Research Article *Gajah 50 (2019) 23-28*

Gauging Farmers' Acceptance of 'Social Barrier' Mechanisms for Preventing Elephant Crop Raids

Malachi Stone[1], Sagarika Phalke[2], Nicholas Warren[3], Dilip Kumar AV[2] and Avinash Krishnan[2]*

[1]*Post Graduate, Conservation and Ecology, University of Aberdeen, Scotland, UK*
[2]*A Rocha India, Bangalore -Karnataka, India*
[3]*A Rocha International, London, UK*
**Corresponding author's email: avinash.krishnan@arocha.org*

Abstract. The villages surrounding Bannerghatta National Park, Karnataka experience high human-elephant conflict in the form of crop loss. Forest Department maintained elephant barriers are not entirely effective in keeping elephants away from farmlands and cooperative participation in crop guarding is low. We assessed farmers' attitudes to suggestions of community implementation of chilli-tobacco barriers and beehive fences to prevent crop raiding. We found 64% of the farmers were willing to implement these methods. Despite the higher effort required, the chilli-tobacco barrier was preferred, due to lower costs. While commitment by farmers to defend their crops are crucial for problem control, the study did not show a very high acceptance of community-led barriers and the attitudes of the farmers towards the Forest Department and elephants were negative.

Introduction

Human-elephant conflict (HEC) affects at least 500,000 families and causes one million hectares of crop damage annually in India (Bist 2002; MoEF 2010). Wildlife conflicts have a negative impact on public support and create a sense of animosity towards conservation efforts (Naughton-Treves & Treves 2005). Therefore, the primary concern and conservation goal for the survival of elephants in range countries is the management of this conflict.

There are currently several techniques practised across South Asia to contain HEC, which are undertaken by state and non-state actors (Fernando *et al*. 2008). However, amongst these, the act of empowering affected communities to take responsibility for preventive action is considered the most sustainable; and is also known to decrease incidences of retaliatory killing (Zimmermann *et al*. 2009; Davies *et al*. 2011; Scheijen *et al*. 2019). These empowering approaches encourage farmers to actively participate in protecting their own crops and thereby ease the pressure on wildlife management; facilitating better interactions between the two (Osborn & Parker 2002). Examples of barriers that could be used by farmers include bio-fences, chilli-tobacco fences and beehive fences. The effectiveness of any barrier is dependent on the amount of effort that is put into them (Desai & Riddle 2015). Therefore they are largely dependent upon the community's willingness to maintain them over the long-term (Rohini *et al*. 2016; Sampson et al. 2019); this maybe in terms of human effort or financial investment.

Bannerghatta National Park (BNP) (N 12°20'–50' and E 77°27'–38') is situated in the state of Karnataka, India. It has an Asian elephant (*Elephas maximus*) density of 0.63 elephants/km^2 (Project Elephant 2017) and supports a population of 150–200 elephants (Gopalakrishna *et al*. 2010). The villages around BNP witness a high incidence of HEC (Varma *et al*. 2009; Suresh 2018). Currently a number of deterrent methods are used. There are eight physical barrier mechanisms that are maintained by the forest department to contain conflict, which cover 70% of the park boundary. These are in the form of solar electric fences, elephant proof trenches, rubble walls, concrete walls, concrete moats, spike pillars, spike gates and

Manuscript Editor: Prithiviraj Fernando

mesh barriers (Gayathri *et al*. 2016). However, these multiple barriers do not prevent elephants moving out of the protected area into farmlands. These barriers are often made ineffective due to structural errors and by local communities who damage them to enter the park for cattle grazing or firewood collection (Saklani *et al*. 2018). Crops are also guarded with traditional deterrents such as firecrackers, chasing and noise. However, these methods increase the risk of injury for both humans and elephants (Varma *et al*. 2009).

The status of community cooperation in crop protection and attitudes towards community-led barriers remains relatively unstudied in the landscape. In 2009 the chilli-tobacco barrier (CTB) was pilot-tested at Bannerghatta and showed varying degrees of success. While interest was expressed by community members, the up-take of the method remained relatively poor (Varma *et al*. 2009). Beehive fences (BHF) have been tested in parts of Africa and Asia as a method to mitigate HEC and create additional income for farmers (Save the elephants 2019). In India, a study was conducted in Kerala on the BHF and was found to be effective in mitigating conflict (Nair & Eluvathingal 2016). However factors such as topography, socio-political differences, and local practises differ between landscapes and could have an impact on the efficacy of barriers.

