas which would have had much larger home ranges in the surrounding forests.

On the other hand, human-elephant conflicts, particularly, loss of human life due to elephants was mainly due to accidental encounters. Presence of sparsely scattered isolated rainforest fragments and patchy distribution of resources would compel elephants to move between forest patches particularly during late hours of the day due to less human activity in plantations. The plantations on the plateau have a good network of roads primarily for company vehicles. However, most of the bus routes are away from majority of human habitations. People who commute between nearest bus stop and residential colonies during late hours if they are unaware of elephant movements in respective locality led to chance encounters with elephants. Majority of cases of human deaths due to elephants occurred on roads and during dark hours, showing that lack of information about elephant’s presence and their movements in estates led to fatal encounters. Across years, such fatal encounters peak during November to February due to intense use of plantation area by several elephant herds (Kumar et al 2010) and high people movement during non-rainy months owing to occurrence of various social events such as temple festivals, marriages etc. (personal observations).

People’s livelihood dependence on plantations and historical loss of prime forest habitats to commercial plantations compel both humans and elephants to share resources on the Valparai plateau. In such circumstances, conflict mitigation measures aimed at promoting coexistence is the key to conservation of elephants in altered landscapes. An integrated approach by involving local communities into the process of resolving conflicts have been suggested as an effective way of dealing with human-elephant conflicts and conservation of elephants in human modified habitats (Osborn and Parker 2003, Hedges and Gunaryadi 2009).
Early warning system

Cable television network

Loss of human life due to elephants elicited anger and caused pain and fear among local communities which negatively affected human-elephant relationships in the Valparai region. Our research clearly indicates that lack of information about elephant presence and their movement through plantations was the primary reason for fatal encounters. The elephant information network was developed as a direct response to this need to provide better awareness and communication about elephant movements to people residing in close quarters of elephants. Use of local cable television channel as a medium to communicate about elephant presence reached over 5000 families living inside plantations. Average number of response to cable television network was much lower as compared to bulk SMS text-messaging service as an early warning system. The decline in response calls of people to cable television network over months was primarily due to initiation of bulk SMS service.

Bulk SMS elephant text-messaging service

Communicating early warning of elephant movements in human use areas to local communities living close to elephant habitats plays a crucial role in the management of human-elephant conflicts (Sitati et al 2005, Hedges and Gunaryadi 2009). Use of mobile phone technology has been recently experimented in Africa and proven to be effective in reducing incidences of human-elephant conflict (Graham et al 2011). Mobile network coverage and use of mobile phones by local people has been steadily increased in the recent years in the Valparai region. Mobile phone communication network provided by three companies namely Bharat Sanchar Nigam Limited (BSNL), Aircel, and Vodafone cover all plantations on the Valparai plateau. Use of mobile phone has now become essential part of people’s daily communication activities. Voluntary involvement of estate workers and cooperation of company management in receiving elephant messages both in English and Tamil (vernacular) in the form SMS text-messaging on mobile phones indicates stakeholders’ interest to be part of conflict resolution. Advance intimation of elephant presence to local communities over SMS service has been cost-effective and a better option than direct communication over mobile phones (Graham et al 2011). SMS elephant text-messaging service was initiated in July and responses to SMS text messages were systematically recorded. We have observed that as the information about elephants was communicated to people widely there was growing response to SMS message service. However, relatively high rate of response to SMS
messages sent during initial months was primarily due to more response calls from people enquiring about the measure and to register their numbers in SMS data base to avail elephant messages over phone. Our research suggests that bulk SMS service has a positive impact on the management of human-elephant conflicts in three key ways.

First, SMS text-messaging enables people to avail early warning intimation in both languages about elephants in their respective locality. Early intimation of elephant presence would help people to avoid fatal encounters by taking timely precautions while moving through elephant presence areas.