Before attempting to introduce this system into Bannerghatta we wanted to understand the community's attitudes and possibility of acceptance of such measures. The objectives of the study were to (1) understand the factors that influence farmers' decisions in accepting community-led interventions to mitigate HEC, (2) assess existing community methods to manage HEC, and (3) explore the possibility of implementing CTBs and BHFs at Bannerghatta.

Methods

Interviews were conducted of 101 farmers in 36 park-edge villages of Bannerghatta National Park, from July to August 2018. Villages that experienced high, medium and low conflict were selected based on crop damage incidents in 2017 (Osborn & Parker 2002). A questionnaire was administered to male farmers between the ages 18–60 (Mabeluanga & Krishnan 2018). The questionnaires were conducted by a bi-lingual interviewer in the local language (Kannada) and responses were recorded in English. The survey consisted of a structured questionnaire with a mixture of open, closed and multiple-choice questions. Questions covered the respondent's demography, dependency on agriculture and existing community-cooperative methods to mitigate conflict. Participants were then given a 5-minute educational presentation on CTBs and BHFs. The presentation focussed on the mechanism of the fences, their implementation, challenges and their associated costs and in addition, expected revenue in the case of BHF. The costs for each of the barrier systems were calculated for one acre of farmland because individual farms in Bannerghatta average between 1–3 acres in area and are generally spread out (Mabeluanga *et al*. 2016). While the presentation concentrated on farmers using these methods as a barrier for individual farms, it also suggested the possibility of cooperation between farmers to reduce costs. The participants were then asked about their perceptions on the efficacy and likelihood of up-take, of the two barriers.

Summary of the main points communicated to the farmers

- The estimated cost to cover a one-acre farm plot with a BHF was Rs 36,000- Rs 40,000 and with a CTB Rs 4,200.
- It would take 8.5 man-hours to install a CTB fence and would take 4–6 hours to maintain the fence at least 2–3 times a month. The cost would be Rs 110 per maintenance.
- For every 20 beehives approximately 10–15 kg of honey can be harvested (Nair & Eluvathingal 2016). With the cost of 1 kg of honey amounting to ~Rs 120–160 (wholesale market price at the time of study).
- A beekeeper could be hired to provide technical support and could assist in installing the BHF. However, farmers would still be expected to provide water to every beehive, sugar water during low flowering seasons and adequate shade. It would take

8–15 hours per week to maintain a beehive colony (Government of India 2018).

The responses from the questionnaires were transferred onto Microsoft Excel spreadsheets, which was also used to analyse the descriptive statistics. The analysis of inferential statistics was conducted using R Studio. A chi-square test of independence was performed on various factors to understand its influence in villager's acceptance of the two barriers. These factors focussed on the cost of implementing barrier, frequency and intensity of conflict experienced and agriculture as a primary source of income.

Results and discussion

Status of HEC in Bannerghatta

Crop depredation by elephants predominantly ranged across five months (September – February) of the year. These findings concur with previously recorded observations of peak conflict in the landscape, coinciding with the maturing of seasonal crops such as finger millet (*Eleusine coracana*) and jowar (*Sorghum bicolor*) (Varma *et al*. 2009; Mabeluanga *et al*. 2016; Pant *et al*. 2016).

Understanding the extent of the conflict is important to understand the willingness and motivation of farmers to engage in a conflict mitigation intervention. Of the 101 farmers interviewed, 99% (n = 100) experienced crop damage by elephants during the past five years (2013–2017). Farmers experienced similar levels of conflict intensity in all the five years with no significant variation between years (Table1) (one-way ANOVA, $F = 0.08$, $p = 0.98$). This highlights the extent of conflict experienced by farmers in Bannerghatta, which is concurrent with experiences from other landscapes experiencing HEC such as Parsa Wildlife Reserve, Nepal (Pant *et al*. 2016) and Manas National Park, Assam (Nath *et al*. 2015).

Of the respondents 2% (n = 2) applied for crop compensation every time they experienced crop damage by elephants. The majority 60% (n = 60) applied for compensation sometimes (i.e. 50% of the time they experienced crop damage) while the rest (n = 38) never applied for compensation. Previous studies have also shown a marked difference between crop compensation claimed and actual levels of conflict (Pant *et al*. 2016). The fact that in Bannerghatta, only 2% of farmers consistently claimed for compensation reflects issues with the process such as difficulty of application, logistical issues, extended time in processing applications and dissatisfaction with compensation amounts. Dissatisfaction with compensation may result in negative attitudes of farmers towards the Forest Department and also decrease tolerance towards elephants (Mabeluanga *et al*. 2016).

Farmers also viewed HEC as a problem of the Forest Department and questioned why they should be expected to finance a solution to a problem caused by "the government's" animals. This view appears to correspond to other studies where villagers view the Forest Department as the only stakeholder in conflict mitigation, and expect the government to finance mitigation measures (Ogra 2009; Rohini *et al*. 2016). Therefore, co-managing conflict by the government and farmers is important to foster cooperation and improve relations.

The majority of farmers interviewed (52%) guarded their own crops without engaging in community collaboration and 31% did not guard their crops. Conflict not only incurs financial costs, but also causes social and psychological issues. This is because crop guarding involves considerable human investment, and is needed mostly at night, which results in social ruptures in a family, poor well-being and increased risk of death and injury (Barua *et al*. 2013). Therefore even though famers experienced conflict, there

Table 1. Average percentage of crop damaged by elephants across five years.

Year	% Crop damage	Variance
2013	39.8	±5.3
2014	39.0	±5.8
2015	38.8	±5.5
2016	38.0	±6.7
2017	38.0	±9.2

may be factors that prevent them from engaging in active crop guarding. This suggests potential for a community-led barrier being implemented.

In the study area currently there is no cooperation when it comes to crop defence amongst farmers; and they were unwilling to work together and did not have a sense of "unity". Unless there is cooperation in implementing barriers such as CTB and BHF, there is a high possibility of the conflict shifting to adjoining farmlands. Elephants have been observed to walk along BHFs in Kenya and Tanzania until they reach a point they can cross (Scheijen *et al.* 2019). Collective guarding and cooperative action amongst local communities is important to mitigate and sustain long-term management of HEC (Mumby & Plotnik 2018; Nyirenda *et al.* 2018). Therefore, the current lack of co-management of the problem could decrease the success of any community-led initiative.

Perceptions of community-led barriers and factors influencing their implementation

The survey found 64% of the farmers were willing to implement CTBs or BHFs with 34% favouring CTB, 11% BHF and 19% willing to try both. CTB was opted for almost three-times more than BHF despite it requiring more labour and maintenance. Therefore the cost of the community-led barrier plays a significant role when it comes to implementation. Measures with low costs and materials which can be sourced locally, appears to be preferred by farmers.

A Pearson's Chi-Squared test of independence was conducted to see whether the crops grown, a farmer's economic status, time since the last attack and severity of crop damage had any significant effect on the farmer's decision on employing new barriers. Results indicated ($p > 0.05$) the following factors have an influence on implementing the barriers. Acceptance was found to be greater when farming was the only source of income v/s having an alternate source of income/job. If the majority of the harvest was used for personal consumption as compared to selling it, farmers were more likely to implement the barriers. Farmers acceptance was found to be higher if they experienced crop depredations by elephants in the past year v/s other years. In addition, farmers who experienced ≥ 40% of crop damage were more open to use of the barriers than farmers experiencing smaller losses. However, it was found that the cost of CTB did not influence the decision to accept ($p < 0.05$).

The effectiveness of CTB appears to be varied. Chilli deterrents appear to have a significant effect in Africa against elephant crop-raids (Chang'a *et al.* 2016) and have shown some success in low-rainfall areas in India (Chelliah *et al.* 2010). However, in Sumatra, when used in combination with conventional guarding methods, it was found to have no added benefit (Hedges & Gunaryadi 2010). In Bannerghatta, a pilot-test showed a success of 99% in preventing elephants from entering a test-plot over a 52-day period (Varma *et al.* 2009). Despite its success the CTB was not continued and its implementation ceased due to lack of resources to support farmers (A. Krishnan, pers. comm.). While Bannerghatta experiences low-rainfall, whether the CTB can be sustained over a longer period needs to be tested.

The success of the BHF in Africa is predominantly due to the aggressive nature of the African honeybee (*Apis mellifera scutellata*) and the response of African elephants (*Loxodonta africana*) towards them (King *et al.* 2007). In India, there are mainly two species of bees used in apiculture- the European honeybee (*Apis mellifera*) and the Indian honeybee (*Apis cerana indica*). While the former produces a larger crop of honey, it is rarely used in South India due to limited availability of flowers that can support colonies and therefore, the bees need to be intensively managed (providing feed of sugar-water) (Kishan Tej *et al.* 2017). Rearable bees in India are thought to be inactive at night. This is when most crop raiding by elephants occurs in Bannerghatta (Varma *et al.* 2009) and elsewhere. Therefore the possibility that Asian bees do not defend their hives at night needs to be investigated. The BHF has only been tested in Kerala and certain parts of North Karnataka (Save the Elephants 2019). Preliminary results from Kerala show that elephants are less likely to enter fields protected by the BHF. A total of 14 instances of elephant presence were recorded during the study period. Only five of those occurred at the BHF, of which three occasion's elephants failed to cross the fence and only in two instances the fence was broken (Nair & Eluvathingal 2016). While this method may have shortcomings, it holds potential as a supplementary source of income to partially compensate the monetary crop loss experienced.

Acknowledgements

Our heartfelt thanks to the local farmers of Bannerghatta who participated in the survey and allowed us to share their thoughts. We are grateful to Ramacharan and Sandeepa M.S for their contribution to statistical analyses. Riju Nair (Kerala Forest Research Institute) and B.V Apoorva (Hive Trust) shared their time and knowledge on the BHF and apiculture, and we are indebted to them. We sincerely thank Prem Mitra, Aswath Honnavar and SurendraVarma for their support and unfailing encouragement.

References

Barua M, Bhagwat SA & Jadhav S (2013) The hidden dimensions of human-wildlife conflict: Health impacts, opportunity and transaction costs. *Biological Conservation* **157:** 309-316.

Bist SS (2002) An overview of elephant conservation in India. *Indian Forester* **128:** 121-136.

Chang'a A, de Souza N, Muya J, *et al*. (2016) Scaling-up the use of chilli fences for reducing human-elephant conflict across landscapes in Tanzania. *Tropical Conservation Science* **9:** 921-930.

Chelliah K, Kannan G, Kundu S, Abilash N, Madhusudan A, Baskaran N & Sukumar R (2010) Testing the efficacy of a chilli–tobacco rope fence as a deterrent against crop-raiding elephants. *Current Science* **9:** 1239-1243

Davies TE, Wilson S, Hazarika N, Chakrabarty J, Das D, Hodgson DJ & Zimmermann A (2011) Effectiveness of intervention methods against crop-raiding elephants. *Conservation Letters* **4:** 346-354.

Desai A & Riddle H (2015) *Human-Elephant Conflict in Asia*. U.S Fish and Wildlife Service. <https://www.fws.gov/international/pdf/Human-Elephant-Conflict-in-Asia-June2015.pdf>

Fernando P, Kumar MA, Williams AC, Wikramanayake E, Aziz T & Singh SM (2008) *Review of Human-Elephant Conflict Mitigation Measures Practiced in South Asia*. WWF. <http://awsassets.panda.org/downloads/review_of_human_elephant_final_reduced_01.pdf>

Gayathri A, Sulaiman A, Kumar D, Phalke S & Krishnan A (2016) *Status of Elephant Proof Barrier Mechanisms in Bannerghatta National Park*. Technical report, A Rocha India, Bengaluru.

Gopalakrishna SP, Somashekar RK, Anand VD & Varma S (2010) Asian elephant and Bannerghatta National Park in Eastern Ghats, Southern India. *Gajah* **33:** 47-52

Government of India (2018) *Honey Mission*. Technical report, Ministry of Micro, Small and Medium Enterprises. <http://www.kvic.org.in/kvicres/update/honeymission/Detailed%20Scheme%20and%20Guideline%20for%20Honey%20Mission.pdf>

Hedges S & Gunaryadi D (2010) Reducing human-elephant conflict: Do chillies help deter elephants from entering crop fields? *Oryx* **44:** 139-146.

King LE, Douglas-Hamilton I & Vollrath F (2007) African elephants run away from the sound of disturbed bees. *Current Biology* **17:** 832-833.

Kishan Tej M, Aruna R, Mishra G & Srinivasan MR (2017) Beekeeping in India. In: *Industrial Entomology*. Omkar (ed) Springer Nature, Singapore. pp 35-66.

Mabeluanga T, Dilipkumar AV, Gayathri A & Krishnan A (2016) Influence of elephant-human interactions on agrarian communities in the Bengaluru-Bannerghatta landscape – A perspective survey. *Gajah* **45:** 28-32.

Mabeluanga W & Krishnan A (2018) *Economic Implications of Risk Mainly Caused by Human-Wildlife Conflict on Small and Marginal Farm Household's Income in the Eco-Sensitive Zone of Bannerghatta National Park, Karnataka, South India*. Report, A Rocha India, Bangalore.

MoEF (2010) *Gajah: Securing the Future for Elephants in India*. Ministry of Environment and Forests, Government of India, New Delhi, India.

Mumby H & Plotnik JM (2018) Taking the elephants' perspective: Remembering elephant behavior, cognition and ecology in human-elephant conflict mitigation. *Frontiers in Ecology and Evolution* **6:** 1-8.

Nair R & Eluvathingal J (2016) Effectiveness of beehive fences to deter crop raiding elephants in Kerala, India. *International Research Journal of Natural and Applied Sciences* **3:** 14-19.

Nath KN, Lahkar P, Dutta SK & Das JP (2015) Human-elephant conflict around Manas National Park, India: Local people's attitudes, expectations and perceptions. *Gajah* **42:** 15-21.

Naughton-Treves L & Treves A (2005) Socio-ecological factors shaping local support for wildlife: Crop-raiding by elephants and other wildlife in Africa. In: *People and Wildlife: Conflict or Coexistence?* Woodroffee R, Thirgood S & Rabinowitz A (eds) Cambridge University Press, Cambridge, UK. pp 252-277.

Nyirenda VR, Nkhata BA, Tembo O & Sia-mundele S (2018) Elephant crop damage: Subsistence farmers' social vulnerability, livelihood sustainability and elephant conservation. *Sustainability* **10:** 3572.

Ogra M (2009) Attitudes toward resolution of human-wildlife conflict among forest-dependent agriculturalists near Rajaji National Park, India. *Human Ecology* **37:** 161-177.

Osborn FV & Parker GE (2002) Community-based methods to reduce crop loss to elephants: Experiments in the communal lands of Zimbabwe. *Pachyderm* **33:** 32-38.

Pant G, Dhakal M, Pradhan NMB, Leverington F & Hockings M (2016) Nature and extent of human–elephant *Elephas maximus* conflict in central Nepal. *Oryx* **50:** 724-731.

Project Elephant (2017) *Synchronised Elephant Population Estimation*. Ministry of Environment, Forests and Climate Change, New Delhi. <http://www.indiaenvironmentportal.org.in/files/file/Synchronized%20Elephant%20Population%20Estimation%20India%202017.pdf>

Rohini CK, Aravindan T, Anoop Das KS &Vinayan PA (2016) Human-elephant conflict around North and South Forest Divisions of Nilambur, Kerala, India. *Gajah* **45:** 20-27

Saklani A, Kumar D, Gayathri A& Krishnan A (2018) Therailway-line fence: A new passive elephant barrier at Bannerghatta National Park, Southern India. *Gajah* **48:** 20-23

Sampson C, Leimgruber P, Rodriguez S, McEvoy J, Sotherden E &Tonkyn D (2019) Perception of human-elephant conflict and conservation attitudes of affected communities in Myanmar. *Tropical Conservation Science* **12:** 1-17.

Save the Elephants (2019) *Beehive Fence*. <http://elephantsandbees.com/beehive-fence/>

Scheijen CPJ, Richards SA, Smit J, Jones T & Nowak K (2019) Efficacy of beehive fences as barriers to African elephants: A case study in Tanzania. *Oryx* **53:** 92-99.

Suresh R (2018) *Wildlife Management Plan for Bannerghatta National Park 2018-19 to 2020-24*. Karnataka Forest Department.

Varma S, Anand VD, Gopalakrishna SP, Avinash KG & Nishant MS (2009) *Ecology, Conservation and Management of the Asian Elephant in Bannerghatta National Park, Southern India*. A Rocha India/ANCF, Bangalore.

Zimmermann A, Davies TE, Hazarika N, WilsonS,Chakrabarty J, Hazarika B & Das D (2009) Community-based human-elephant conflict management in Assam. *Gajah* **30:** 34-40.