Second, SMS text-messaging communication has facilitated to develop two-way communication about elephant presence between conservation group and people residing in respective localities where elephant movements were noticed. This was apparent from the results that as communication about elephant presence increased there was an increase in people’s responses to SMS messages. A majority of responses (71%) include enquiring about elephant locations and safety measures to be adopted besides conveying information about elephant presence in their localities. Response of people to add their numbers to the data base to avail elephant message facility indicate positive effect of bulk SMS service and willingness to be part of human-elephant conflict management to avoid fatal encounters with elephants. Since this measure is low cost and simple in operation, it can be replicable and sustainable in other areas to effectively address human-elephant conflict.

Third, early warning messages would promote sense of responsibility among recipients to share information with others, communicating it to concerned authorities to seek help, and improve better coordination among local communities to be precautionary and prevent incidental encounters with elephants. Enhancement of effective elephant information network would increase tolerance levels of people towards elephants. Message facility would also help company management to adopt work safety measures to shift estate workers away from elephant presence fields to other areas in tea and coffee plantations.

Of the two kinds of early warning networking measures, it seems that bulk SMS service has been more intimately received by people than cable television networking, as responses of people to cable television network reached lowest with a corresponding peak for the bulk SMS service during December and March. This may be because early warning messages over mobile phones seem to develop a sense of "my message" attitude
in recipients than messages on television which often convey as a general public announcement.

*Elephant alert indicators*

A novel way of intimating people in advance in human areas, mobile operated elephant alert indicators are useful to warn people of elephant presence in human use areas during late hours of the day. The red flashing LED lights situated in highest points of tea factories, bungalows, and residential places are visible up to a distance of 1 km from nearest bus stops. Flashing signals from the lights would attract people attention and indicate elephant presence in respective localities. This method is useful when people are unable to access cable television channel or receive or read SMS text-messaging on mobile phones. Training for light operators and direct interactions with local communities to convey significance of lights would help interpret the importance of alert indicators and adopt appropriate preventive measures while moving in elephant presence areas. Our research results clearly indicate that there has been active involvement of people to operate alert indicators to warn people of elephant presence in their respective localities. An increase in operations of alert indicators from registered mobile numbers by people and decreased activity by NCF (conservation group) indicate people participation in elephant early warning system and sharing responsibility to intimate others of elephant presence instead of depending on other agencies.

**CONCLUSIONS**

The present research indicates that development of elephant information network is one of the useful applications in management of conflict mitigation. Novel methods of using network technology to develop low cost early warning systems coupled with active participation of stakeholders would make these measures sustainable and replicable in other areas of similar habitats. However, the present research also identifies several limitations in the application of these measures elsewhere.

Firstly, cable television channel facility has been widely distributed in most part of the country. Nevertheless, availability of local media channel is progressively becoming limited due replacement of cable channel network by *Direct To Home* (DTH), a digital satellite service for high quality television programmes in rural areas and also non-availability of local television channel because of remoteness of locations in some areas. This may limit conveying of early warning elephant messages to people over cable network.
Use of bulk SMS service for early intimation of elephants to people requires trained persons with basic knowledge of computer applications and introduction to internet services to send out messages in English and local languages. Sometimes, messages may not be delivered to concerned recipient due various reasons such as poor/no mobile network coverage, no space in the inbox mobile phone of recipient, and unable to support messages in local languages on certain company mobile phones. Communication of elephant messages over mobile phone is also dependent on recipient literacy capabilities.

Installation of alert indicators involves purchase and installation costs and recurring cost of SIM card to meet validity of card and SMS packages. Relatively high cost of lighting units may become a constraint for its application in similar landscapes but poorly developed areas unless there is a support from the Government or non-governmental agencies. Training people to operate indicators and awareness programmes for local communities to interpret the significance of indicators would play important role in the management of human-elephant conflict.

Use of modern technology to develop elephant information and communication network is highly suitable to management of human-elephant conflict (Graham et al 2009 and 2011). A combination of measures that ensures timeliness in communication of elephants would help increase people's tolerance of elephants, avoid fatal encounters, and promote human-elephant coexistence in altered landscapes. Sustainability of elephant information network using modern methods of communication technology depends on understanding and continued adoption of techniques by local stakeholders in future.

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Appendix 1

Local and national media coverage:


